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January 3, 1896	Sheet Table of Electric Supply Stations in London and the Provinces.
January 10, 1896	Coloured Sketch Map of Provincial Electric Supply Stations.
January 17, 1896	Steel Plate Portrait of Dr. John Hopkinson.
January 24, 1896	Coloured Map of London Mains and Districts.
January 31, 1895	Sheet Table of Expenditure on Electric Supply Undertakings.
March 13, 1896 / April 17, 1896	Supplement Sheet Table of Electric Supply Accounts.

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NOTES.

In our issue of July 5th our New York correspondent called attention to a novel electric tramway system, which had recently been developed by the Westinghouse Electric Company. It seems that for some considerable time Mr. GEORGE WESTINGHOUSE, jun., has been experimenting with a view to the perfecting of an electromagnetic underground system of electric traction. At a critical moment, however, it was discovered that the essential features of his invention had already been patented by Mr. JEROME WHELESS, and were being worked by the Electromagnetic Traction Company on an experimental line in Washington. Promptly the Westinghouse Company acquired the patent rights to this invention, and the system is now being introduced by them into this country. Last week we had an opportunity of inspecting a small model of the type of road track and car which it is proposed to adopt. The perfect working of a model is very little guide, even to the mechanical suitability of any new system of traction, and it can form no indication whatever as to its financial qualifications. Unfortunately, the exact cost of this system, per mile of track, does not appear to be forthcoming just yet; and all we have been able to learn is that it is cheaper than the slotted conduit system but dearer than the overhead trolley—a very wide range indeed. Be that as it may, we shall await with interest the development of this system on a commercial scale; for it is one which, for all its possible drawbacks, possesses advantages. In the Westinghouse system all that is visible to the naked eye is a double row of iron contact plugs, lying nearly flush with the track and spaced in pairs at about 20ft. apart, together with the covers of an equal number of road boxes containing the electromagnetic device for connecting the contact-plugs to the feeders whenever a car passes over them. The electromagnetic device is worked by a couple of small storage cells carried by the car, the current from which passes through the pair of contact-plugs and a local relay circuit. We hope shortly to give a detailed description of the electromagnetic switch employed.

At the meeting of the Institution of Mechanical Engineers last Thursday week, the Lille experiments upon the comparative efficiency of ropes and belts for the transmission of power —from which we expected so much, and got so little—were the subject for discussion. The unanimous opinion of the speakers seemed to be in accord with our own opinion, expressed in our leading article on these experiments, in our issue of May 3, 1895. At that time we pointed out that the results of these trials of ropes and belts threw no useful light on any one of the questions which pressed for answer, in regard to the economical use of these methods of power transmission. All the speakers who took part in the discussion last Thursday week seemed to regard the Lille undertaking as a good opportunity for useful work thrown away. It appears to have been marred by two principal defects: a deadening formalism, which led the commission to draw up rigid resolutions and blindly to adhere to them, to say nothing about the nonsense of striking a medal; and a want of apprehension of the practical matters requiring investigation. Indirectly, however, these experiments have proved useful; for they have led to a very practical discussion of the subject by the Institution, in which competent authorities said useful things; and we hope they have also stirred up engineers to recognise the need for a thorough investigation, and that someone will take up the matter and carry it to a final solution.

MR. CROMPTON was disposed to regard the matter as being of less importance now than it was a few years ago. The time was at hand when ropes, belts and shafts would gradually vanish before the conquering electromotor; and makers of pulleys were promised a bad time in the near future. He, however, favoured an inquiry into the matter of the efficiency of rope and belt gear; and took the view that one of the most accurate methods of experiment was to employ two similar dynamos geared togther, the one running as a motor driving the other. If the internal efficiencies of these machines have previously been obtained by the two-dynamo method; and if the in-put and out-put of electrical power be measured, when they are running geared, the mechanical power wasted in the gear is quite easy of calculation from the data thus afforded.

TAKING indicator diagrams for the purpose of discovering whether the ropes or the belt consumed the greater amount of power seemed to Mr. MICHAEL LONGRIDGE very much like putting a hazel nut and then a walnut under a steam hammer, and comparing indicator cards to find out which nut is the harder to crack. The placid conclusion of the Lille committee that there is really not much difference between the efficiency of rope and of belt gear is, it would appear, due

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to the whole of the difference between them being swallowed up by the errors of observation, owing to the very roundabout method chosen and the large magnitude of the quantities directly measured.

Interest in the use of three-phase transmission for electric traction has been augmented, in this country, since it was decided to adopt it for the Dublin electric tramways. This will be the first application of that particular system in the United Kingdom; but two examples have already been in existence for some time in the United States, and a third has recently been put into operation. The first case of this kind is to be found at Norwich, Connecticut, where three-phase current is transmitted a distance of 4½ miles, and a synchronous motor drives the continuous-current generators through countershaft and belts. The next instance is to be found at Sacramento, in California, the continuous current for the 500-volt trolley circuits in that place being generated by three-phase current supplied at 11,000 volts, the power being transmitted at this pressure from a water-power station 24 miles from the railway generator house. In this case, also, belt gear is used for coupling the polyphase motor to the continuous-current generators.

The latest example of American practice in this respect, however, at Lowell, Mass., shows considerable improvement upon the two earlier ones. The obvious advantage of combining polyphase motor and continuous-current generator in one machine has been recognised and utilised. The three-phase current is there generated at 360 volts; and is then transformed up to 5,500 volts, at which pressure it is transmitted partly to the further end of the railway, and partly to a point about mid-way between its termini. The length of railway served is 15 miles. At the two points fed the pressure is first reduced from 5,500 volts to 360 volts, and the three-phase current is then transformed into a continuous 500-volt current. We understand that the system has proved a great success, and has already enabled the railway to grapple with a very large traffic.

The daily Press is admittedly an important, nay, an almost indispensable factor of modern civilisation, but there is room for improvement, and in no direction is this more conspicuous than in the columns dealing with scientific and engineering matters, which are too often treated in the same slipshod and sensational style as the latest "horror." A good instance of this penny-a-liner method is the following paragraph clipped from a recent issue of the *Manchester Evening News*. London oculists, we are told, are in a state of very undignified agitation; they are "up in arms against the very serious danger to the community caused by the electric light. Dr. Critchett, Dr. Nettleship, and other eminent eye-doctors are agreed on the point that unless a stop is put to the exposure of uncovered electric lights in the streets and in shops and offices, we shall all become blind, or nearly so. The mischief is not so much in frosted glass globes as in the plain glass ones, which expose the dazzling wires. These lights have the same effect upon the eye as gazing at the sun. Experts think so strongly in the matter that they even suggest that Parliament should take it up, and prohibit the use of plain-glass globes for electric light unless they be properly shaded. The case, however, hardly seems one for compulsory measures. The warning given by the oculists should have the effect of inducing more thoughtfulness on the part of the public."

Not even the most enthusiastic electrician would, we suppose, suggest that naked arcs and incandescent filaments were objects to be gazed at without limit. But naked arc lights are not usually placed so as to come within the line of sight, and when they do so accidentally, whatever may result, the injury to the eye is quite negligible. The filament of a glow lamp is, on the other hand, more likely to meet the eye, but a frosted bulb is an extremely simple and most absurdly common way of entirely getting over that difficulty, and whatever the discomfort—and it is not small—which the absence of frosted bulbs may cause to those with weak eyes, the actual permanent injury to the eye by the glowing filament is no greater that than due to an ordinary gas flame. These pseudo-scientific paragraphs would, however, we expect, be left unread unless their writers liberally salted them with exaggeration and discovered certain blindness in glow-lamp filaments and serious public dangers in everything.

Owing to pressure on our space we have been compelled to hold over some of our correspondence until next week.

International Science.—The Paris Municipality agreed on Monday to erect a statue of Sir Isaac Newton. A street in Paris already bears his name.

Cable Interruptions and Repairs:—

	Date of Interruption.
Cadiz-Teneriffe	Sept. 25, 1895.
Maranharn-Para	Oct. 10, 1895.
Bonny Cameroons	Oct. 30, 1895.

Amazon Cable.—The survey of the route for the Amazon cable, and the landing places and sites for 14 stations have been settled upon. The gentlemen who have been engaged on this work are now *en route* for London.

The Arc Light.—Prof. Silvanus Thompson's Cantor Lectures on this subject, delivered in January last, are now being published in the *Journal* of the Society of Arts, Lecture I. appearing in the issue of October 25th.

General Electric Company of America.—It is stated by American technical journals that in 1886, when the Edison works moved from New York to Schenectady, 400 men constituted the working force, and they found quarters in three moderate-sized buildings. To-day 4,500 men are employed by the General Electric Company. They occupy 65 buildings, utilising 40 acres of ground.

University College, London.—Evening classes for advanced lectures and laboratory work will be opened early in November. The departments open will be Applied Mathematics, Mechanical Engineering, Electrical Engineering and Chemistry. Students wishing to enter should communicate by letter with the professor of the subject they propose to take up. The work is being carried out at the wish of the Technical Education Board of the London County Council.

Obituary.—The death, on Friday last, is announced of Dr. Julius Maier. Dr. Maier was born in Stuttgart, and was educated there and at Göttingen University. He came to England in 1866, and was science master at Cheltenham College from 1872 to 1883. He was author, joint author or translator of several electrical books, the most noteworthy being the

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one on "The Telephone and its Practical Applications," published in November, 1888, in which he collaborated with Mr. Preece. Dr. Maier's death took place at West Kensington; he was 55 years of age.

A Proposed New Madagascar Cable.—A committee has been holding meetings at the Ministry of Posts and Telegraphs to study the question of laying a submarine cable between Tamatave, Reunion and Mauritius. The estimated cost is from £100,000 to £140,000. If this scheme is carried out Madagascar will possess a double connection with the general cable network of the world.

Trinidad.—It is reported that a satisfactory agreement has been arrived at by the Government with Brazil in regard to the small island of Trinidad, off the Brazilian coast, upon which a naval party was landed to ascertain its suitability as a station for the new South American cable. It is understood that the title to the island is no longer in dispute, and that the incident may be regarded as closed.

Fires of Electrical Origin in America.—In a Paper read before the Fire Underwriters' Association of the North-West, Chicago, Mr. W. H. Merrill stated that a comparison of causes among 815 electrical fires published in the first eight reports shows that 113, or over one-seventh, of these losses were caused by the crossing of telephone, telegraph and similar wires with trolley or electric light wires. Heavy current flows established by such accidents through telephones, telegraph instruments and switchboards always result in damage to these devices, and oftentimes in their destruction, and the communication of fire from them to surrounding combustible material. The total loss due to these 113 fires was $324,957.50 (about £65,000), which is a pretty large sum to charge to accidents which must be considered preventable.

Flywheel Accident.—"The bursting of a flywheel and partial wreck of the Hudson Electric Light Company's station at Hoboken, N.J.," says the *Electrical Engineer* of New York, "points a lesson which may well be impressed upon those in charge of central stations. It seems that a short-circuit on the line had blown the fuses, and during their replacement the engineer had slowed down the speed of the engine *by raising and holding up the governor*. The new fuses had no sooner been replaced, however, when they blew again, and the engineer becoming 'rattled,' in order to slow the engine down again, held the governor *down*. The result was natural, and the engine raced until the flywheel burst. The unfortunate engineer paid with his life the penalty of his carelessness. But it seems hardly credible that anyone should take such a means of reducing an engine's speed, instead of shutting off the steam at the valve."

Dirty Lamp Posts.—Commenting on the dirtiness and unsightliness of many street lamps, the *Journal of Gas Lighting* says that it "is greatly to be wished that the authorities who are responsible for giving and maintaining an air of smartness in the streets, would look more keenly into this matter of the lamp-posts, and remove the old stagers which, although aged, are not in the smallest degree venerable or picturesque in their decrepitude. And when they do set up new and acceptable lamp-posts, it could be desired that they should show more solicitude about keeping them clean. A dingy or smeary lantern is a great reproach to whoever may be responsible for its condition; and cracked and broken glass is the abomination of desolation. But, in England, lamp-posts, railings, guard-posts, and all the miscellaneous appurtenances of a modern thoroughfare, usually exhibit an innocence of soap and water that is anything but creditable to us as a cleanly people."

The Pacific Cable Scheme.—Reuter's Agency states that, at the invitation of Sir Charles Tupper, a meeting was held at the office of the High Commissioner for Canada on Tuesday morning to discuss the Pacific cable scheme. In addition to the High Commissioner for Canada, there were present the representatives of the Australasian and South African Colonies. The instructions sent by the various Colonial Governments to their representatives were discussed, in view of the probable forthcoming conference with the Secretary of State. Reuter's Agency is informed that the Colonies, being quite prepared substantially to support the scheme, are desirous that the question should no longer remain in abeyance. It is added that the reported granting of a concession for an exclusive American cable between the United States and the Hawaiian group will probably necessitate the landing of the British cable on another Pacific island at a higher cost. The date of the conference with Mr. Chamberlain will not be fixed until the return to town of the Secretary of State.

Electric Locomotives for the Huron Tunnel.—It is stated, says the *Electrical World* of New York, that the management of the Grand Trunk Railway is contemplating the adoption of electric locomotives to haul its passenger trains through the tunnel under the Detroit river at Port Huron, the locomotives to be similar to those in the Baltimore and Ohio tunnel under Baltimore. "A desire to avoid smoke and cinders was amongst the causes which induced the Baltimore and Ohio Company to instal electricity. The Grand Trunk is forced to abandon steam engines, so it is said, because of their effect upon the tunnel structure. The latter, cut through the rock, is lined with steel casing, at the back of which is a filling of what is said to be a peculiar kind of asphalte. The tunnel is 1⅛ mile in length, and the gradient at both ends is 105 feet in the mile. Specially constructed locomotives, weighing 95 tons and having eight drivers, were used to haul the train through. In developing energy enough to haul long heavy trains it has been found, it is stated, that the excessive heat and escaping steam from the engines is exercising a deteriorating effect upon the asphalte backing, and it is stated that steam has been found to exercise a serious influence upon the other portions of the tunnel structure."

Efficiency of a Generating Plant.—At the fifth convention of the Canadian Electrical Association at Ottawa, on September 17th, Mr. James Milne read a Paper entitled "From Coal Pile to the Meter." The author presented an interesting series of curves, calculated from different sources, showing the efficiency of the various parts of a generating plant. These results, expressed in percentages, are given in the table below :—

Power for running generators	100
Power available at switchboard	92
Power available at meter	78·20

Efficiency of the electrical apparatus, including outside circuit = 78½ per cent.

Engine	100
Available for generating current	83·3
Available at switchboard	75·72
Available at meter	64·35

The commercial efficiency from engine to meter is 64·35 per cent.

Boiler equivalent	100
Indicated H.P. at engines	7·04
Available for generating current	5·79
Available at switchboard	5·33
Available at meters	4·53

The efficiency therefore from the boilers to the meter is 4·53 per cent.

Coal pile equivalent	100
Available at stop valves of boiler	62·47
Indicated H.P. at engine	4·4
Available for generating current	3·62
Available at switchboard	3·33
Available at meter	2·83

The Action of Flywheels.—An interesting experiment is described in *Electric Power* of New York, relating to the endeavour to secure the more uniform running of a dynamo driven by a gas engine. The first proceeding was to determine the amplitude of the angular displacement of the flywheel relative to the normal position it should occupy if speed were invariable. The flywheel was illuminated by means of a Geissler tube, excited by a Rhumkorff coil, regulated so that its flashes coincided with the frequency of the passage of the flywheel arms through a given position. So long as the flywheel velocity was constant, the arms were visible at this instantaneous position by the light of the flashes, and the wheel appeared to be stationary; but when the velocity varied and the wheel ran slower it appeared to have a slow retrograde movement, for the arms did not reach the given position at the moment of flash. Then, a fresh explosion taking place, the wheel would appear to slowly reverse its movement and over-

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run the flash point. In fact, the wheel appeared to swing slowly between two extreme positions, and its angular movement was easily measurable, the eye grasping readily the progress of the alternate advances and retrogressions. In light running, with one explosion every four or five cycles, the maximum angular movement was 50deg. With load on, and only one explosion missed out of four or five possible, the angularity was 8deg. for successive explosion cycles, and attained barely 12deg. after a non-explosive cycle followed by explosion.

Lightning Arresters for Light and Power Circuits.—In its issue of October 17th the *Elektrotechnische Zeitschrift* discusses the above-named subject. The gist of its remarks are as follows:—It is about 50 years since electrical engineers recognised the necessity of protecting electrical circuits by lightning arresters, and during that time the apparatus constructed for this purpose has generally proved quite satisfactory for telegraphic and telephonic circuits. The same, however, cannot be said of the apparatus intended for the protection of light and power circuits and electrical machinery. It may seem strange at first, that a contrivance which is reliable enough to protect the most sensitive receiver of a transatlantic cable cannot be employed for the protection of far more robust objects, such as dynamos or transformers. There is, however, a difference in principle. While in the first instance it is sufficient to keep the discharge from the instruments, in the second the instrument is required, in addition, to prevent the working current from following the path created for it by the lightning discharge. It is especially this latter condition which makes the problem so difficult, and which has resulted in a great number of ingenious contrivances. The practical value of these are regarded differently, and though the *Elektrotechnische Zeitschrift* would not like to say that the various lightning arresters at present in the market are not the best which can be made under existing circumstances, it would like to point out that even these do not afford that degree of safety which could be wished for in the interest of the industry. The main reason for this uncertainty, in which we still remain in regard to the best types of lightning arresters, is that we are still unable to produce artificial lightning which would allow of a systematic testing of apparatus. So far, laboratory experiments give us only an approximate verdict on the value of this or that type, and the real test must be left to nature and chance. In this way, of course, much data may be got together in time, and would allow of the design of lightning arresters on scientific principles. Up to the present, however, this point has not been reached, and an attempt to treat this question systematically and on the basis of experiment would be of great advantage to electrical engineering. Such an attempt could be made through the combined action of the different electrical societies of Germany. The experience gained with the existing type of apparatus should be first collected, and then, together with all other material, put into the hands of a committee for further investigation. The *Elektrotechnische Zeitschrift* proposes to further discuss the subject in its columns, and invites correspondence.

Silverton (Col.) Three-Phase Transmission Plant.—An interesting application of the three-phase system of transmission of power has recently been carried out at the Silver Lake Mines, near Silverton, Col., where power is transmitted a distance of three miles through some of the roughest country in Colorado. It is attracting considerable attention among mining men, as it is the first three-phase plant installed in the Rocky Mountain region. The Silver Lake group of mines, says the *Electrical Engineer* of New York, lie about four miles south-east of Silverton, and are situated at an altitude of 12,300ft. above sea level. Previous to the installation of electricity the mill, which is situated on the shores of the Lake, near the mouth of the mine tunnel, was run by steam. Coal was brought to the steam engine by a tedious path up the mountain, and by the time it reached the furnace cost $8.75 a ton. The plant is now operated by water power, which is brought from the Animas River, above Silverton, through a 3ft. by 4ft. flume 9,750ft. in length, which carries 2,350 cubic feet of water per minute. One of the great advantages of electrical utilisation is here demonstrated, for it was found less expensive to build this costly two-mile flume, running from above Silverton down to a spot where the necessary head could be utilised, and then to transmit the electricity back to the mine, rather than to continue to burn coal at the price which it brought at the mouth of the Silver Lake mines. The head of water obtained is about 180ft., which develops on the water-wheel shaft 640 H P. The plant consists of two 4ft. double-nozzle Pelton water wheels, with special buckets belt-connected to two 150 kilowatt General Electric three-phase generators. The current from these machines is delivered at 2,500 volts, and is transmitted over a distance a little more than three miles to the Silver Lake mill and mine. The conductors are bare copper wires, one for each branch of the three-phase circuits. These are strung from the power house, up the mountain passes, and through the rugged country. In one place where a chasm has to be spanned the wires are strung on poles 275ft. apart. At each insulator the wire is run through a short piece of rubber tube as an extra precaution against leakage. Lightning arresters are placed at each end of the line, and an additional safeguard against damage by lightning is provided in the shape of a barbed iron wire, which extends the entire distance of the line along the tops of the poles, and is grounded at every second pole. Arriving at the mine, the current is supplied to a 100 H.P. three-phase induction motor run directly from the primary circuit. Another 100 H.P. motor, as well as one of 75 H.P., are located beneath the ground, and current is supplied to these at a pressure of 220 volts, the reduction in pressure being effected by step-down transformers. In addition, a 15 H.P. motor runs a pump raising water from the Lake to the mill, and one small 1 H.P. motor operates a blower and the lights for a bunk, office and other buildings, both being connected to the secondaries.

Current Electrical Science.—Prof. Cardani, of Parma University, contributes an important Paper to the *Nuovo Cimento* dealing with the RESISTANCE OF CIRCUITS TO ALTERNATING CURRENTS. The work begun by Dr. Lodge and Lord Kelvin is carefully elaborated, and the results appear to admit of no doubt. Resistances were measured by the heating effects, as was done by Ignaz Klemencic (see *The Electrician*, October 18th, p. 812). The wires were surrounded by a tube containing petroleum, and communicating with a capillary "thermometer tube." The heat developed in the wire expanded the petroleum, and the rise of the petroleum in the capillary tube indicated the amount of heat and the temperature. An influence machine was discharged through a divided circuit, consisting of two such wires with thermometers. In this manner various wires were tested for resistance to alternating discharges. The law of diameters seems to be a very complicated one. For copper and brass there was a certain diameter, for which the resistance was a maximum. Platinum is the best conductor at larger diameters, but when it becomes very thin the resistance increases enormously. As regards the vexed question of the comparative resistances of iron and copper, Prof. Cardani finds that at larger diameters they are equal, but that thin iron has a lesser resistance than thin copper. Another Paper of some interest is one by A. Garbasso, on the double refraction of RAYS OF ELECTRIC FORCE. This was observed with Righi's tinfoil strip apparatus. Double refraction effects were obtained with calcite, Iceland spar, felspar and mica.—In the *Journal de Physique* for October, MM. Abraham and Lemoine describe an attracted disc electrometer for VERY HIGH POTENTIALS, say 100,000 volts. The commercial type is constructed on the principle of Roberval's balance, and is claimed to measure within 1 per cent. A curious feature about this instrument is the primitive manner in which the guard ring is brought into position, viz., by bending the S-shaped soft-copper wires by which it is suspended. Accurate results are obtained so long as the distance between the plates does not exceed half the width of the guard ring. *Apropos* of Cardani's assertion that the resistance of some wires increases with their diameter, we have in the *Journal de Physique* the equally startling announcement that the resistance of a spark is greater the smaller the gap. This is explained on the hypothesis of a counter E.M.F. due to a detaching of particles by the short violet sparks. The strong white sparks offer less resistance. If anybody doubts this let him try the experiment.

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MOTIVE POWER AND GEARING.*

(*Continued from page 822, Vol. XXXV.*)

BY E. TREMLETT CARTER.

The Otto Cycle.

Historical Summary.—The invention of the gas engine was made when it was first perceived that the power of explosives, such as gunpowder, to move things might be applied to make them move machinery, and when this power was first thus applied. To the Abbé Hautefeuille, pious and worthy son of an Orleans baker, is due the credit for having invented the earliest recorded gas engine, on these lines; for it was in the year 1678 that he devised a pump by which water was raised by the expansive energy of ignited gunpowder. Passing over the long series of inventions of the gunpowder type, however, we find that in 1791 the first engine in which gas, admitted as such into the engine, acted explosively was invented by one John Barber. The gaseous fuel was obtained by the distillation of wood, oil, coal and other hydrocarbon producing substances. A great advance was made in 1801 by Lebon, a French engineer, who conceived the idea of compressing the gas and air in two separate cylinders before admitting them to the explosion cylinder. It was not until 1833 that the gas engine was fitted with a governor to control its speed, this improvement having at that date been introduced by Wright. The governor, in this case, was caused to control the richness as well as the quantity of the explosive charge admitted to the cylinder. Wright's engine also had the improvement of a water jacket for keeping the cylinder cool. Some five or six years later, an Englishman, one William Barnett, who had already devised two types of gas engine, now developed a third invention, which anticipated in a remarkable degree many of the features of the modern gas engine. Like all of the early engines, his was double-acting; but its most important feature was the realisation of Lebon's scheme, of a separate compression pump for the gas and air. Another interesting feature was the ignition of the gas at the dead point, previous engines having been devised to explode the charges nearer the middle of the forward stroke. In 1860 a type of engine which, at a later date, became considerably developed, was introduced by two Italian engineers, Barsanti and Matteucci. Their engine was designed to cause the explosive force to act upon a piston momentarily free and disconnected from the crank shaft. The cylinder was vertical, and the explosion lifted the cylinder to such a height as to produce a very high ratio of expansion of the gas. In this high expansion lay the extraordinary merit of the engine. When at its highest point, the heavy piston was geared to the crank shaft, and, in its down stroke, caused this to revolve. Both the weight of the piston and the atmospheric pressure acted to drive the crank during the working stroke.

None of these engines, nor of any up to this date (1860), had been commercially successful motors; and, of those few which were actually made, a very small proportion were capable of running for any great length of time. They were none of them practical engines. At this date, however, Lenoir patented his earliest gas engine, which, gradually improved as time went on, but substantially unaltered, was the first type of commercial engine driven by the explosion of admixed gas and air in a cylinder. A great number of the Lenoir engines were rapidly put to work in this country and in France; and these remained in action until a better class of gas engine was able to replace them, many of them lasting for a great number of years. The Lenoir engine was double-acting, horizontal, and designed to admit the gas and air and to exhaust the waste gases by means of two slides, which were driven by eccentrics on the crank shaft. Ignition was by electric spark; and all parts of the cylinder were water-jacketed. During the early part of each stroke the explosive mixture was drawn in; and at half stroke or a little later this was fired, the explosive force acting throughout the remainder of the stroke.

* From a forthcoming work to be published by *The Electrician* Printing and Publishing Company. All rights are reserved.

Stratification.—An erroneous notion, which it is important to notice, was very prevalent at this time, and throughout a much later period, relative to the arrangement of the various gases in the cylinder during the in-draught stroke. It was supposed that the several portions of gas, air and residual products of combustion arranged themselves in strata; and valves were designed to have the supposed effect of stratifying the gases as follows: (1) next to the piston was to be a layer of products of combustion; (2) behind this was to come a layer of mixed explosive gas; (3) still further back it was sought to have a stratum of gas alone; and (4) at the very back of the cylinder there was to be only air. It was believed that the strata of incombustible gases acted as cushions, to mollify the shock of the explosion on the piston and cylinder end. It is remarkable to what a very late date this doctrine was preached, even from engineering chairs in our colleges. Yet, when we think in how short a time an escape of gas at one end of a large room can be detected by a nose at the other end; or when we remember that the entry into a large apartment of a person smoking tobacco soon causes the entire room to be filled with the odour of the weed; we find it impossible to believe that a rapidly moving piston does not produce sufficient commotion among the gases which it draws into the cylinder to utterly destroy any want of homogeneity and completely obliterate every trace of stratification. It seems most probable that at the moment of explosion the whole of the space behind the piston is filled with a gas of uniform composition.

Beau de Rochas.—The Lenoir engine and the host of imitations of it having been placed upon the market, and having worked on a commercial basis for some two years or so, facts and data were becoming available for a systematic study—in the light of the science of that day—of the causes of inefficiency, and of the conditions which might be expected to lead to greater economy in working. Had the inventors themselves possessed that degree of scientific knowledge which was requisite for such a study they themselves might have discovered and have applied to their engines the great and far-reaching principles which were being worked out by Beau de Rochas, in France. But empiricism had entirely guided these inventors; and it was not until Beau de Rochas published his patent specification, in which—not an engine—but a great general mode of working was specified, that the gas engine was placed upon a sound, economical basis of construction. *Verbum sat sapienti.*

Beau de Rochas published his conclusions in 1862. They specified that the four essential conditions of high efficiency in a gas engine were:—

(1). That the ratio of the cylinder volume to the surface of cylinder and ends should be as large as possible.

(2). That the piston speed should be as high as possible.

(3). That the exploded gases should be expanded to as large a volume as possible.

(4). That the initial pressure of the gases at the moment of explosion, or commencement of expansion, should be as high as possible.

In projecting an engine wherein these conditions might be fulfilled, Beau de Rochas laid the foundation of the modern type of gas engine; and by embodying this project in his patent he foreshadowed the greatest, if not the only, master patent which the history of the gas engine has known. This project, indeed, was no other than the so-called "Otto" cycle of operations of the gas engine; and though it was drawn out in every detail by de Rochas, it was reserved to Otto to construct the first engine actually working upon this system. Hence the term "Otto cycle."

The Otto Cycle.—What Beau de Rochas proposed and what Otto, but not until 1876, actually accomplished, was the construction of a gas engine working with the following cycle or rotation of operations, each operation occupying the period of one complete stroke of the piston:—

1st Stroke.—Charging stroke: in-draught of gas and air in explosive proportions.

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2nd Stroke.—Compression stroke: compression of the explosive charge into the small volume of the clearance behind the piston.

3rd Stroke.—Working stroke: ignition of the explosive charge at or near the dead point and expansion of the fired charge.

4th Stroke.—Exhaust stroke: rejection of the products of combustion from the cylinder.

It must be carefully borne in mind that the above is a specification of a system of working rather than of a definite engine. Various kinds of gas engines work on the Otto cycle. When this cycle takes place at only one end of the cylinder, there will be one explosion and one working stroke every two revolutions of the crank shaft; unless, indeed, as is often the case, there are two or more cylinders actuating the same shaft. In some engines both sides of the piston are acted upon, an Otto cycle occurring at each end of the cylinder: in such cases there will be an average of one working stroke per revolution.

Otto's Engine.—Continuing our historical summary, we may pass over the years intervening between the date of Beau de Rochas's publication (1862) and 1876, the date when the first engine constructed to work upon the de Rochas (or Otto) cycle was patented. The honour of the invention and making of this first of the modern type of engine is due to the celebrated German engineer whose name is now universally identified with the cycle of operations described in the preceding paragraph. The essential characteristic of Otto's gas engine was that all four of the operations were arranged to take place in the same cylinder, the gas being compressed after admission, as advocated by de Rochas. The engine was single-acting, the non-working end of the cylinder being open. The operations took place substantially as they do to this day—that is to say, the first out-stroke drew the gas and air into the cylinder, the first in-stroke compressed the mixed gas and air into a capacious clearance space behind the piston, ignition now took place, and the second out-stroke occurred under the impulse of the fired gases, while the second in-stroke cleared out the greater part of the waste gaseous products of combustion. The gas and air admission, and the firing of the charge were controlled by a slide valve placed at the working end of the cylinder; and the exhaust was effected by a "mushroom" valve, which was opened by a cam and closed by the action of a strong coil spring. Firing was effected by a gas flame carried in a pocket or chamber in the inner side of the slide valve.

Thermodynamics of the Otto Cycle.—We may now discuss some of the more important properties of the working substance in a gas engine which follows the Otto, or any practically similar cycle. It must first of all be pointed out that the Otto cycle is not a cycle of operations of the working substance, but of the engine; it is in no sense analogous to Carnot's cycle. The gas itself undergoes no complete cycle, and it is rejected irrecoverably at the exhaust. The most important questions relate to the highest temperature attainable during the working stroke, and the lowest possible on exhaust. Upon these the limiting efficiency of the Otto cycle must depend. Robinson has calculated that if all the heat of combustion could be liberated in the moment of explosion, and before any useful work could be done, or any heat be lost, a temperature of about 3,900°C. would be attained, the mixture consisting of 5·76 cubic ft. of air for each cubic foot of coal gas. On the other hand, we have the evidence as to dissociation, first educed by St. Claire Deville, that chemical union between two gases cannot take place above a certain temperature, the magnitude of which depends on the nature of the gases. With oxygen and hydrogen the dissociation temperature is said to be about 1,200°C. (2,192°F.), in which case the limiting temperature of the gas in an engine cannot exceed this figure. If, for argument's sake, we take 2,000°F. as the highest theoretically possible temperature, and—since the exhaust is at atmospheric pressure—212°F. as the lowest possible exhaust temperature, we shall find that the theoretical limiting efficiency is as high as 72 per cent!

Conditions which Reduce the Efficiency.—By comparison with the theoretically highest efficiency of a steam engine, that of a gas engine is an extraordinarily high figure; the cause lying in the enormously greater temperature attained by the working substance. But, just as the steam engine never attains its highest efficiency, so there are conditions of action in the gas engine which, either by necessity or by imperfection of construction, involve greater losses than the foregoing calculation specifies. We will now briefly enumerate these:—

(1) *Structural Conditions.*—The development of a temperature approximating to 2,000°F. in a metal cylinder provided with a reciprocating closely-fitting piston is, with the materials at present available, a structural impossibility. Gas at so high a temperature remaining long in contact with the parts of the engine would speedily raise them to red or even white heat. Moreover, not only is the topmost temperature limited, but that highest temperature which is permissible cannot be allowed to last very long. Heat must continually be abstracted from the gas, during the whole of the working stroke, in order that the cylinder walls and piston may not become over-heated. Thus, heat is being rejected from the working substance at temperatures far exceeding that of the exhaust; and, in actual practice, the greater part of the total heat has to be abstracted in this way.

(2) *Chemical Conditions.*—It is chemically impossible for the whole of the charge to be fired instantaneously at the beginning of the working stroke. The chemical combination between the gas and oxygen is of necessity gradual; and, in practice, it lasts throughout the working stroke. As a consequence, only a portion of the heat is liberated at the highest attained temperature, a considerable other portion being developed at a gradually lowering temperature. There are practical reasons why this condition is preferable to the development of all the heat instantaneously at the topmost temperature, even if this latter were possible.

(3) *Thermodynamic Conditions.*—Apart from the need for wasting heat in order to keep the engine workable, an unnecessary amount of heat is wasted by the rejection of the exhaust gases at too high a temperature. The direct cause of this is the insufficient expansion which the exploded gases receive before release.

(4) *Mechanical Conditions.*—The mechanical imperfections of the gas engine, working under the Otto cycle, comprise limitations of piston speed, whereby the hot gases are detained in the cylinder; and the limitation of the working stroke to one one-fourth of the motion of the engine, whereby the engine has to turn itself against its internal friction for three idle strokes to every active one.

Where the Heat Goes.—We are now in a position to track down the various portions of the total heat developed, to see where they are wasted and where used, and to consider in what ways the wastes may be minimised. The channels of outlet for the heat are:—

I. Indicated work, comprising internal work done mechanically and external work.

II. Exhaust heat.

III. Water jacket heat, or heat abstracted through the cylinder walls, in order to keep the engine cool.

IV. Ignition gas heat, or the heat which is used in maintaining an ignition flame.

V. Incomplete combustion of the gaseous fuel.

Indicated Efficiency.—Actual tests show that the indicated efficiency of gas engines depends upon their size and rated power. Working at its most economical load, a gas engine has a higher economy, up to a certain point, the larger is its size and rated power. For moderate sizes, the consumption of average town gas, at the best load, will be about 20 to 25 cubic ft. per I.H.P. per hour; and in very large and well-attended engines it may fall to 15 cubic ft. per I.H.P. per hour. Very small engines in general work often consume from 25 to 30 cubic ft. per I.H.P. per hour at their rated loads. The 2-cylinder tandem "Otto" gas engines, by Messrs. Dick, Kerr and Co., built for the Belfast gas engine electric supply station, and rated at 120 I.H.P., were guaranteed to consume not more than 26 cubic ft. of gas per electrical horse-power, and were found on trial to consume

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24 cubic ft. per electrical horse-power at full load. The combined efficiency of the engine and dynamo being 76 per cent. (by actual tests made at Kilmarnock), it follows that the consumption of gas was about 18·24 cubic ft. per indicated horse-power per hour; while the guarantee was equivalent to 19·76 cubic ft. per indicated horse-power per hour. Again, in a large number of gas engines at Messrs. Crossley's works, having an aggregate of 250 H.P. to 350 H.P., the consumption of anthracite (for Dowson gas) was about 1lb. per indicated horse-power per hour, the load varying according to the requirements at the works. This represents a dynamical efficiency of about 18 per cent. The following Table gives further evidence on this question:—

Table XXXI.—*Efficiency and Economy of Gas Engines working on the "Otto" Cycle.*

Gas engine.	Date of test.	Authority or experimenter.	Duration of test.	I.H.P.	$\eta = \frac{\text{B.H.P.}}{\text{I.H.P.}}$	B.T.U. per I.H.P. per hour.	Cub. ft. gas per I.H.P. per hour.
Otto-Crossley.	1881	Adams	...	33·6	0·82	16,000	23·6
Ditto ...	1888	Soc. of Arts	6 hrs.	17·12	0·86	12,120	20·76
Ditto	1892	Capper	2 hrs.	13·32	0·85	...	20·87
Simplex .:.	1885	Witz	2 hrs.	9·10	...	13,338 per B.H.P.	20·38 per B.H.P.
American "Otto.".	1893	Sprangler	3 days	127·6	0·72	...	0·95lb. solid fuel for Dowson gas.

Brake Efficiency.—The foregoing Table shows the ratio of the brake horse-power to the indicated horse-power in a number of "Otto" gas engines; and it may now be generally stated that for engines of large or moderate powers, the ratio varies from 80 to 85 per cent. at full load. With small gas engines it is often very much lower than this, causing the gas consumption per horse-power to rise to high figures. Taking an average of 82 per cent., and estimating the average consumption of gas at 20 cubic ft. per indicated horse-power per hour, the gas having a thermal value of 740 B.T.U. per cubic foot, we find that the proportion of the total heat developed which is utilised in external work is about 14·5 per cent. And according to the same data, the heat wasted in internal (engine) friction is about 2·61 per cent. of the total heat developed.

Exhaust Heat.—The temperature of the products of combustion throughout the period of exhaust depends upon the following conditions: (1) the piston speed, (2) the richness of the exploded charge, (3) the amount of gas admitted in each charge, and (4) the water-jacket arrangements; as well, of course, as upon the size of the engine. It is generally found that, with an unchanged ratio of expansion, an increase in piston speed causes a rise in temperature of the exhaust gases—*more* heat is carried away by the exhaust. The reason for this is evident, since the gases, being hurried through the working stroke, have not so much time to impart their heat to the walls and the water jacket; and though a greater amount of useful work may be done, owing to the improvement in the pressure throughout the stroke, yet more heat will pass away with the waste gases. Of the heat saved from the jacket waste, some will be added to the exhaust waste. The remedy for this is to introduce a greater ratio of expansion of the gases, so that the heat may be abstracted in useful work. In ordinary practice, and with the "Otto" cycle, the temperature of the exhaust gases varies between 600°F. and 900°F., and the proportion of heat rejected in these gases averages about 16 per cent.

(To be continued.)

A Proposed Long-Distance Electric Railway in France.—It has been decided to construct an electric local railway, about 60 kilometres long, between Besançon and Levier. The line will be on the overhead-conductor system, and have a gauge of 1 metre.

ENERGY LOSS IN DIELECTRICS.*

BY P. GASNIER.

A condenser, the plates of which are subjected to a constant difference of potential, is, as soon as it is completely charged, traversed by a current which generates heat within it. The insulation resistance of condensers being, as a rule, very great, the current is small and the evolution of heat is scarcely appreciable, even when large potential differences are employed. But if we subject the same condenser to an alternating difference of potential equal in effective value to the continuous one mentioned above, the evolution of heat is far more considerable. This fact, made evident by the experiments of Siemens, and in 1891 by the experiments of Hutin and Le Blanc on a paraffined paper condenser subjected to an alternating pressure of 1,500 to 2,000 volts, shows that in this case there is added to the conductive loss a more important one, which is of a different nature. Steinmetz† was the first to measure these energy losses, taking a paraffined paper condenser of three microfarads, and found that with an alternating current of a frequency of 170 $\sim$ the loss was nearly equal to twelve times that produced by a continuous current at the same pressure. Steinmetz also found that the greater the loss due to an alternating current as compared to that due to a continuous current, increasod proportionately to the square of the pressure. He attributed this heating to a phenomenon analogous to that which takes place in magnetic metals submitted to a variable field; hence the name "dielectric hysteresis," prematurely applied to a phenomenon upon which electricians are not yet agreed, notwithstanding the large number of experiments which have been made. Pending new tests elucidating this question completely, it will be of interest to see what has already been done, and what are the conclusions which different experimenters have drawn from their work.

R. Arno,‡ who showed that a dielectric cylinder rotated in a rotary electrostatic field, applied this phenomenon to the measurement of the energy loss in dielectrics submitted to varying electrifications. The rotary electrostatic field was produced by four plates cut from a hollow cylinder and connected in pairs and subjected to two alternate potential differences having a phase difference of one-quarter of a period. The dielectric cylinder was bifilarly suspended inside and enabled the torque exerted by the field to be measured, and consequently, the angular speed of the field being known, the energy loss in the dielectric could be determined. R. Arno found the following relation between the energy loss and the strength of the field: $W = KE^{1\cdot6}$, K being a constant. Thus the exponent 1·6 discovered by Steinmetz for magnetic hysteresis turned up again. For a paraffined paper condenser Steinmetz found, however, the exponent 2.

Arno attributed, with considerable reason, the energy loss which he had discovered, to the existence of a lag of the electrification; in other words, to dielectric hysteresis. Two sorts of lag may, however, produce energy loss: either a lag in time—that is to say, a lag between the value of the electrostatic field inside the dielectric, and its value outside, or a lag analogous to that of magnetic hysteresis, where the electrostatic field, inside the dielectric, assumes values which are smaller for a rising field than for a falling field. Both these kinds of lag are shown in the magnetisation of iron. The experiments of Bour§ and of Lord Rayleigh,‖ the object of which was the determination of the value of the permeability as a function of the inducing field, showed that iron exhibits a lag with regard to magnetisation which must not be confounded with ordinary hysteresis, and which prevents the magnetic condition of the iron from following the rapid variations of the magnetising field. This phenomenon exhibits itself particularly in weak inducing fields in which the value of the permeability is constant. This phenomenon, to which Ewing gave the name of "viscous hysteresis," and which has also been called "transient hysteresis," or "progressive magnetisation," and which exhibits the general features of viscosity, gives rise to a loss of energy for a cyclically varying inducing field. The final value of the induction diminishes when the frequency of the variation of the field increases, which results in the permeability having a smaller value when it is measured with a rapidly changing field than when it is measured with a slowly changing field.

The experiments of Edwin E. Northrup¶ show the same phenomenon in the case of dielectrics. The value of specific inductive capacity is larger for a slowly-varying field than for a rapidly-

* From *L'Industrie Électrique*, October 10th.

† *Electrical Engineer* (New York), March 16, 1892. *See* also *The Electrician*, Vol. XXVIII., p. 602, April 8, 1892.

‡ *Accademia dei Lincei*, October 16, 1892, and April 30, 1893. See also *The Electrician*, Vol. XXX., p. 516, March 3, 1893, and Vol. XXXI., p. 201, June 23, 1893.

§ *Wied. Ann.*, 1880.

‖ *Phil. Mag.*, 1887.

¶ *Phil. Mag.*, Vol. XXXIX., January 1895, pp. 78 and 95.

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varying field, and is a function of the rapidity of the change. The following are results obtained for paraffin and glass :—

Paraffin (fusing point 54·5°C.) :—
K=2·32 for a slowly-varying field.
K=2·25 for a rapidly-varying field.
Difference=3 per cent.

Glass :—
K=6·25 for a slowly-varying field.
K=5·86 for a rapidly-varying field.
Difference=6·2 per cent.

The experiments of Blondlot and J. J. Thomson have shown even greater variations. These facts seem to show that there is a viscous dielectric hysteresis analogous to that found in iron.

The loss of energy observed by R. Arno in dielectrics may also be due to the existence of an hysteresis analogous to magnetic hysteresis, properly so-called, and which consists in the fact that for two equal values of the inducing field obtained, one when it is rising and one when it is falling, there are two different values of the induction, independent of the rapidity of the variation of the field. The method employed by Arno does not permit this question to be settled.

The experiments of Janet* on the phenomenon of mica-condenser charges when the condensers are subjected to rapid electric oscillations gave veritable hysteresis cycles with curves analogous to the well-known curves of Ewing and Warburg. Janet showed that in a condenser subjected to rapid oscillations the charges are smaller for equal potential differences when the potential is rising than they are when the potential is falling. This lag may be attributed either to hysteresis or dielectric viscosity, or to a combination of these two causes. The experiments of Janet did not enable him to be very precise on this very important point.

A. Hess,† in a memoir presented to the Société de Physique, attributed dielectric losses to heterogeneity and to the existence within the dielectric of particles which are the seat of true currents ; hence he believed there was a loss of energy totally different to that caused by the phenomenon of hysteresis. Hess likened a condenser with a heterogeneous dielectric to two condensers in series, one having an infinite resistance and the other a certain amount of resistance. Making this assumption, a mathematical investigation enables us to predict the formation of residual charges, and show that the phenomena of charge and discharge take place just as though two such condensers connected in series were replaced by a single viscous condenser. An experiment was carried out on two Carpentier condensers, one of 0·1 microfarad, and the other of 0·5 microfarad, shunted by a resistance of 100 megohms, the two condensers being connected in series. The experiment showed that in such a system the charge takes place very slowly, and that it is possible after a first and instantaneous discharge to obtain a large number of residual discharges.

Charles Borel,‡ in a Note on the dynamic phenomena due to residual electrification of dielectrics, comes to the same conclusion as Hess. Charles Borel discovered that a condenser of paraffined paper suspended at its centre by a cocoon fibre, took up a rotary movement in an alternating electric field, if a glass rod was placed on one side of the disc, the plane of the disc and the axis of the rod being parallel to the lines of force of the field. According to M. Borel this rotation is due to the phenomenon of internal and external conduction, and the heterogeneity of the dielectric plays a very important part, heterogeneous dielectrics being those which produce the strongest effect upon the disc. Charles Borel also attributes to the phenomenon of internal and external conduction the rotation of dielectric cylinders in a rotary electric field, discovered by Ricardo Arno.

The experiments of Messrs. A. W. Porter and D. K. Morris,§ on a paraffined paper condenser having a capacity of 5 microfarads, seem to dispose of the existence of a dielectric hysteresis similar to a magnetic hysteresis. A 5-minutes charge gave no trace of hysteresis. On the other hand, the same condenser presented in a very marked manner the phenomenon of viscosity. A 1-second charge exhibited, as time went on, an increase approximating 5 per cent. Messrs. Porter and Morris conclude that dielectric losses are due to these viscous effects, and not to hysteresis.

Benischke,‖ in some experiments made with a bolometer showing a difference of temperature $\frac{1}{1000}$th of a degree Centigrade, and intended to determine the rise of temperature in a paraffin plate subjected to the action of an alternate electrostatic field, failed to observe any rise of temperature, and concluded that there was no such thing as a dielectric hysteresis analogous to magnetic hysteresis. After experiments on paraffined paper, Benischke attributed the energy loss of condensers to the three following causes : losses due to the formation of residual charges (viscosity), losses due to the Joule effect, and mechanical losses due to the vibration of the sheets of the condenser.

Eisler* recently published the results of measurements made on a paraffined paper condenser having a capacity of 2·5 microfarads, subjected to an alternating current, the frequency of which was varied. The current was furnished by a Siemens 8-pole machine driven by a variable speed motor. One and the same electrometer was used to measure the effective pressure at the terminals of the condenser, the effective current and the power absorbed, which enabled the experimenter to determine the lag with great precision. Each experiment necessitated three successive measurements, and during this time the speed of the generator was kept very constant and was measured with great care. The difference of potential at the terminals of the condenser was kept constant at 34·9 volts. The frequency was varied from 17·9 to 45·1∼. Eisler's results are summed up in the following table :—

∼	Effective charging current (amperes).	Lag ϕ.	Apparent resistance of condenser (ohms).	Energy lost per cycle (ergs).
17·9	0·0084	86°21′	64,800	10,490
29·3	0·0137	85°50′	35,100	11,670
33·9	0·0153	85°56′	31,500	11,420
41·7	0·0186	85°41′	24,900	11,790
45·1	0·0198	85°28′	22,100	12,250

The apparent resistance of the fourth column is the resistance which for the same potential difference would give rise to the same loss as that produced in the condenser. The conductive loss was negligible, the condenser having an insulation resistance of 289 megohms. The last column gives the loss in ergs per cycle, and it will be observed that this loss increases as the frequency increases. Eisler thinks that this loss, which he attributes to viscosity, should attain a maximum for a certain frequency higher than that which he was able to get.

Eisler also carried out measurements with a constant frequency, varying the difference of potential at the terminals of the condenser. He found, like Steinmetz, that the loss of energy for a given frequency was proportional to the square of the potential difference. Eisler represents the loss of energy by the following equation :—

$$W = k\,C_n \times f(n) \times u^2,$$

in which k is a constant, dependent upon the dielectric, C_n the capacity of the condenser for the frequency under consideration, and $f(n)$ a function of the frequency, u the effective difference of potential, the product $C_n \times f(n)$, having a maximum for a certain value of n.

It follows from all the experiments enumerated above that the existence of dielectric hysteresis analogous to magnetic hysteresis has not up to the present been demonstrated, which leads one to the belief that it does not exist. That being so, we are confronted by two hypotheses—that of viscous hysteresis and that of internal conduction. This latter, which is very interesting, and was put forward by Hess, explains very well all the phenomena of residual charges, and furnishes a law for the variation of energy loss analogous to that found by Eisler ; it also enables us to predict the existence of a maximum energy loss at a certain frequency, pointed out also by Eisler. The influence of the existence, within a condenser subjected to variations of charge, of conducting particles cannot be doubted, and the various experimenters who have operated with impure dielectrics must have taken it into account. Nevertheless, this fact does not exclude the possibility of the existence of a viscosity analogous to that presented by iron, and new experiments are necessary on very pure dielectrics to settle the matter.

THE PORTRUSH ACCIDENT.

The following is the text of Major Cardew's Report to the Assistant-Secretary of the Railway Department of the Board of Trade, with regard to the recent fatal accident to a person named Thomas Walne, which occurred on the Portrush tramway in August last :—

Description of the Line.

The tramway upon which the accident occurred is a line 6 miles in length, constructed under powers given by the Giant's Causeway, Portrush, and Bush Valley Railway and Tramways Act, 1880, between the town of Portrush and Bushmills, along the side of the public road, and an extension which is more properly a railway, 2 miles in length, across private property, to a terminus in the immediate vicinity of the Giant's Causeway.

* *Comptes Rendus*, December 26, 1892, and February 20, 1893. See also *L'Industrie Électrique*, March 10, 1893.

† *Journ. de Physique*, April, 1893 [Meeting of December 16, 1892]. See also *L'Industrie Électrique*, January 10, 1893, p. 16.

‡ *Comptes Rendus*, May 23, 1893 ; *L'Industrie Électrique*, June 10, 1893, p. 265.

§ *The Electrician*, Vol. XXXIV., p. 735, April 12, 1895. Also *Proc.* Roy. Soc.

‖ *Wiener Sitzungsberichte*, No. 102, Vol. II., p. 1345.

* *Zeitschrift für Elektrotechnik*, June 15, 1895

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The line is worked chiefly by steam engines, but in addition electric motors are provided in a few of the cars, and electric power is supplied to these except for the portion of the line within the town of Portrush, where steam power is used exclusively. The electric power is supplied from a generating station at some distance from the line by means of overhead wires, the energy being obtained from water power. The charged conductor, by contact with which the electric current is transmitted to the motors on the cars, is a stiff iron rail supported at a height of about 18in. from the ground on the side of the tramrails next the hedge or boundary of the road. At road crossings and at gateways into fields, &c., the conducting rail is omitted for the requisite length, and connection effected by means of an underground cable across the break of continuity. The return circuit is provided in the usual way by means of the tramrails, copper bond wires being used to connect together the several lengths of rail. No attempt has been made to secure the public using the road or cattle driven along it from contact with the charged conductor rail.

Summary of Evidence.

The evidence submitted on behalf of the ratepayers was chiefly directed to the support of their contention that the charged rail in its present condition constituted a danger to horses and cattle, and an annoyance to the public using the highway. Evidence was given of the death from electric shock obtained from contact with the charged conductor of this tramway at various dates since the line was opened, of four horses and five head of cattle, besides injuries to other animals, and that in some cases payments had been made by the Tramway Company to the owners by way of compensation. This evidence was not seriously rebutted by the Tramway Company, whose principal scientific witness, Prof. G. F. Fitzgerald, M.A., F.R.S., of Trinity College, Dublin, admitted that in the present state of the line there is danger to cattle or horses driven along the road.

The complainants relied upon the finding of the coroner's jury as proof that the unfortunate death of Mr. Thomas Walne was due to electric shock. The Tramway Company, however, produced the principal witnesses examined before the coroner, to whom I read their evidence as given in the copy of the proceedings at the inquest supplied by the complainants, which they declared to be correct. I also examined these witnesses myself, and would draw special attention to the statements of Miss E. J. Adair that Walne was breathing naturally, and took brandy after the fall, turning up his face to obtain it; and of Dr. Huey, that in his opinion if there had been no current on the rail the man would be alive now.

The circumstances of the accident, so far as I was able to arrive at them, are that the deceased, Thomas Walne, was riding a bicycle along the road from Bushmills to Portrush about 7:30 p.m. on August 26, 1895. At a short distance from Bushmills he attempted to turn his bicycle on to the tramway, which is at this point separated from the ordinary roadway by a stone curb rising a few inches above the roadway. The machine striking against this curbstone, was upset, and Walne was thrown violently over the tramline and fell across the raised rail, which was electrically charged at the time, so that this rail was across the lower part of his chest, his hands and head probably touching the damp grass on the bank on the far side of the raised rail, one of his legs over the bicycle and the other under it, and the bicycle lying across the tramway rails. He was heard to shout three times as if in agony. His companion, who was about 100 yards behind him at the time, tried to pull him off, but was at first unable to do so on account of the shock he himself sustained. Finally, he accomplished his purpose by wrapping his mackintosh round his hands. Walne was then carried across the road and supported, while brandy was administered to him. He appeared to be conscious and was breathing naturally. He was able to swallow the brandy. Shortly afterwards he was removed to the station at Bushmills, where he was seen by Dr. David Huey. He had then ceased to breathe, but the heart was beating slowly. Artificial respiration was resorted to without effect, and he died about half-an-hour after the fall. Dr. Huey examined the body and found several marks of burning on and below the breast, but no post-mortem examination was held.

The complainants also produced scientific evidence proving disregard by the Tramway Company of the regulations for electric working imposed by the Board of Trade, and this evidence I am able to supplement from my examination of the line and generating station.

This witness, Mr. A. E. Porte, electrical engineer of Dublin, also suggested that the existing danger might be remedied by covering in the charged rail so as to prevent accidental contact with it, that the turbines at the generating station should be governed automatically, and that there should be a self-recording voltmeter at the station at Bushmills open to public inspection. I will deal with these suggestions later.

The evidence produced on behalf of the Tramway Company was to the effect that in numerous cases shocks had been received by human beings from the charged rail, in some instances contact being made for several minutes, without permanent injury.

Inspection of Line and Generating Station.

This inspection was made on the afternoon of September 25th. I found that the regulations imposed by the Board of Trade had been disregarded in many particulars, as follows:—Regulation 5, entirely disregarded. Regulation 6, entirely disregarded. Regulation 7. I do not consider the voltmeter in use efficient for the purpose, as although it appeared to be approximately correct in its indications, it was far too small to be read conveniently at the distance at which the man stands to regulate the current. Regulation 9, entirely disregarded. Additional regulation as to notices along the line insufficiently attended to. I only saw three such notice boards, and the inscription on these was almost obliterated. Bye-law IV., disregarded in the cars I saw.

I took several tests of the electric pressure at the station at Bushmills, being the nearest point of the line to the generating station, and at the generating station itself. The volts on the line varied considerably, the highest reading I obtained being 310, and the average about 290. At the station the readings were much the same. As the regulation was entirely by hand I tested what would be the effect produced by ordering the attendant to leave the regulating wheel alone, as if he had been suddenly incapacitated. Under these circumstances the pressure only rose to about 320 volts. The water was, however, rather low at the time, and at periods of full supply no doubt a greater rise of pressure might be produced; indeed, Mr. Boyd, the inspector to the Tramway Company, stated that the highest reading he had observed at any time at the generating station was 360 volts.

The charged rail appeared to me to be a decided obstruction, especially at road crossings, and in front of field gates, &c. It seemed to me hardly practicable for a man to drive a herd of cattle along the road, or into a field abutting on it, without great risk of one or more animals receiving a shock.

Conclusion.

Having carefully considered the evidence produced at the inquiry held by me, and the observations made at my own inspection, I am of opinion:—

(1) That Thomas Walne died from the combined effects of severe injury caused by the fall across the rail and electrical shock.

(2) That the tramways in question are at present, when the insulated rail is electrically charged, a danger to the public and an annoyance to the ordinary traffic.

(3) That the Giant's Causeway, Portrush, and Bush Valley Railway and Tramways Company have not paid sufficient attention to the regulations imposed upon them by the Board of Trade.

As to 1, I consider that the lethal effect of the electric current was due to the large extent of contact made by the body of deceased with the charged rail, the considerable pressure—viz., a large portion of the weight of a man of nearly 13 stone, with which the contact was made, and the length of time, at least several minutes, during which the current was passing through his body.

With regard to 2, it must of course be borne in mind that this electrical tramway was one of the earliest constructions of the kind.

In my opinion the danger that has undoubtedly existed has been largely due to the position of the charged rail at a height of about 18in. from the ground. Had this rail been placed at the ground level it would have been far safer than it is at present, while if it had been raised to a height of not less than 8ft. from the ground, and greater width of opening allowed at gateways and road crossings, I think that with proper regulation of the electric pressure the working of the line would have been practically free from danger. As at present arranged the charged rail is easily touched by man or beast, and the effect of the shock is exceedingly likely to cause a fall across the rail, which in itself must probably produce physical injury, and also such a contact of the body with the rail that the resulting electric current is large enough to cause death unless assistance should be given at once.

With regard to 3, the Tramway Company allege that they have found a practical difficulty in complying with some of the regulations imposed upon them by the Board of Trade. There may be some grounds for this statement, but this difficulty should have been brought to the notice of the Board of Trade with a view to the modification of these requirements, and even this excuse does not extend to all the failures on the part of the Company to comply with regulations.

Recommendations.

I recommend that the Tramway Company should be required, under the provisions of Section 20 of the Act of 1880, to remove without delay the danger and annoyance to the public which have been proved to result from their existing arrangements by adopting one of the following (three) remedies, viz.:—

(1). To remove the existing charged rail altogether, and adopt an overhead system, in which case the limit of electrical pressure might be reconsidered.

(2). To raise the existing charged rail to a height of not less than 8ft. from the ground.

(3). To effectively protect the existing charged rail as suggested by the complainants. This expedient, however, appears to me to be difficult to carry out, and in all respects the least desirable of the three.

The Tramway Company should also be required to exhibit in a conspicuous position at their Bushmills station an efficient and correctly indicating voltmeter connected to show the electrical pressure at this point of their line, and it is desirable that this should be arranged to make a continuous record, but in any case its indications must be clearly visible to the public.

Further, the Tramway Company should be called upon for a full explanation of the failure on their part to comply with the regulations made and imposed upon them by the Board of Trade.

In the meantime I think the Company, having regard to the danger which has been shown to exist, should discontinue their use of electrical power until they have carried out the alterations decided upon, working their line entirely by steam power for the present.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

MONDAY, November 4th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ENGINEERS.

7:30 p.m. Ordinary Meeting at the Royal United Service Institution, Whitehall. The following Paper will be read: "The Effect of Strain on Railway Axles and the Minimum Flexion Resistance Point in Axles," by Thomas Andrews, F.R.S.

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SPECIAL NOTICE.

Last week's number of "THE ELECTRICIAN" completed Vol. XXXV. With this week's Number is issued (Gratis) the Index to that Volume. Complaints of non-receipt should be promptly made to the Publisher.

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THE PORTRUSH ACCIDENT.

In another column we publish the full text of Major CARDEW's Report on the fatal accident to a venturesome cyclist which took place last August on the Portrush-Giant's Causeway line. The circumstances surrounding this fatality will doubtless be within the recollection of our readers, and they are, moreover, set forth in some detail in the Report. Suffice it to say here that on trying to surmount the kerbstone separating the tramway from the roadway, the cyclist was upset and was thrown on to the charged conducting rail, which runs alongside the line at a height of about 18in. from the ground; with his head and hands he apparently made contact with the damp grass on the bank beyond, and with his legs and his bicycle he made contact with the rails behind. Death was the result.

Although the Board of Trade Inspector's remarks cannot prove pleasant reading to the Company concerned, and although the carrying out of his recommendations will involve expense, we do not think any fair-minded individual can find much fault with the tone of the Report, nor cavil at the recommendations therein made. The evidence, after making all due allowance for the exuberance of the native imagination, showed sufficiently clearly that the Inspector does not overstate the matter when, in his second conclusion, he asserts "that the tramways in question are at present, when the insulated rail is electrically charged, a danger to the public and an annoyance to the ordinary traffic." And the correctness of that conclusion once admitted, the recommendation that the charged conductor should either be raised out of harm's way or effectively shielded, and that pending the carrying out of these necessary alterations the electrical working of the line should be suspended, cannot, having in view the fact that the line can be worked by steam, be deemed unduly harsh. The

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Portrush line, it is true, is, electrically speaking of course, a mediæval structure; indeed, almost primeval, so early (September 28, 1883) in the history of electric traction did it first come into operation. The Company has, therefore, especially if we remember that the line is financially not an overwhelming success, much justification for its remissness in bringing up its methods and devices to the latest Board of Trade pattern; the Inspector, indeed, almost admits as much. At the same time such an excuse cannot be pleaded indefinitely, and it is not unreasonable that the Board of Trade should take advantage of an occurrence such as the one in question to insist on immediate compliance with its regulations, drawn up, it must not be forgotten, with the assistance of those likely to be affected by them. Cyclists *ought* not, of course, to try to jump kerbstones and ride along tram lines, but the sweet unreasonableness of human nature is a constant and well-known factor, and adequate precautions must be taken against it. There is, moreover, nothing of a circular-saw nature about a charged electrical conductor. Red paint and warning notices are all very well in their way, but they invariably fail to protect just when they are most wanted—that is to say, in moments of forgetfulness and foolhardiness. A plain rail, raised a few inches off the ground, separated from the roadway by a kerb of fewer inches still, looks so entirely innocent that, notwithstanding the Education Act of 1870 and the latter day spread of technical knowledge, an adventurous cyclist may very well be excused for not realising the presence of danger: the danger of a too close proximity to a circular saw is, on the other hand, obvious to the meanest comprehension.

"Ill blows the wind that profits nobody," and this Inquiry will not have been altogether in vain if it arrests once for all the quest after the minimum voltage that is necessarily fatal. It is certain that the unhappy cyclist was not exposed to a greater pressure than 400 volts, and was probably exposed to a much lower pressure. His death is one more evidence that in such cases it is not nearly so much a question of voltage as one of condition of health, of duration and goodness of contact, and of the power at the back of the volts. Again, the belief prevailing in the country side that the line was frequently charged to an abnormally high potential, has also been satisfactorily dissipated. Likewise we may venture to hope that the recent fatality will put a stop to the pleasant practice, which obtained, we understand, amongst the country folk living near the line, of making use of the charged conductor as a source of medicinal shocks. Last, and by no means least, the Report of Major Cardew should serve to bring home to some of our central station managers the fact that the plea of the impracticability of the rules will not avail them if mishaps, for which Board of Trade electric supply rules provide, occur. Rules and regulations the Board of Trade are bound by law to impose; so that it is of no use to grumble at their imposition. And these rules and regulations are, moreover, bound to be stringent, to satisfy the public and —to save the Board of Trade in the day of trouble. The only thing to be done is to take the fullest possible advantage of the Board of Trade invitation to discuss and amend. If, after all, conditions are laid down which central-station engineers disregard as being impracticable, the blame for accidents traceable to non-compliance will inevitably fall directly on the shoulders of the central-station engineers. Success alone justifies defiance of constituted authority. The natural rigidity of Governmental rules has up to now been considerably tempered by judicious blindness, on the part of the powers that be, to well-intentioned infractions. But when mishaps arise no Government Department, no matter how desirous it may be not to unduly hamper an infant industry, can publicly condone disobedience. The position is an awkward one, but whether it is more so for the central-station manager than for the unlucky Department that is expected to legislate in advance, and provide for all possible contingencies, we should be sorry to say.

THE JANDUS ARC LAMP.

In response to the invitation of Messrs. Drake and Gorham we visited, on Thursday, the 24th ult., their works, adjoining those of Messrs. Johnson and Phillips at Old Charlton. Here special machinery has been put down for the manufacture, in large quantities, of the above arc lamp, the invention of Mr. Jandus, and it was with the object of inspecting the working of the lamp, the principle of its action and the facilities for its manufacture, that we paid our visit.

It is claimed that in this lamp we have one which, with a single pair of carbons, will run without retrimming for 200 hours. Also, that it will run singly in parallel across 100-volt constant-potential circuits without waste of power; or, when specially adapted for thus working, in series on constant-current circuits, requiring in the latter case an E.M.F. per lamp of about 75 volts. On the occasion of our visit we saw lamps running in parallel taking currents from 2½ amperes up to 6 amperes. They all seemed to burn very steadily during the time we had an opportunity of watching them.

The method by which this extended burning life of the carbons is obtained consists in enclosing the arc by closely fitting globes, so that during the greater portion of the time the arc is in existence it is surrounded by an atmosphere almost wholly destitute of oxygen. The lower and negative carbon rod—which does not move, and is about 7in. long—is fixed in a holder connected with the negative terminal of the lamp. Resting on a seating in this holder, and kept down by a thumbscrew in such a way that little or no air or gas can enter from below, is a small globe, high enough to enclose the arc and to reach about 1in. above it when the carbons are new. The top of this small globe is closed by a steel cap, with a hole in the centre sufficiently large to give clearance for the upper and positive carbon rod to feed easily and without any friction into the globe. Outside the small globe and enclosing it is a larger one, which is made airtight at the top by being gripped by the rim of its opening between asbestos packing rings. The bottom opening of this globe is closed by an inverted-saucer-like valve, which is pressed up against the flared opening of the globe by a spring so as to allow egress, but prevent ingress, of air. When the arc is formed the heat expands the air in the globes, the surplus escaping through the valve in the large globe. Soon the air inside is robbed of its oxygen, the latter uniting with the carbon to form CO and CO_2, the globes ultimately being filled solely with (probably) CO and the unaltered nitrogen. As a result the rate of combustion of the carbons is very slow, enabling one pair of ½in. carbons, 12in. and 7in. positive and negative lengths respectively, to last, with a current of 4 amperes, for 200 hours.

The illustration, Fig. 1, well shows the negative carbon holder and the spider, which enables it to be attached to the negative framewood of the lamp by a sort of bayonet joint, after having been withdrawn for the purpose of cleaning and recarboning. In the upper part is seen the small opal globe with its steel cap in place, through the hole in which has been inserted the positive carbon, after having been fitted with its brass tube holder. In the lower part is shown the brass saucer-shaped disc which acts as a valve to the large globe. The whole arrangement shown in the cut is ready for insertion into the lamp from below, through the opening in the large globe, which, for the purpose of retrimming and cleaning the lamp, does not need to be released from the main framework to which, as stated above, it is fixed airtight.

Since the positive is the only moving carbon, the lamp is non-focussing. The regulating mechanism will be best under-

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stood by reference to the accompanying sectional sketch (Fig. 2), which is merely indicative of the general arrangement of the gear, and does not in any way represent the actual proportional sizes of the parts indicated, nor even their particular shape, except in a general way. The solenoid carrying the main current is shown at *s*. Inside this is a hollow core, *a*, fixed by screws to *b*, which slides into a brass-lined dashpot, *c l*. Firmly fixed to *c* is a brass tube, *g*, over which slides easily the dashpot piston *b*. Four slots (two of which the section shows at *e e*) are cut in the lower end of the core *a*, wide enough to admit loosely the milled brass rings *d d* in the position shown. To keep these four rings in place an iron wire ring *w* is threaded through them and encircles loosely

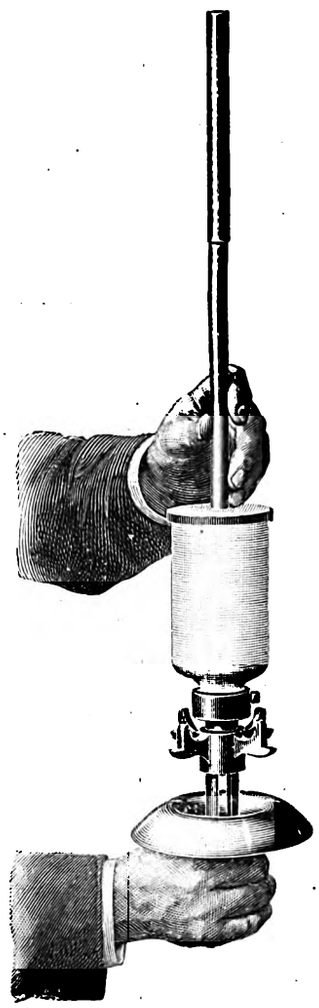

Fig. 1.

the round core *a*. The positive carbon *p* carried in the split end of the brass carbon holder *h* after it has been pushed into the holder against a shoulder. When the lamp is idle *s* has no power to uphold *a* and *b*; therefore *b* is in its lowest position, and the clutch rings *d* rest on the top of the brass tube *g*. The carbon *p* and its holder is then free to fall into contact with the negative carbon. When, however, current is switched on, *s* sucks up *a*, the rings *d* fall or roll towards the carbon *p*, and ultimately grip it, lifting it with *a* and striking the arc. When the arc gets (by consuming the carbons) abnormally long, *b* has dropped low enough for *g* to free the pressure on *p* of the rings *d* and then *p* slides to feed.

To keep the carbon centred, lower down, and also to perform the function of supplying it with current, the device *n n* is used. It is shown in the sketch detached from the main body of the lamp, but in reality it is fastened by *n n* to the lamp; *n m m n* is an annular brass ring, notched on its inner and outer circumferences to a certain depth, leaving a continuous portion *m m*, on which are strung a number of brass rings, *k*, with their planes radially disposed. To keep them radially and symmetrically spaced is the function of the notches in the ring *n n*.

These rings *k*, by their weight, all fall against the carbon rod or its holder (when it has fallen so far), and before it can move sideways has to elevate all the rings on that side. The brass carbon holder *h*, cannot, like *p* the carbon, pass through the hole in the steel cap of the small globe, so that the lamp is cut out when *h* has fallen so far that it rests on the cap.

We learn from a prospectus of the lamp that "the mechanism contains neither . . . dashpots . . . nor carbon rods." We should be perplexed in the use of this lamp if the parts which certainly act as a dashpot were removed, and if we were not allowed the use of carbon rods.

For parallel working, which seems the special field for which this lamp is adapted, the regulating solenoid is a series coil carrying the main current, and is iron-clad. The voltage across the arc is, in the 4-ampere lamp, about 75 volts. In the framework of the lamps intended for working in parallel is fitted a resistance (insulated with asbestos) which absorbs 20 volts. We were told that the lamps for working in series on constant-current circuits were fitted with a shunt coil in addition; and placed co-axially with and on top of the series coil, these, with 5 amperes, take 75 volts per lamp.

The length of the arc is about from $\frac{3}{8}$in. to $\frac{1}{2}$in., and even this length burns steadily without apparent flaming, a condition

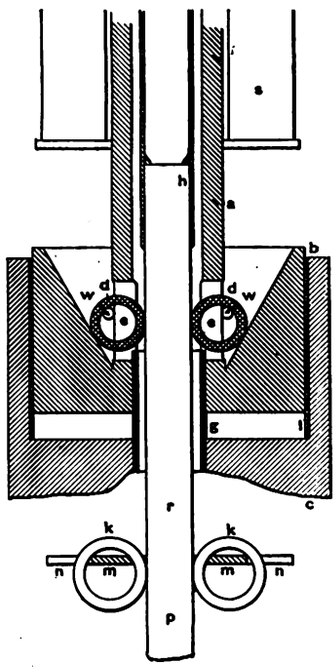

Fig. 2.

probably promoted through the prevention of convection and other currents of air by the closely-fitting globes.

This extra length of arc requires a difference of potential of about 30 volts in excess of that required in the old and usual length of $\frac{1}{8}$in. or $\frac{1}{10}$in. Since the source of by far the greater portion (about 80 per cent.) of the light emanating from an arc lamp is the crater, it is difficult to see the reason why such an abnormal length of arc is used in the "Jandus" lamp; unless it is expected by this means to overcome that very literal *bête noire* of all former efforts to produce a practical lamp on this principle—the blackening of the enclosing globe, due to the condensation of carbon vapour. Mrs. Ayrton has recently shown by her experiments on arcs that as the current is decreased so is the potential difference across the arc for a certain length of arc increased, and so is also increased the rate at which the potential difference increases with increase of length of arc. Therefore, if keeping the current fairly low and the potential difference across the arc high are the conditions under which blackening is got rid of, we shall expect to

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find (when experiments of efficiency are concluded) that it has only been done at a sacrifice of efficiency.

Since the negative carbon is the same size as the positive one, it is doubtful whether the gain in distribution of light due to the extra length of arc is so great as it would be if the negative carbon used were a size smaller than the positive. Moreover, the diffusing action of the opal globe tends to shift the centre of distribution of the light from the crater to the surface of the globe, thereby rendering the shielding effect of the negative carbon of less importance.

Against the probable low efficiency of this lamp we find qualities which for certain purposes will tend to make it a success, viz., a very much lower cost of carbon renewals and labour, the possibility of using a low current, and the convenience of being able to connect the lamps singly across circuits of 100 volts. For lamps burning 10 hours per night for a year the length of carbon used in the old form to that in the "Jandus" lamp is something like as 560ft. is to 35ft. The carbons burn fairly flat instead of pointing and cratering on the negative and positive poles respectively. This result was to be expected when we take into account the long arc, the low value of the current, and the absence of an atmosphere surrounding the arc conducive to combustion. Prof. Silvanus Thompson has shown that the result of surrounding the arc with chlorine or carbonic oxide is that the carbons burn flatter, with a less perfectly developed point and crater. These results, together with state of the carbons in the "Jandus" lamp, seem to prove the truth of the suggestion, which was made some time ago, that the cause of the peak on the negative carbon is the absence of an oxidising agent in that region. Mrs. Ayrton has lately shown that the negative is less pointed the smaller the current and the longer the arc. These three reasons for the flat burning of the carbons are all concurrently present in the "Jandus" lamp in a high degree, compared with the usual arc lamp.

Until we have the results of experiments to determine the efficiency of this new lamp it is useless to speculate as to its fitness for public lighting on a large scale. In any case there would seem to be a field for its use as what may be termed a domestic arc lamp for the lighting of shops and shop windows, where nightly attention to trimming is an inconvenience. It would seem also, from the fact of its being so perfectly enclosed, that it would be a good lamp for factories, in which the air is dust-laden, and frequently so much so as to be combustible.

We were told while at Charlton that the success of this lamp in the United States has been great, and that the Edison Company, who attend to the trimming of their consumers' lamps, allow a rebate of 10 per cent. to those who use the "Jandus" lamp, on account of the saving it affords the Company in trimming.

STREET LIGHTING BY ARC LAMPS.*

BY ANDRÉ BLONDEL.

(Continued from page 849, Vol. XXXV.)

Simplified Means of Evaluating the Useful Effect of an Arrangement of Public Lamps.

The definition of the useful effect of public lighting is a very important point in connection with plans and contracts for lighting, for following the usual rules for these, one can arrive at absolutely different results, and the application of this or that seemingly insignificant condition is often followed by grave consequences. Up to the present engineers have sought to characterise the useful effect by a single photometric quantity. This we believe to be wrong, for we have just seen that the consideration of the single kind of illumination is insufficient. Nevertheless, it is possible that in practice it may be found advantageous, on account of its simplicity, to be content with an incomplete notion, seeing that it gives an idea which approaches somewhat to the very complex quantity which it is desired to measure. Let us, then, examine from this point of view the different solutions which have been successively proposed. Previously, the useful effect was defined from the plane surface illuminated and the minimum horizontal illumination realised. In contracts the value of this minimum, which was considered sufficient for the needs of traffic, was indicated, and it was required simply that the undertakers should light the given surface without going below this minimum. This was in particular the well-known system of the railways of the Belgian State. This left to the *concessionnaire* absolute freedom in the choice of the height and the distribution of the sources of light. In these conditions it was very advantageous for the undertaker to exceed this minimum by the least possible amount, and in consequence to use small lights very close together, and to adopt gas in preference to electricity. M. Weissenbruch, in a work which has become classical,[14] has shown the inconvenience of such a condition, which, if it is taken as the only condition, does not take into account the superabundant light emitted by large lanterns at short distances. This, from experience gained, should not be considered useless. M. Weissenbruch has concluded from this that it is necessary to take into account the mean illumination of the illuminated surface. To calculate this M. Wybauw has introduced a new notion, that of "volume of illumination," to which he has been led by combining the isolux curves drawn on the plan of the illuminated surface with the curves of the levels defining an imaginary topographical surface as previously indicated. The volume comprised between this surface and the zero line constitutes the volume of illumination, and it is obtained by successively measuring with the planimeter the zones of equal illumination. The mean ordinate of this volume is a measure of the mean illumination. It is by this classical method that M. Maréchal obtained the mean illuminations of the highways of Paris. (We give later on the very interesting results of these calculations.) This method has the great advantage of more fairly re-establishing the balance in favour of large lamps, since it takes account of the illumination produced at all distances.

But the considerations by which it is proposed to thus arrive at the idea of the mean illumination are, as I have already often stated, calculated to give a false idea of the physical quantity which represents the volume of illumination. This is simply the total *flux of light* which the illuminated plane receives,[15] and it is consequently independent of the direction of the illuminated surfaces, while the definition of the volume of illumination seems to consider exclusively the horizontal illumination. The mean illumination has no need of any complicated definition; it is simply "the ratio of the total luminous flux received by a surface, to the area of that surface."

Determination of the Useful Flux of Light.

All the writers whom I have quoted measure the horizontal illumination at the level of the roadway. They thus implicitly admit that the pavement is the only part of the public thoroughfares which it is important to illuminate. I am of opinion this is an erroneous hypothesis, for it is also very necessary that the passengers on the footpaths should be able to see each other and find the doors of their houses. The light may then be considered as useful at least up to 1·50 metres above the roadway in all cases, and we shall see still further that this is very often insufficient. Doubtless this consideration has led Herr Wedding[16] to measure the horizontal illuminations on a plane situated at 1·50 metres above the pavement, but this writer has not appreciated the fact that the horizontal illumination does not apply to these conditions, for there is not a single object to illuminate horizontally at 1·50 metres above the ground. If we take the plane of illumination as

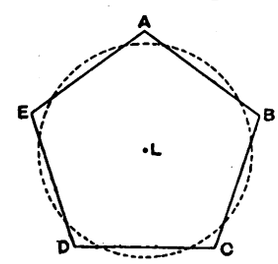

Fig. 11.—Approximate determination of the flux at a spot illuminated by a single lamp.

1·50 metres, or, better, at 2 metres, it should be but to measure the total flux which traverses it. Whatever may be the horizontal plane chosen as a limit, the flux that it receives can only be calculated exactly by means of the isolux curves, described a little higher. But under this form the method is very laborious, so that we content ourselves very often with more rapid approximate valuations, which are perfectly justifiable in problems of this nature, where to seek extreme accuracy would be useless. For instance, in the case of an arc L placed at the centre of an irregular place—A B C D E (Fig. 11)—one can take

* From *Le Génie Civil.* Translated by Mr. John Hesketh.

[14] "Comparison of Various Schemes for Lighting an Open Space," *Bulletin de la Société Belge des Electriciens*, 1889.

[15] The quantity chosen as the unit of illumination by M. Maréchal, under the name of "*are-bougie-mètre*," is in reality a *flux* of 100 lumens, and the "*are-bougie-mètre-heure*" is a *quantity of light*—the "*hecto-lumen-heure*."

[16] Dr. Wedding, "Photometrische Messungen an Bogenlampen," *Verhandlungen des Vereins zur Beförderung des Gewerbefleisses*, 1889, p. 105.

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as the useful flux that which is contained in a cone of revolution which cuts the vertical of B at a height of 2 metres. This cone being determined by its angle, the corresponding flux is measured on the polar curve in the manner indicated previously. In more complicated cases, where there is a series of lanterns distributed in any manner whatsoever, to obtain the mean illumination, it is not necessary to draw the isolux curves of the resultant illumination. It is sufficient to measure separately the useful flux produced by each lantern and to add these results. It is then very easy to make the calculation, for the isolux curves of each source are circles, of which the area is easy to determine.

To explain more clearly this process, I will take an example. Take a rectilinear street (Fig. 12), having a breadth $C_0 D_0 = b = 35{\cdot}20$ metres, illuminated by lamps L_1, L_2, L_3, placed 6 metres

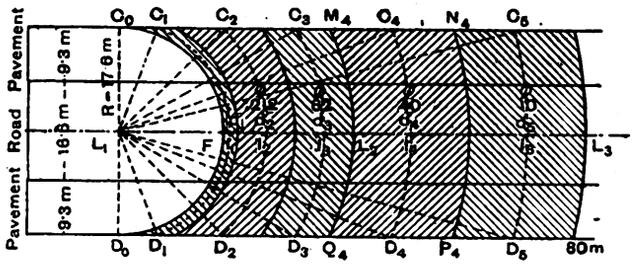

FIG. 12.—Determination of the useful luminous flux in a street.

high in the centre of the street, and the distance between them a equal to 40 metres, and of which Figs. 13 and 14 are the polar curves of the luminous intensity.[17] It is required to find the useful flux on an illuminated plane situated on the pavement. We will trace in vertical projection on Fig. 15 the curve of the distribution of horizontal illumination due to L_1 in the vertical plane, passing through L_1, L_2, L_3, the illuminations being determined at 6 metres below the lamp. We will suppose that the illumination at a greater distance than about 80 metres, for instance, is negligible. We then describe on the horizontal plane a series of isolux circles, starting with a circle of radius r equal to 17·60 metres and tangent to the houses. This forms the base of a

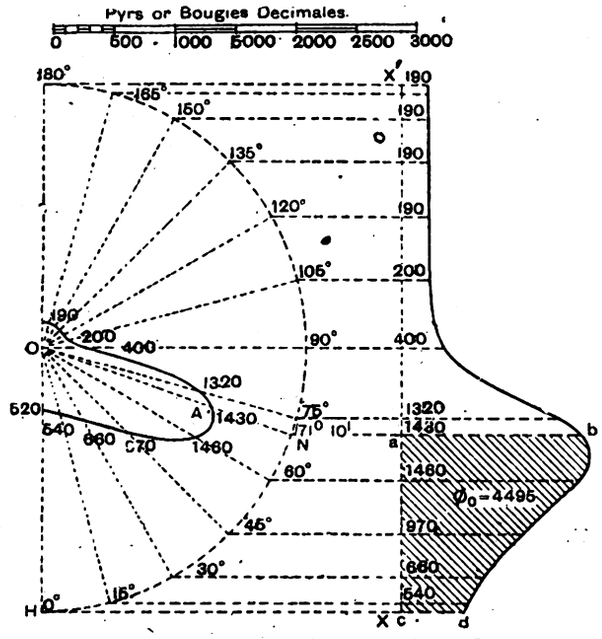

FIG. 13.—Photometric polar curve of luminous intensities of a 10-ampere continuous-current arc placed under a 34cm. holophane globe.

FIG. 14.—Curve of corresponding luminous flux.

cone, of which the half angle at the apex, determined by its tangent $\frac{17{\cdot}6}{6} = 2{\cdot}932$, is 71° 10′, and the half flux ϕ_0 contained in this cone is, from Fig. 13, equal to $\frac{4,495}{2} = 2,247$ lumens. We may assume that in each of the shaded zones of Fig. 12, such as M_4, N_4, P_4, Q_4, the illumination is equal to the mean value E_4, corresponding to the dotted circle $C_4 D_4$, and may take as an approximate expression for the surface S_4 of this zone the product of the length of the arc of the circle $C_4 D_4 = a_4 r_4 = l_4$ into the width of the zone d_4.

We shall thus find for the half flux ϕ in the different zones 1, 2, 3, 4, 5 the approximate values given by Table III. below. From whence the total flux :

$$\phi = 2(\phi_0 + \phi_1 + \phi_2 + \phi_3 + \phi_4 + \phi_5) = 5,386 \text{ lumens.}$$

This only applies to a single lamp. To reckon the total effect, without taking into account the effect of the ends of the street, it is sufficient to suppose these indefinite. Then if n is the number of lamps it contains, the surface illuminated is $n\,b\,a$, and the mean illumination is simply $\frac{\phi}{ba}$, that is to say, the ratio of the flux produced by each lamp to the surface of the rectangle comprised between two consecutive lamps.

We shall then have as a mean illumination

$$E_m = \frac{5,386}{40 \times 35{\cdot}20} = 3{\cdot}82 \text{ lux.}$$

Planimetering direct from the isolux curves reproduced later, we get $e_m = 3{\cdot}90$.

We thus see that the approximate method gives a result which is sufficiently exact, and since the flux ϕ_0 is preponderant, it is sufficient to determine very roughly the following fluxes by reducing the zones investigated to 2 or 3 only (Table III.). If we had

TABLE III.—*Table of Fluxes.*

—	d Metres	a Deg.	r Metres	t Metres	s Square metres	e Lux	ϕ Lumens
Interior zone corresponding to the cone of 71° 10′ ...	...	...	...	...	...	...	2,247·00
1st exterior zone ...	2·40	142°	18·80	46·59	111·81	1·085	121·31
2nd " " ...	10·00	90°	25·00	39·27	392·70	0·54	212·05
3rd " " ...	10·00	61° 30′	35·00	37·57	375·70	0·166	62·36
4th " " ...	20·00	41° 30′	50·00	36·21	724·30	0·056	40·56
5th " " ..	20·00	29°	70·00	35·42	708·54	0·015	20·62
Half total flux							2,692·90

wished to calculate the useful flux at any height h', we should have made the same calculation, only determining the illumination at a

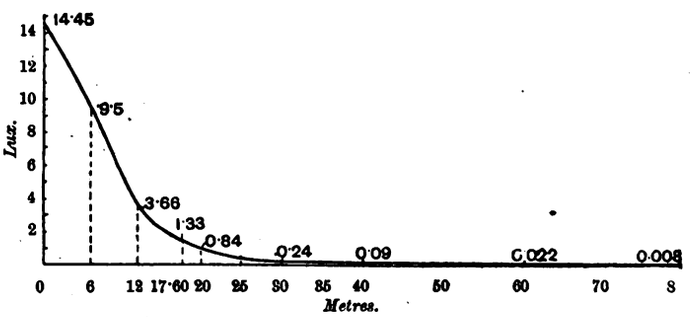

FIG. 15.—Curve of horizontal illumination due to a 10-ampere continuous-current arc, placed under a 34cm. holophane globe.

plane situated at $(6m - h')$ below the lantern. We should have thus found a flux $\phi' > \phi$, and the mean illumination of the entire lighted surfaces would have been

$$\frac{\phi'}{b\,a + 2h'a} = \frac{\phi'}{(b + 2h')a},$$

the two heights of the houses being added simply to the width of the street. Thus, in many cases, we may, I think, go yet still further, and consider as useful all the light emitted in the space below the horizontal plane passing through the luminous focus; for the illumination of frontages, trees, &c., up to a height of 7 or 8 metres, is almost always advantageous, not only because it allows of the diffusion of light, but also because it permits the eye to take in the whole of a street, and the buildings which enclose it. We may then take, as a measure of the useful flux, all the lower hemispherical flux, which is given directly by the polar curve. This method will give us figures erring a little occasionally in excess,[18] but it is so simple that its use is to be recommended. It is, besides, the most equitable in straight streets, where houses are well illuminated. Since we shall then have calculated the total number of *lumens* reckoned as useful it will suffice to

[17] The curve chosen to illustrate this is that of a 10-ampere arc placed under a holophane globe of 34 centimetres, as used in the Grand Boulevards.

[18] But very little, in the case of the continuous-current arc; for in the preceding example, instead of 5,386 lumens, we should have 6,610, or 13 per cent. more.

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divide this number by the total surface illuminated to have the general mean of the illumination in *lux*. In the preceding example the lower hemispherical flux is 6,610 lumens from the polar curve. The total surface illuminated is, for one lantern, 40 (35·2 metres + 2 × 6) = 1,888 square metres. The mean illumination of the entire street is then

$$E_m = 3{\cdot}50 \text{ lux.}$$

M. Wybauw has introduced a modification into the calculation of the mean illumination, which consists in assuming a uniform value (value of the illumination along the 45deg. line) for the illumination at the level of the foot of the lamp-post within a cone of 45deg., on the pretence that, if the illumination is greater, it does not count for anything. This view of the matter has been objected to in general by specialists, but without solid arguments. We hope to show by that which follows that this view should not be entertained when considering the lighting of public ways, and at the same time we hope to destroy a widespread prejudice relative to the distribution of light.

Choice of the Best Distribution of Light for Public Lighting Purposes.

That which characterises all the sources of light actually employed for public lighting is the superabundant illumination which they produce in the immediate vicinity of the foot of the lamp-post. The result of this is almost truly a spot of light with edges more or less defined, outside of which the illumination follows an extremely

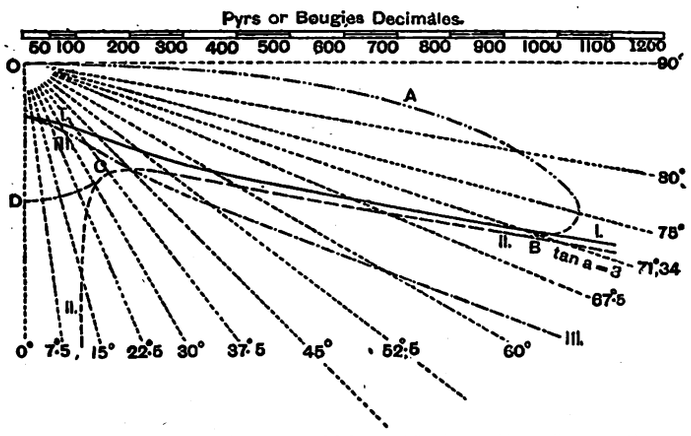

Fig. 16.—Photometric curve which would give uniform illumination on a horizontal plane. I.—Curve for uniform normal illumination. II.—Curve for uniform vertical illumination. III.=Curve for uniform horizontal illumination. O A B C D—Ideal photometric curve.

rapidly decreasing law. This fact has long since struck all the engineers who are interested in lighting, and they have all been in unison in criticising it and expressing the view that one should distribute the light more rationally; not lavishing it at the foot of the lantern, but utilising it in the more distant parts of the street, which are those generally cheated. If we take the horizontal illumination as the characteristic of lighting, the solution which appears at first to be the most perfect is to endeavour to obtain for it a uniform value, and those specialists who endeavour only to illuminate the ground resolutely accept this proposition as the desideratum for each of the lamps taken separately. The curve of the distribution of luminous intensities which obtains this result has, as we know, the following equation: $I_\alpha \cos^3 \alpha = \text{const.}$ This form is represented in Fig. 16, curve III. It is this curve which Mr.

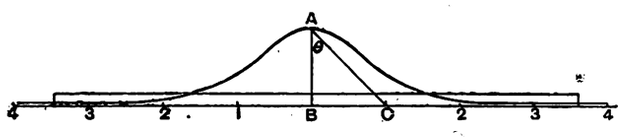

Fig. 17.—Effect of making the horizontal illumination of a source uniform, the luminous flux remaining constant. (The undulating curve represents the illumination before "uniformisation," and the small rectangle the illumination made uniform.)

A. P. Trotter endeavoured to obtain in 1892 with the assistance of his apparatus, of which we shall speak later; but the little appreciated results of this experiment and a more exact knowledge of the desiderata for ordinary foot passengers should make it known to-day that an uniform illumination would not have a single chance of success in the present state of our resources; and even if we obtained it its partisans would quickly abandon it on account of the opposition of the public, for the public is indifferent as to the uniformity of the illumination. They wish to have a street not only moderately well lighted as a whole, but also to have some places more brilliantly illuminated. This would no longer be the case immediately we distributed the same flux of light uniformly, unless the slight increase of the minimum illumination which would result was sufficient to compensate for the loss of the maximum illumination. To enable us to make a calculation, let us take, for instance, the most simple case—that is, a lamp having the same intensity I in all directions, and let I equal 500 pyrs; let us place it at 6 metres high, and let us use it to illuminate a circle having as a diameter seven times that height.[19] The curve of the horizontal illuminations has the form represented by 4 A 4 (Fig. 17).

The flux of light ϕ emitted in the cone with an aperture of 74° 12′, corresponding to the circle with a base of 7 metres, is here very simply the product of I into the solid angle of the cone

$$\sigma = 2\pi (1 - \cos 74° 12'). \text{ [see No'e 20.]}$$

We find, then, $\phi = 4{\cdot}5\ I = 2{,}250$ lumens.

The surface illuminated being $\pi (21)^2 = 1{,}320$ sq. metres, the mean illumination $= \frac{2{,}250}{1{,}320} = 1{\cdot}7$ lux, while the minimum and maximum illuminations determined directly are, respectively,

$$\frac{500}{6^2} = 14 \text{ lux and } \frac{500}{6^2 + 21^2} = 1{\cdot}05 \text{ lux.}$$

In consequence, by making the illumination uniformly 1·7 lux, which corresponds to the small rectangle in Fig. 17, we shall gain only 0·65 lux on the minimum illumination, while the maximum would fall from 14 to 1·7 lux. The public is much more sensible of the second effect than of the first, and in consequence would find the street less perfectly lighted. This apparent diminution of lighting would be more marked the greater diameter of the circle, for the curve of distribution shows that the ratio of the vertical intensity to the oblique diminishes very rapidly.

(To be continued.)

[19] This is the condition assumed by Mr. Trotter, and Fig. 17 is borrowed from his interesting paper on the Uniform Distribution of Light.

[20] The solid angle σ is defined as the surface intercepted on a sphere of radius 1. It is deduced from the known expression for the surface of a spherical zone $2\pi r (1 - \cos \theta)$.

THE ELECTRIC LIGHTING OF EDINBURGH.*

BY HENRY R. J. BURSTALL.

The electric lighting of Edinburgh, as is also the case in many of the most important towns in England and Scotland, is in the hands of the Corporation; and was finally decided on late in 1893, when the work of designing and superintending the whole scheme for public and private supply was entrusted to Prof. Kennedy. Work was commenced at the station and in the streets in May, 1894, and the station was opened for the continuous supply of electrical energy on April 11, 1895, the exceptionally severe winter having seriously delayed the progress of the station buildings.

Districts.—From the electrical point of view the City of Edinburgh may be said to consist of two districts, differing from each other both in character and in their positions relative to the centre of the city. The older part of the city by the Castle, and the district north of Princes-street, include the greater part of the business premises, together with a residential district in which the houses are large and closely built, and where the demand for current may be expected to be great. The district to the south and east of the central porton is either residential or of such a character that the demand for current can never be as large as that in the northern and central district. The residential part of this district contains many houses which stand detached from one another, thus diminishing considerably the possible number of lamps in proportion to the frontage. Having regard to the different districts to be served, and taking into account all the local circumstances, it was decided, after comparison of the various systems of supply and distribution which could be used, to adopt a low-tension three-wire system for the central and northern district, and an alternating-current high-tension system for the southern and eastern district, both systems being worked from one central station and under the same control and management. A good site was found for the central station between the Caledonian Railway and Dewar-place. The foundation here is rock; and the station being on the railway, coal is brought direct into the boiler house in the railway trucks at a minimum of expense. The position of the site is such that, while being fairly central, it is in a neighbourhood where there is little chance of complaint as to nuisance, real or otherwise.

Station.

The building, which is a handsome brick erection with brown stone frontages to Dewar-place and Torphichen-street, is from the designs of Mr. J. Cooper, the burgh engineer, and was erected under his superintendence. The site is roughly triangular; the

* Paper read before the Institution of Mechanical Engineers.

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boiler house occupies nearly the whole of the north side, and the two engine rooms are parallel to and south of it; the general offices occupy the extreme south of the site, and are large enough for the accommodation of the whole of the clerical staff, as well as for the resident engineer and his assistants. Above the boiler room are the workshops, and the floor above the western end of the engine rooms is used for the battery room, store room, and meter store and testing rooms. The eastern part of the engine room is covered with a light iron roof, with ample provision for light and ventilation. The boiler room is covered with a concrete floor, which will ultimately be used as a coal store. There is ample space in the buildings at present erected for considerable extensions without any extra outlay beyond the foundations for new engines and boilers.

Boiler House.—The boiler house (Figs. 1 and 2) is 158ft. long by 48ft. wide, occupying nearly the whole of the north side of the site.

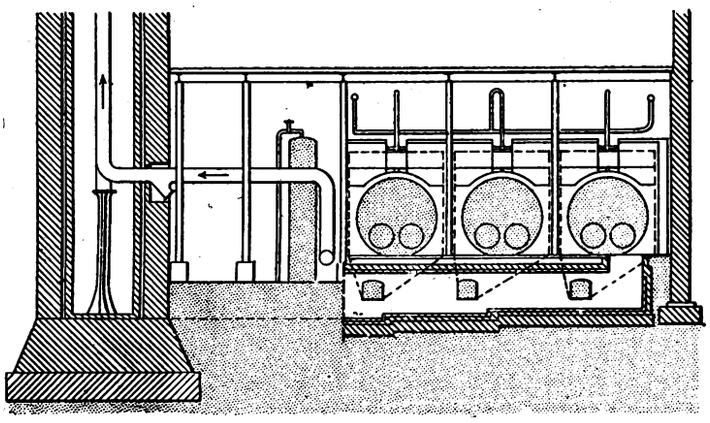

FIG. 1.—Boiler House.

It is designed to contain 17 boilers, of which at present only the six at the west end are in place. The main flue runs along the centre under the stoking floor into the chimney, which is placed in the centre of the length of the house, and is 8ft. square inside and 160ft. high, being lined with firebrick for a height of 60ft. The side flues from each boiler enter the main flue at a slight angle, and each flue is fitted with a butterfly damper; a damper is also placed in the main flue close to the chimney.

action of the gases. The steam circulates from a standpipe on the boiler to the back leading pipe, through the superheated tubes to the cast-iron pipe at the front, and thence to the main steam pipe; proper valves are arranged so that the superheater can be entirely shut off and the steam be taken direct to the main steam pipe. Each superheater is fitted with a safety valve and draining cocks. The superheater coils are readily accessible for cleaning and examination by doors at the front and by movable plates at the top; or, if necessary, they can be lifted bodily away from the boiler. The course of the furnace gases is from the furnace to a brick combustion chamber at the back of the boiler, through the boiler tubes to a wrought-iron smoke box at the front, thence up and along the top of the boiler, past the superheater tubes to the back, and there down each side to a centre flue under the bottom of the boiler. A damper is provided, by which the gases can be sent direct to the sides of the boiler without passing the superheater tubes. Sinclair's mechanical stokers are fitted to each boiler, and are worked from two lines of shafting, which are carried by the columns of the boiler house and driven by an electric motor.

Steam is taken from each boiler through a standpipe, with valves to the superheaters; and from the latter through a large copper bend to the main steam pipe, which forms a complete ring round the present boilers. This ring joins the engine room main at two points, and is provided with valves, so that the failure of any one pipe will put only the corresponding boiler out of use. Drain valves are placed wherever water may accumulate, and are all connected to a steam trap which returns the condensed water to the feed tank.

The pump room is opposite the chimney, and is entirely closed in. It contains at present one duplex steam pump and two three-throw pumps driven electrically; each pump has a maximum capacity of 4,500 gallons per hour. The electrically driven pumps are specially designed to run with a large range of speed; and for this purpose can be connected with either the 230-volt or the 115-volt mains. The steam pump has its steam supply connected with two points of the main steam pipe, and its exhaust is connected with the feed heater. Each feed pump has an independent suction from the feed tank, and two independent deliveries into two separate lines of pipes, each of which can be connected with either range of the two duplicate rings of feed pipes, either through the feed heater or direct. The duplicate rings of feed pipes are carried round the stoke hold in chases in front of the boilers; and each boiler is connected with both rings of pipes by separate feed check valves delivering into a common internal pipe. A Kennedy water meter is connected with one range of feed pipes, so that the whole of the water going to the boilers can be measured. In the pump room is

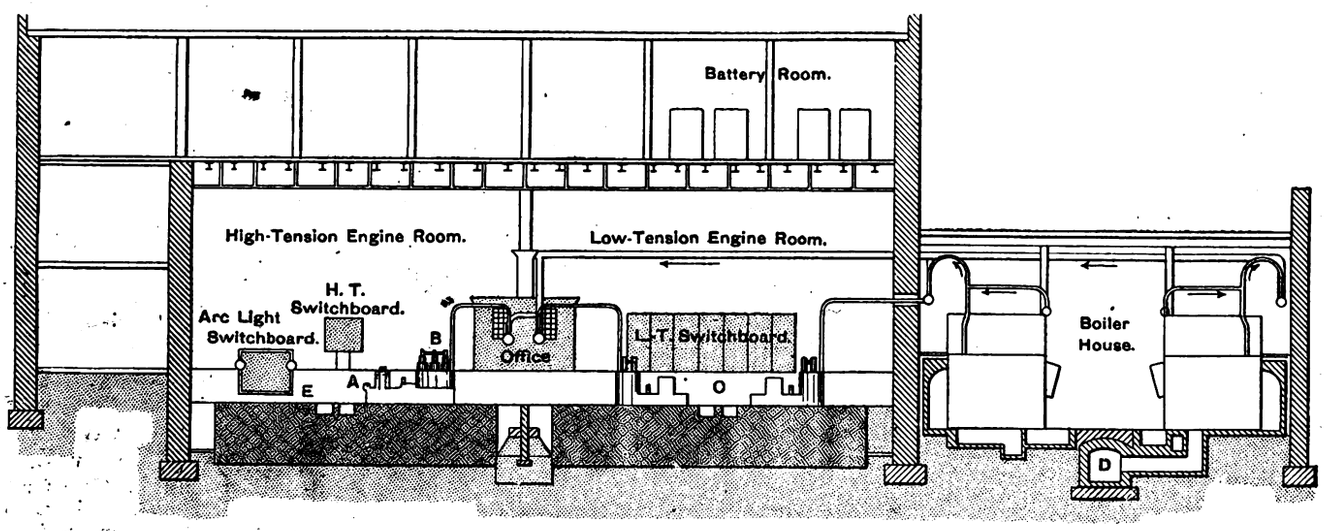

FIG. 2.—Engine Rooms and Boiler House. A, alternators; B, 150-I.H.P. engines; C, 100-I.H.P. engines; D, main flue; E, Rectifiers.

The boilers are of the dry-backed marine type, each 10½ft. mean diameter and 12ft. long, with two Purves flues, 3¼ft. inside diameter, and 166 tubes of 3in. internal diameter. The boilers are of steel, with wrought-iron tubes, and have been built in accordance with Board of Trade rules for a working pressure of 160lb. per square inch above atmosphere. They are fitted with the usual mountings, and have duplicate feed check valves.

On the top of the boilers are fitted superheaters, each consisting of two nests of tubes enclosed between the top of the boiler shell and a fire-brick casing above, with a space left in the centre for the steam valves, safety valve, &c. Each superheater consists of 32 vertical flat coils of wrought-iron tube 1½in. diameter, running from a large cast-iron pipe at the back of the boiler to a similar pipe at the front, all joints being outside and protected from the

placed the electric motor for driving the mechanical stokers with its countershaft; and there is ample space for more pumps when they are required.

Under the pump room is the feed tank, which communicates with a large storage tank at the end of the boiler house; another feed tank is also provided under the workmen's room, so that there is an ample reserve of water in case of accident to the water supply. A siding from the Caledonian Railway runs into the boiler house, and the coal brought in the railway trucks is at present stored in the east end of the boiler house; on the station being extended, the coal will be stored over the boiler house, and let down through shoots to the mechanical stokers. In designing the plant at present in the boiler house, provision for extensions has been kept in mind; and the arrangements are such that new plant can be added at any

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time, without interfering in any way with the working of that already in use.

Engine Rooms.—The engine rooms (Figs. 2 and 3) are each about 102ft. long, and are side by side, forming really one room divided by a line of columns which carry the roofs and the beams for the travelling cranes. The engine room next the boiler house is reserved for the low-tension plant, and is 46½ft. wide; the other contains the high-tension plant, and is 41½ft. wide. A platform, raised 4ft. above the engine room floor-level, runs the whole way across the west end of both engine rooms; and on this are placed the switchboards and regulating gear for both the low and high-tension systems, as well as the office of the engineer on watch.

Low-Tension Engine Room.—The machinery at present in the low-tension engine room (Figs. 2 and 3) consists of eight engines, four of 100 I.H P., two of 250 I.H.P., and two of 360 I.H P., with their dynamos; and provision is made for eight more engines of 360 I.H.P. in the future. All are Willans central-valve engines driving their dynamos direct. All the dynamos are two-pole shunt-wound machines with drum armatures, all wound to give 270 volts, except two which are driven by two 100 I.H.P. engines; these two are wound to give 135 volts, being used as balancing machines on the three-wire system.

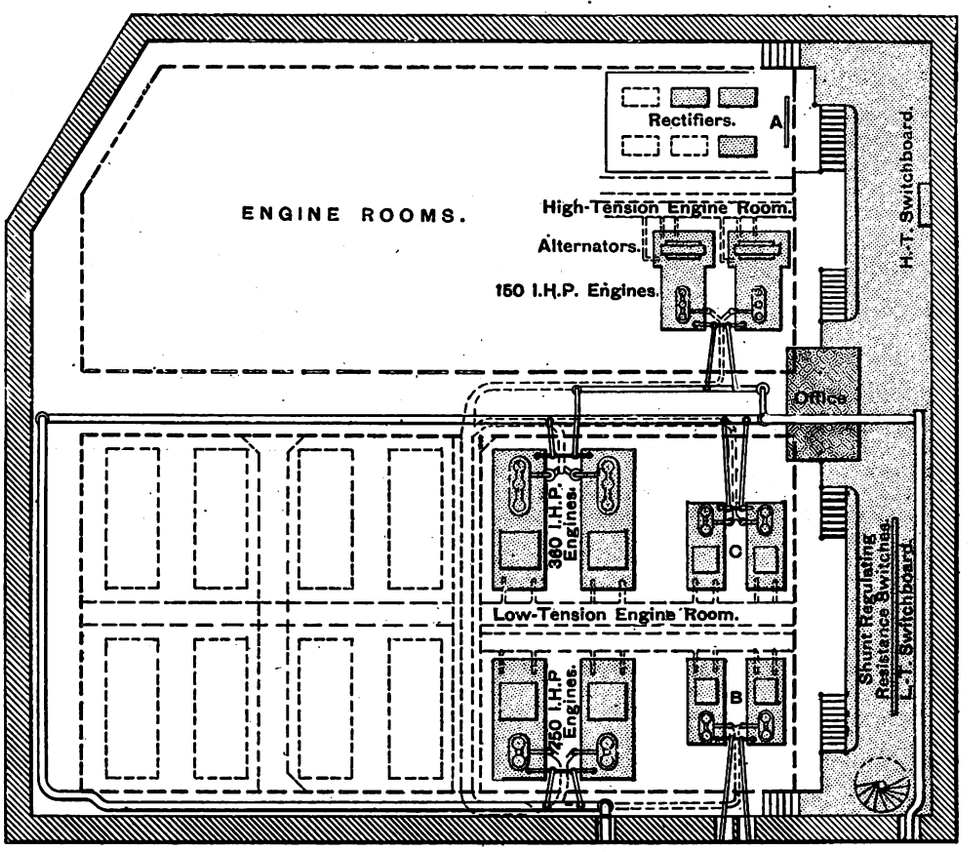

FIG. 3.—Plan of Engine Rooms. A, arc light switchboard; B, balancing machines; C, charging machines.

The steam-piping forms, with part of the boiler-house ring, a complete ring round the low-tension engine room (Figs. 2 and 3), and is connected with the boiler-house ring at two points. The main ring in 8in. internal diameter throughout; the straight lengths are of steel, with thick flanges screwed and brazed on; the tee pieces and valve boxes are of cast iron, and the bends of copper with steel flanges. All bends are of large radius, and no expansion joints are used or required. The engines are erected in pairs, and are connected with the main ring by two long copper bends (Figs. 2 and 3); in the main ring a valve is placed between the branches to the two pipes, with a cross-over pipe and valve at the engines, so arranged that the engines can take their steam from either side of the valve in the main ring. The pipes are slung by long rods from brackets fixed on the walls or columns, so as to allow free movement.

In every section of the main ring are placed two drain-valves, one connected with a drain ring, which is common to half the drains, and is connected with a large steam trap, whereby all condensed water is returned to the feed tank. The other drain valve is connected direct to the exhaust pipe, and is used only on emergency, or when the steam is entirely shut off from that section of the pipes. The separators on all the engines are connected to a second steam trap, which returns the water collected to the feed tank; the drains from the cylinders, &c., are connected to the exhaust pipe. The whole of the steam pipes and valve boxes, as well as the drain pipes up to the steam traps, are covered with non-conducting composition, and special non-conducting covers are fitted on all the flanges; in fact, every attempt has been made to reduce the loss by condensation in the steam pipes, which forms so considerable an item in the losses that occur in central-station work.

All the engines are fitted with cooling pipes in the crank chambers, to which the water is carried in a line of pipe round the engine foundation block, and taken thence to the feed-tank by a second line. Each engine is fitted with a valve on the exhaust; the exhaust steam is led by a copper bend into the main exhaust pipe, which is carried in chases in the engine foundation block and along the void between the block and the walls. The main exhaust pipes are of cast iron, and are led through a Berryman feed heater in the boiler house to the chimney (Figs. 1 and 2). Only one heater is fixed at present, but provision is made for three more when required. From the heater the exhaust steam is carried up to the top of the chimney by a vertical cast-iron pipe 21in. diameter. Valves are provided so that the exhaust steam can be carried direct to the vertical exhaust pipe, without going through the heater.

The whole of the machinery stands on a concrete foundation-block 7½ft. thick (Figs. 2 and 3), which is separate from the foundations of the walls. A void 3ft. wide is left at each side of the block, which is also stopped some distance in front of the switchboard platform, thus forming a large chamber at the west end of the two engine rooms for the connections, &c. An 8-ton travelling crane, running the whole length of the engine block, is provided in each engine room, for convenience in overhauling, &c. These cranes are worked entirely from below by means of ropes.

Leads.—The main leads from the dynamos are drawn through curved wrought-iron pipes let into the concrete, into chases in the centre of the engine foundation-block (Figs. 2 and 3), along which they are carried to the chamber under the switchboard platform. The leads from the field winding of the machines are also carried in the same manner to their regulating resistances, which are placed under the platform; the switches for these resistances are fixed upon the handrail on the platform, in front of the switchboard, the leads from the resistances being brought up through the posts of the handrail.

Switchboard and Conductors.—The switchboard, and the whole of the apparatus for regulating the dynamos and batteries, and for the distribution of the current, are placed on the platform (Figs. 2 and 3) and are directly under the eye of the engineer in charge. The

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switchboard consists of seven slate panels, each about 7ft. high; and stands 4ft. from the west wall of the engine room, thus allowing ample room to do any work on the connections, &c., at the back. The instruments and gear for regulating the battery are mostly placed on the centre panel, and those for the switching and manipulation of the dynamos and feeders are on the six outer slates; the connections for the positive side of the system are on the left hand, those for the negative on the right, and the middle wire is connected on the centre panel.

(To be concluded).

FRENCH SUBMARINE CABLE ENTERPRISE.

The following article, from the *Journal des Débats* of October 19th, shows in a very striking manner the mixture of state-craft and sanguine financial anticipations underlying the present restlessness of our French friends in the matter of cable enterprise :—

If, as we anticipated in a previous article, it is decided to support the establishment of a French submarine cable network, we cannot do better than follow, in this matter, the example of our rivals across the Channel, and imitate their methods of procedure. The first point which we shall do well to imitate relates to landing rights. In this connection the English Government has always granted the greatest facilities to companies, contenting itself with a simple declaration, and not demanding in return any rights or advantages of a nature likely to hamper the success of the enterprise. With us, on the contrary, it would seem as if we did our best to repulse requests of this kind by an unnecessary display of red tape. Requests for landing rights, even if no special privileges are desired and the responsibility of the State is in no way involved, result in a demand for the most arbitrary guarantees, and the most irksome delays and formalities have to be endured; unjustifiably large deposits of money are exacted, and a tariff is imposed which is complicated by the rules of the inland service and by State control. These are obstacles which it would be advantageous to sweep away, and there need be no difficulty about doing so.

A second, and perhaps more important point, is that of subsidies. It is obvious that such large undertakings as submarine cable enterprises cannot risk the enormous capital required without offering special guarantees to investors. The truth of this principle has long been recognised by the English Government, which has never hesitated to grant cable companies such subsidies as may be necessary to permit them to attain the desired end. The English Government serves out to these companies at present a total sum of 5,105,000fr., and it is owing to this intelligent and generous support of the State that the English companies have been able in so short a period to attain the prosperity they enjoy to-day. It is to be hoped that the French Government will not hesitate to afford to French companies support which is indispensable. It has already given to an English company, the Spanish Submarine Telegraph Company, the sum of 1,700,000fr. for the Teneriffe-St. Louis cable; it grants also to three English companies—the Eastern Extension, the African Direct, and the Eastern—annual subsidies amounting in all to 637,500fr. for the telegraph service between Saigon and Haïphong, that on the West Coast of Africa, and between Obock and Perim. What reason can there be for refusing to French companies the support which is accorded to foreign concerns?

The conclusion to be drawn from these bare statements is very obvious. Up to the present, we have either not known how to act, or we have not desired to act; we have left everything to our rivals. More than this, we have to a certain degree contributed to their success. We must recognise our error, and turn over a new leaf. The French submarine cable network will have no chance of being laid and prospering unless we have the wisdom to suppress administrative obstacles and to grant to national enterprise the support required to enable it to compete with the powerful English companies.

The benefits to be derived from the establishment of a French submarine cable system are manifold. We have pointed out some of them in the course of our investigations. They are of the patriotic order; by this we mean the avoidance of the danger which accrues to our country so long as it depends upon a rival power for telegraphic communication with its colonies. From the commercial point of view, one might say that France can and should become the telegraphic centre and the inevitable telegraphic intermediary in so far as concerns communications exchanged with countries beyond the sea. The geographical situation of France favours this. France is the natural terminus of all the telegraph lines of the Continent of Europe, and it is in France that these lines ought to connect with the submarine cables coming from America. If, as we may reasonably hope, European messages intended for across the sea, and messages from across the sea intended for Europe, go by way of France, not only will this result in the immediate and tangible benefit of acquiring for this country its share of the money paid, but we shall be the first country to receive the financial, commercial, and political news of the entire world. This advantage at the present belongs to England. Thus, thanks to the English submarine cables, London is, so to speak, the central bureau for the news of the entire world. Is it not possible that Paris, better situated than London, should attain this position in good time?

The question arises, are we in a position to construct and lay submarine cables? This question may be answered with an energetic affirmation. We are no longer, to-day, so far as concerns special plant, the tributaries of a foreign country. We possess factories where submarine cables are made in such a good style and so cheaply that we are able to dispense with English assistance. These cables, moreover, have been tested. It was French industry which constructed the cables between Guiana, Martinique and Brazil (3,142 kilometres), which constructed and laid the cable between Marseilles and Oran and Marseilles and Tunis (2,187 kilometres), the cable from Australia to New Caledonia (1,468 kilometres), and the cable from Majunga to Mozambique (700 kilometres). We have consequently ready to hand the necessary industrial appliances and technical knowledge.

Let us therefore make use of them, since the opportunity presents itself, and in this connection let us draw attention to a final point, viz., the amount of new work which the building up of a new network of submarine cables, and the repair of cables already laid, will bring to the national industry. There have been enough complaints of the difficulties which our industry experiences in finding new fields for its activities. Here is one which is a new field opening before it and the size of which may be gauged by a single statement. The submarine telegraph network at present existing has cost one milliard of francs. To-day it is nearly at the end of its tether. Engineers calculate that before 10 years it will be necessary to construct at least 100,000 kilometres of cable to replace lines which have become useless. If we add to this enormous length the new French network which is about to be built up, one may gauge the amount of work which will be brought to French industry. This is a consideration which cannot be neglected, and we submit it to the consideration of those who are responsible for the welfare of the country.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October 19, 1895.*

The American Street Railway Association.—The Convention of the American Street Railway Association at Montreal during the present week promises to be a very successful one, at least in its commercial aspects. Reports received show that the exhibits of various manufacturers of machinery and material are quite extensive, and that a small army of commercial people are present in the interests of their various houses.

The Thomson-Houston Arc-Light Dynamo Regulator Patent.—The United States Circuit Court of Appeals of Chicago has upheld the decision of the district court, declaring void the Thomson-Houston patent for automatically adjusting brushes upon the commutators of dynamo-electric machines in order to insure a constant current for arc lighting. The Court holds that the mechanism of the regulator does not involve invention, but is merely an adaptation of known methods, to modified or analogous use, no new law or mode of operation being brought into play, and at most only an improved and enlarged action effected. In answer to the argument that if there is no invention in the regulator, why did not someone else make a like improvement, the Court says that such an improvement was made by Maxim at an earlier date.

Death of Mr. Franklin L. Pope.—On Sunday evening of this week Mr. Franklin Leonard Pope was instantly killed by an electric shock at his residence at Great Barrington, Mass. It appears that early in the evening it was found that the incandescent lamps in the house could not be lighted, and Mr. Pope went to the cellar in order to make an examination at the transformer. Very soon after one of the family heard a sound as if caused by a falling body, and upon hurrying to the cellar discovered the body of Mr. Pope near the transformer with life extinct. At the recent Niagara meeting of the American Institute of Electrical Engineers Mr. Pope read a Paper on

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the Great Barrington plant, which he had just finished reconstructing; the former Edison and Westinghouse machinery was discarded, and two-phased currents brought from a water-power plant some seven or eight miles distant at a voltage of 2,100, the old 1,000-volt converters being used on the alternating circuits, and sub-station converters on the old Edison circuits. Whether the obvious elements of danger introduced by this arrangement was the cause of the fatal shock cannot now be learned. Mr. Franklin Leonard Pope was born in 1840, and at the age of 17 took up telegraphy and was rapidly advanced to positions of responsibility. He was assistant engineer on the exploration and survey in 1864 of the projected Russo-American telegraph line. For the last quarter of a century he has devoted his attention more particularly to inventions, patent practice and technical literature, and has acted as an expert in a number of the most important electrical patent suits. From 1884 until 1890 he was editor of the *Electrical Engineer*, and in 1886 served as president of the American Institute of Electrical Engineers. Mr. Pope possessed the keen intellect, steadiness of purpose and high character typical of the New Englander, and it is noteworthy that he recently removed his residence to his birthplace in the heart of New England, though his business interests were centered in New York City, a half-day's journey distant. No member of the American electrical profession stood higher in the estimation of his *confrères*, both professionally and personally, than Frank Pope, and the news of his untimely death has been received everywhere with expressions of the most extreme regret.

CORRESPONDENCE.

MAGNETIC FORCE AT ANY POINT IN A PLANE CIRCUIT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have succeeded in tracing to its source the discrepancy pointed out by Mr. W. H. Everett (*Electrician*, p. 827) between M. Colard's result and his own. The $\cos\theta$ in M. Colard's formula should be $\cos^2\theta$. His formula for a polygon is correct, and when the polygon becomes a closed curve it reduces to

$$F = \int \frac{ds}{r\rho\cos^2\phi} = \int \frac{d\theta}{\rho\cos^3\phi}.$$

Hence we have the remarkable geometrical proposition that round any closed curve,

$$\int \frac{d\theta}{\rho\cos^3\phi} = \int \frac{d\theta}{r},$$

a result which I believe is new.—Yours, &c.,

J. D. EVERETT.

Derryvolgie-avenue, Belfast, October 22, 1895.

P.S, October 31st.—This agrees with Mr. Russell's result in your last.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having been absent in vacation, I missed M. Colard's letter in *The Electrician* of September 20th, to which my attention has been directed by Mr. Everett's letter.

M. Colard is quite right to point out that my expression for the force in a rectangular circuit (and, of course, my expression for the force in a triangular circuit in *The Electrician* of September 27th) holds generally for any polygonal circuit, and therefore for any curved circuit. It is very easy to prove that, for any plane circuit, the force at any point, O, in the plane is

$$\int \frac{ds}{\omega\rho},$$

where ds = element of circuit at point P, ρ = radius of curvature at P, and ω is the perpendicular from O on the first pedal of the circuit. This gives at once the expression

$$\int \frac{ds}{r\rho\cos^2\theta}$$

for the force, where, as M. Colard defines, θ is the angle between r and ρ.

There is merely a *clerical error* in M. Colard's expression, with which Mr. Everett finds fault by showing that, in the simple case of a circle, M. Colard's expression leads to an erroneous result.

I need scarcely say, however, that for purposes of actual calculation, Ampére's simple expression (twice the area of the little triangle whose base is ds and vertex O, divided by r^3) is that which is most useful.—Yours, &c.,

GEORGE M. MINCHIN.

Malahide, Englefield-green, Surrey.

MAGNETIC UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Our attention has been called to the claim made on behalf of our colleagues in the United States for rights in a system of names to the magnetic circuit, rights which date antecedent to the German claims of *gauss* and *weber* recently favoured by the Britannic Association. We are desired to make known, however, that this claim has been pegged out already, before the meeting of the Electrical Engineers of the United States; and, had it not been for recent chastisement operations on a western neighbour, which has consumed some of our time, this protest would have been made sooner.

We now have the honour to inform you that three years ago the Institute of Japanese Military Engineers met to consider the question of naming units of all sorts; and after some sittings they issued a comprehensive dictionary of all the units that can ever be wanted, with names attached. They followed the lead of the Britannic Association in selecting C.G.S. units where possible, and in choosing proper names of persons, but they avoided the choice of German or French and still more of Russian names. The fact that they selected largely the names of prominent citizens of their colleagues in the United States must commend the use of this dictionary to that noble country; but neither have they forgotten the British Isles, as the following quotations will show.

The unit of magnetic permeance they named the *Ayrton*, the unit of reluctance the *Perry*, the unit of hysteresis the *Ewing*, and the unit of earth tremor, or vibrations generally, the *Milne*. Further, they named the unit of magnetic induction the *Edison*, the unit of electrostatic flux the *Tesla*, the unit of intensity (of all kinds) the *Silvanus*, and the unit of density the *Forbes*.

But it is needless to quote further from the pages of this comprehensive dictionary, in which few notorious persons are left unrecognised, and which has received the official sanction, not only of H.M. the Mikado and of his powerful Highness the Commander-in-Chief of the Japanese Army, but is countersigned by Admiral Ito. Now know ye, therefore, that any further attempt to wrest these names to other uses or to modify the distribution of distinguished names hereinbefore settled and determined on, is contrary to the spirit of international comity, and if persisted in may be the means of provoking to unlooked-for hostilities.

In the assurance, meanwhile, of goodwill and fraternal amity, we address you these lines on behalf of the Japanese Government and of the Institute of Japanese Military Engineers in conclave assembled, and we subscribe ourselves,—Yours, &c.,

TOROSKI TONO
HARENDRA MUKERJI
L. NISHIGAWA
} *Chief Commissioners.*

Given at Tokio, September 1, 1895.

BOOKS RECEIVED.

"Circular Sewer Discharges." By "A Municipal Engineer." (London: The St. Bride's Press, Limited.) Price 1s.

"The Commercial Guide and Trade Directory of Japan." Compiled and edited by R. Tayui. (London; Messrs. Kegan Paul, Trench, Trübner and Co.)

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LEGAL INTELLIGENCE.

Sabow and Co. v. Barwise.

At the Brompton (London) County Court, on October 24th, the plaintiffs, electrical engineers, of Fulham, sought to recover the sum of £18 in respect of work done in fitting up the electric light in the defendant's shop at Bond-street, London. The plaintiffs became acquainted with two men named Sylvester and Foster, who said they could procure orders for electric lighting work if the plaintiffs would supply the necessary materials and give them a share of the profits, they agreeing to do the practical part of the work. The terms agreed upon were that Sylvester and Foster should be paid 8d. an hour for their work, and should take a share of the profits when the orders were completed. The work was in due course carried out, but when application was made to the defendant for payment it transpired that the money had already been paid to Sylvester. The result was that not only had the two men been paid for their work, but had collected the plaintiff's account.

The defendant said he regarded Sylvester and Foster as principals, and he paid them the account because he never saw the plaintiff in the matter.

Judge STONER said it was pretty clear that the plaintiffs had been very badly treated by their representatives, but he had no alternative but to order a non-suit. If the plaintiff could prove fraud, however, he had the opportunity of prosecuting the men.

The facts in an action, Sabow *v.* Benson, were of a precisely similar character, and, without going into the evidence, his Honour said there must be a non-suit.

South Staffordshire Tramways Company v. Ebbsmith and Wain.

Application was made to the Master of the Rolls and Lords Justices Kay, Lopes, A. L. Smith and Rigby in the first Court of Appeal on the 24th ult., for leave to appeal from an order of Mr. Justice Hawkins refusing to the plaintiffs inspection of the bank books of the defendant, Mr. Ebbsmith, and of the Dickinson Tramways Appliances Company. It was alleged against Mr. Ebbsmith that during the seven years in which he acted as solicitor for the plaintiff Company he sold at exorbitant prices worthless patents to the plaintiff Company without disclosing the fact that the Dickinson Tramway Appliances Company (nominally the vendors of the patents) was really himself; that he sold land to the plaintiff Company, which it was unable to use under its Articles of Association; and that by means of shareholders created by himself meetings of the Company were influenced, and the plaintiffs claimed a return of secret profits alleged to have been made by the defendant while he was in a fiduciary position towards the Company. Application was originally made to Mr. Justice Hawkins for leave to inspect the banking accounts of Mr. Ebbsmith and the Dickinson Company, in order to discover what moneys had been paid to the defendants Ebbsmith and Wain (late Chairman of the plaintiff Company). This leave was refused, and permission was now asked to appeal. After argument their Lordships allowed the appeal.

Pasley v. Bury.

At the County Court, Yeovil, on the 24th ult., an action was heard in which a claim was made for £39. 11s. 6d., the price of a 3 H.P. "Demon" gas engine sold and delivered. There was a counter-claim of £25 for work done to the engine. Plaintiff, who was in business at Sherborne, was an engineer, and the patentee and manufacturer of the "Demon" gas engine. The defendant, who lived at Burnley, Lancs., wished to purchase a gas engine for driving a dynamo, and in November last year wrote ordering an engine of 3 H.P. from Mr. Pasley for £35. 10s. These engines were partly made by Messrs. Carson and Toone, engineers, of Warminster, and to them was entrusted the construction of this particular engine. It was delivered in Burnley in December, and plaintiff claimed that it was thoroughly tested before leaving the works with very satisfactory results. He pointed out that especial regularity was required for electric lighting work, and to secure this it was absolutely necessary to have (1) a flywheel on the dynamo and a second flywheel on the engine, (2) an absolutely firm bed, and (3) proper fixing at the commencement by properly qualified workmen. Mr. Bury did not order a second flywheel, and that would account for the engine being a complete failure for its work. On January 22nd defendant wrote complaining of the engine, and saying that he had made various alterations in its structure. On March 20th plaintiff wrote asking payment. A letter was read showing that defendant consented to pay £38 on the engine being put into proper order. The plaintiff accepted the proposal. Defendant wrote on June 25th offering to pay £30 if the engine was made to run properly, an offer which was refused. The whole difficulty arose, it was contended, from the ignorance of the defendant of the working of gas engines in connection with the electric light. No engine would run electric lights unless it had two flywheels, and the prolonged axle on the engine was made for that purpose.

Mr. WILLIAM CARSON TOONE, engineer, of Warminster, said his firm had made 207 gas engines for the plaintiff. The engine was built and tested under his personal supervision. The test was in every way satisfactory. The fixing and adjustment of the engine was a matter of nicety, and if unskilfully fixed would not work well. The thickness of a bed for the engine should be from 2ft. to 2½ft. Two flywheels should always be used on the engine when used for electric lighting.

Mr. ERNEST COOMBES, engineer, Birmingham, said in 1894 he purchased one of plaintiff's 2 H.P. gas engines for electric lighting purposes. The engine had run very satisfactorily and he had found no defect whatever in it. The engine took three days to properly fix.

The defendant's case was that the onus of proof that the engine did run rested with the plaintiff. As an engineer and millwright he had had 20 years' experience with gas engines. The bed for this engine was laid with 2ft. of concrete and a 7ft. stone, through which bolts ran from below the concrete. Within half an hour of starting the engine the lip of the gas-feed valve wore away, and the governor would not operate, consequently the engine raced. The exhaust valve broke, and the plaintiff sent him another valve. He wrote to the plaintiff that the engine would not go, and he replied, giving him instructions for making alterations, which he followed out. The engine would stop suddenly, and it never ran unless someone was in attendance and looked after it. The engine was then at a Mr. Berry's house, to whom he had sold it to drive a dynamo. He had had no experience with engines like the one in question, where the point of ignition was adjustable, neither had he any experience of the governing arrangement.

Mr. BERRY, hotel proprietor, said the engine was ordered to drive his dynamo. Defendant was at his place for four or five hours daily for weeks attending to the engine; in fact, it never went unless someone stood by it all the time to regulate the gas. The engine was on his premises eight months.

For the plaintiff, it was urged that it had been admitted by the defendant that he had never seen a similar engine to the one in question. He did not understand the working of the governor or the adjustment of the ignition tube. The engine, he submitted, was perfectly able to do the work required, but the whole difficulty arose from the defendant's ignorance.

The JUDGE decided that if the defendant had had the engine properly fixed no difficulty would have arisen. The plaintiff had given the defendant many instructions, but the defendant did not understand the working. He gave judgment for the plaintiff on the claim and counter-claim, with costs on the higher scale.

At the Southampton County Court last week the action brought by the local electric light and power company against Mr. C. Freeman, jeweller, was struck out of the list after having been before the Court since May last. In the meantime the case has been settled on terms agreed between the parties; but it was pointed out that the Company could not, under their Act of Parliament, bring an action at law on disputed accounts for the supply of electric current, but must proceed by arbitration.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—**The 1895 (thirteenth) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is READY. In addition to the old well-known features of the book, which are brought up to date, a quantity of new and useful matter has been added, rendering the book more than ever indispensable to the Electrical, Engineering, and Allied Trades. Price 7s. 6d., post free 8s. 3d., abroad 9s. The Edition for 1896 is in active preparation, and orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. The usual circulars, &c., will be sent out early in November.**

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES *can be obtained of the Booksellers or direct from the Publishing Offices:—*

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

TENDERS INVITED.—The Corporation of Derby invite tenders for the wiring, fittings, &c., for the completed portion of the Derby Municipal Technical College, at Green Hill. Specifications, &c., can be obtained from Mr. J. E. Stewart (borough electrical engineer), Electric Lighting Station, Derby, on and after Monday next, and tenders must be sent in to Mr. H. F. Gadsby, Town Clerk, by noon on Tuesday, the 12th inst. Some further particulars are given in our advertisement columns.

——— The State Railway Telegraph Department at Saarbrücken, Germany, invite tenders for the supply of 1,500 telegraph poles. Tenders to be in by the 15th inst.

——— The Metropolitan Asylums Board invite tenders for the execution of wiring and other work in connection with the

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electric light installation at the Brook Hospital and Ambulance Station, Shooter's Hill, S.E., from specification, drawings, &c., prepared by Prof. A. B. W. Kennedy, which can be obtained at the offices of the Board, Norfolk House, Norfolk-street, Strand, W.C. Tenders must be in by 11 a.m. of Monday, the 18th inst. Further particulars are given in our advertisement columns.

ELECTRIC LIGHTING SCHEMES INVITED.—The Battersea Vestry offer premiums of £50, £30 and £15 for the best three schemes, reports, designs and estimates for a system of electric lighting for the parish. Schemes must be delivered to the Vestry Clerk (Mr. W. Marcus Wilkins) by December 12th next.

ELECTRIC METER COMPETITION.—Our advertisement columns contain brief particulars of a prize offered by the Royal Scottish Society (called the Keith prize of £50), for improvements in electric meters for domestic supply. The prize is offered with a view to aid the development of electricity for every-day use. Papers, drawings, &c., must be sent in by May 1st next. Conditions of the competition can be had from the Secretary of the Society, 117, George-street, Edinburgh.

TENDERS ACCEPTED.—The Croydon Town Council received 24 tenders for wiring and fitting up the Town Hall, Courts and Free Library for the electric light. The chief point of interest lies in the great disparity in the figures of the highest and lowest tender, which were £2,685 and £1,124. 15s. respectively. It will also be noticed that the offer of a local firm (Messrs. Wenham and Waters), though not the lowest, has been accepted. Below is a full list of the tenders :—

Wenham and Waters, Croydon (*accepted*)	£1,253	0	0
Hirst and Co., Croydon	2,685	0	0
Cunnington (J. S.) and Co.	2,459	0	0
Smeeton and Page	2,250	0	0
Pettit and Hards	2,070	0	0
Winfields (Limited), Birmingham	1,980	0	0
Rashleigh Phipps and Co.	1,880	0	0
Laing, Wharton and Down	1,861	1	9
Peto and Radford	1,824	0	0
Graham and Biddle	1,776	12	10
Fowler, Lancaster and Co., Birmingham	1,775	0	0
Hands (A. C.) & Co., London, and Page and Miles, Brighton	1,743	5	0
Joel (H. F.) and Co.	1,688	17	0
Hollingam and Saward	1,675	0	0
Edmundsons (Limited)	1,643	0	0
New and Mayne	1,590	0	0
Lund Bros. and Co.	1,548	0	0
Strode and Co.	1,537	0	0
Paterson and Cooper	1,530	10	0
Roger Dawson (Limited)	1,467	10	0
Vaughan and Brown	1,455	0	0
Spagnoletti and Crookes	1,450	0	0
Waring (S. J.) and Co.	1,325	10	0
Binko (H.) and Co.	1,124	15	0

(Remainder of London).

——— The Corporation of Belfast have accepted the tender of the Acme Gas Engine Company for the supply of two direct-coupled gas engines and dynamos for their electricity works. The engines are of 150 I.H P. each.

——— The tender of Messrs. Wm. Harvie and Co., of Glasgow, has been accepted by the Lanark District Council for the electric lighting of the Motherwell Hospital for £2,082. 14s. Prof. A. Jamieson is the consulting engineer for the work.

——— The Burslem Town Council have accepted the tender of Messrs. Crompton and Co. for wiring and fitting up the public baths for the electric light for the sum of £213 ; four arcs and 43 16 c.p. incandescents will be used.

——— The tender of Messrs. Veale and Co., of St. Austell, has been accepted for the installation of the electric light at the factory of the British and Colonial Explosives Company ; 107 incandescents will be used, and the contractors have guaranteed that the work shall be completed in eight weeks.

——— The Metropolitan Asylums Board have accepted the tender of the Callender Company for supplying and laying electric light cables at the hospital ships for £125.

POSTPONEMENT OF SALE.—Messrs. Wheatley Kirk, Price and Goulty give notice that the disposal of the business of Poole and White (in liquidation) which has been announced to take place at the Mart, in one lot, at an early date, has been postponed for the present.

CHANGES OF ADDRESS.—Messrs. E. P. Allam and Co. announce that, owing to increase of business, larger offices and showrooms for electric light fittings have been taken at 14, Hatton-garden, Holborn, London, E.C., to which address all communications for the firm should be directed.

——— Messrs. King, Mendham and Co. have found their present premises in Narrow Wine-street, Bristol, inadequate for carrying on their business, and have taken larger premises at 10, Victoria-street, where extensive alterations are being made to adapt them to the requirements of a manufacturing business.

BUSINESS FOR SALE.—Electrical engineers can obtain particulars from Messrs. Wheatley Kirk, Price and Goulty of a small electrical business for disposal in London, which would well suit a person with a small connection to add to the present business.

APPOINTMENT.—The Electricity Supply Committee of the Lancaster Corporation have appointed Mr. C. M. Johnson (assistant electrician under Mr. A. S. Barnard) to be electrician at the electricity works, vice Mr. Barnard. The appointment is on probation for a period of three months, and the salary is at the rate of £100 per annum! Mr. Johnston is "to perform such duties as the Committee may from time to time determine, and to act under the instructions of the borough surveyor."

APPOINTMENT VACANT.—The Ealing District Council invite applications for the position of chief electrical engineer for their electricity works. Applications must be sent in to the Clerk (Mr. Wm. Ruston) not later than 3 p.m. on Wednesday, the 6th instant. Some further particulars are given in our advertisement columns.

——— The professorship of applied mathematics and experimental physics in the South African College, Cape Town, will be vacant at the end of 1895. The salary of this appointment is £500 per annum, with a possible increase of £100. Applications must be sent in, addressed to "Cape," care of *Nature*, 29, Bedford-street, Strand, W.C.

——— The appointment of Head Master of the Science, Technological and Commercial Department of the Plymouth Technical Schools is vacant. The salary is £300 per annum. Particulars can be obtained of the Secretary, Mr. T. W. Byfield, and applications must be sent in by the 15th inst.

DYNAMO BRUSHES.—The Boudreaux Dynamo Brush Company of St. Martin's House, Gresham-street, E.C., forward a sample of a new anti-friction gauze dynamo brush, which is made from the same metal alloy as the well-known Boudreaux foliated brush, and possesses, it is claimed, the same advantages, with the exception that the duration of the brush is not quite as good. The gauze brush is, however, 25 per cent. cheaper, owing to the fact that the gauze pattern can be produced at less cost than the rolled metal type. The result of proceedings taken by M. Boudreaux against infringement of his patents has, it is stated, resulted in his rights being maintained.

COMPAGNIE FRANÇAISE DES CABLES TÉLÉGRAPHIQUES. — This Company announce that their New York address is now 44, Broad-street.

AGENCIES.—Messrs. Conze and Simon, of 52, Queen Victoria-street, E.C., have been appointed sole agents for the Cologne Accumulator Works, and are prepared to give prices and particulars regarding this firm's type of accumulator. These cells have been largely used all over the Continent for many years past, and it is claimed that their efficiency and durability have been abundantly proved.

——— The Stanton Iron Works Company inform us that they have appointed Messrs. Beck and Co. (Limited), Great Suffolk-street, Southwark, S.E., as their representatives for London and the South and West of England, vice Mr. Frederick Davis, who has retired.

THE "ENGINEERING MAGAZINE."—The November issue of this magazine fully maintains its high standard of excellence both as regards the number and variety of the subjects dealt with and its numerous illustrations. The articles in the number include:—"The Currency Problem and its Solution," by A. Mills ; "Taxation in the United States," by E. Atkinson ; "Contemporary English Architects and their Work," by W. Heathcote Statham ; "The Prevailing Scarcity of Skilled Mechanics," by A. E. Outerbridge, jun. ; "The Distribution of Power in Collieries," by Ll. B. Atkinson ; "Transatlantic Steamships of 1856 to 1880," by S. W. Stanton; "Will a Bridge across the Hudson River Pay ?" by Gustav Lindenthal ; "The Limits of Electric Power Transmission," by A. D. Adams ; "The Colorado Springs Waterworks," by A. Lakes ; and "The Massachusetts Railroad Commission," by W. A. Crafts. The usual Exhaustive Review of the industrial Press is also given. This number, as well as all the back numbers, may be obtained at the offices of the European Edition, 1, 2 and 3, Salisbury-court, Fleet-street, London, E.C. A complete index to the main articles in the magazine from the commencement in April, 1891, is now ready, and will be forwarded post free on request.

ALLEGED FALSE PRETENCES.—Before Mr. de Rutzen, at the Westminster Police Court on Monday last, a Frenchman named Jean Molas, calling himself an electrician, was charged with obtaining £250 by false pretences. Defendant pleaded not guilty and was remanded for a week.

ANGORA (TERCEIRA, AZORES).—A proposal for lighting this, originally the capital town of the Azores group, by electricity, has

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been adopted, an influential committee of citizens having been formed to take the steps necessary to the formation of a local company. Señor Chassereux, cheese and butter factor, takes a leading part in the movement. There is no gas on the island, and the prospects of electric lighting are considered good. Water power will probably be utilised.

ASYLUM LIGHTING.—The work in connection with the extensive alterations and additions to the Murthly Asylum, Perth, is now approaching completion. The electric light has been installed by Messrs Anderson and Munro, of Glasgow, to the specification of Mr. W. A. Bryson.

BEDFORD.—In order to dispose of certain misstatements that have been made in this town as to the financial position of the Corporation's Electric Lighting undertaking, the Electric Light Committee have furnished the local Press with a copy of a report presented by the Clerk of the Urban Sanitary Authority (Mr. T. S. Porter) upon this subject. This report is as under :—

"October 23, 1895.

"The annual amount payable in respect of interest and repayment is as follows :—

First annual instalment of principal			£480	
One year's interest on £12,000			390	
			—£370	
£370 per annum equals about	£16	14	7	per week.
Fuel, &c. (£7. 8s.), wages, &c. (£8. 8s.), salaries, &c. (£3), equals	18	16	0	,, ,,
Total cost	£35	10	7	
Actual gross earnings for week ended Oct. 2',	38	5	0	=+£2 14s. 5d.

"A number of premises are waiting to be wired, and applications have been received from many ratepayers to have their houses connected ; but no current can be supplied to new customers until the works of extension are completed."

BLACKWALL TUNNEL.—The contractors of this important undertaking on Wednesday invited some hundreds of visitors to an inspection of the subaqueous communication which has been successfully established between the Poplar and Greenwich shores of the river Thames. A large number of engineering celebrities were present and expressed their admiration of the excellence of the work. The whole tunnel was lighted from end to end by incandescent lamps. The tunnel is to be open for public inspection tomorrow (Saturday) and Sunday between 10 a.m. and 10 p.m. at the small charge of 3d. per admission. The work has been completed without serious accident or loss of life.

BRAY.—At the last meeting of the Town Commissioners it was decided to apply for a Provisional Electric Lighting Order. Our readers will remember that the Commissioners recently obtained power to purchase the existing works from the liquidator of J. E. H. Gordon and Co. (Limited) for the sum of £3,060.

BRIGHTON.—At their meeting yesterday the Corporation discussed a long report on the subject of the Brighton and Rottingdean Seashore Electric Railway, prepared by their surveyor, Mr. F. J. C. May, who recommends that the Rottingdean and Seashore Electric Railway Company be asked to complete the line outside the borough and make certain experiments thereon in order to enable the Corporation to judge "whether the project is likely to be beneficial or prejudicial to the interests of Brighton." This course is recommended owing to certain modifications of the original design of the cars, which the Company claim has been necessitated by the regulations made by the Board of Trade. With respect to the suggestion that the Company should first complete their line outside the borough, thereby entailing the stoppage of the works within the borough area, Mr. R. St. George Moore, the Company's engineer, points out that this would render the completion of the line within the period allowed by the Company's Act of Parliament impossible. Mr. Moore insists that the Company has done everything possible to meet the wishes of the Corporation officials.

BURNLEY.—The Town Council have received the formal sanction of the Local Government Board for borrowing an additional sum of £5,500 for electric lighting purposes. The borough electrical engineer (Mr. F. Thursfield) has been authorised to attend the forthcoming conference on the new regulations proposed to be made by the Board of Trade with regard to the supply of electric current.

CALCUTTA.—The Commissioners of this city are giving serious attention to the electric lighting question. Fresh tenders are called for the lighting of Harrison-road, and it is considered probable that further extensions will shortly be decided upon. It would appear that the Commissioners have expressed an intention of using overhead cables, but this proposal meets with strong objections from the Indian Press.

CARDIFF.—Mr. W. J. Bird Clerke held a Local Government Board inquiry last week into the application of the Town Council to borrow £12,885 for electric lighting purposes. The Mayor stated that the compulsory area was now lighted electrically, and the present loan would be devoted to defraying the excess of expenditure over capital already borrowed, to extending the electric light mains, and to the erection of a testing station. Mr. S. F. Walker opposed the application on general and particular grounds, and especially because the present works were not paying and, he asserted, could not pay, and that any further increase of the outlay under the present arrangements would add to the deficit. He asserted that at the present time they were losing £6,000 a year, including interest on the money borrowed. In the course of the discussion which followed, Mr. W. Harpur (the borough engineer) stated that the increased demand for electric current certainly justified the additional expenditure. They had applications during the last two months for an average of 1,000 lamps per month, and the demand exceeded the Council's most sanguine expectations. In fact, they would shortly have to consider the question of enlarging the generating station. In the end Mr. Walker appeared to a small extent satisfied with the answers vouchsafed to his multitudinous and not always relevant questions, Mr. Harpur stating that Mr. Walker's assertions were, in the bulk, "absolutely wrong," and that, in one case especially, the Corporation were having work done for between £600 and £700, against £1,000, the tender of Mr. Walker's own firm. At the same time, it is only fair to Mr. Walker to mention that, according to the report in the local Press, "his firm did not want the contract."—The Corporation have decided to remove the rectifiers from the Town Hall to the Central Station at Canton, at an estimated cost of £700 or £750, as such removal will effect a saving in wages of about £175 per annum. Applications for installations are coming in in a very satisfactory manner, and the Mayor has expressed an opinion that twelve months hence the electric light at Cardiff would prove not only a public boon, but a paying concern.

CARDIFF EXHIBITION.—The forthcoming Commercial Exhibition at Cardiff is to be rendered additionally attractive by the construction of a model coal mine, occupying a space of 110 yards in length and 40 yards in width. The Executive Council, at their meeting last week, advanced arrangements considerably, and the success of the Exhibition is practically assured. The Corporation have been asked to provide the current for lighting the Exhibition, but the suggestion which finds most favour is that the Executive Committee should provide the installation, and that the Corporation should be approached to purchase the plant at reduced rates after the Exhibition is over. A committee has been appointed to consider the matter.

CHURCH LIGHTING.—The electric light has just been introduced into St. Andrew's Church, Southport.——All Saints' Church, Norfolk-square, London, W., is to be lighted electrically.

CORK.—The second report of the Electric Lighting Committee has just been presented to the City Council. The Committee report that in accordance with the Council's authority they had engaged Mr. T. W. Smith, of Manchester, to advise them with reference to the proposed application for a Provisional Order. Mr. Smith recently made an inspection of the city, and, in a report, states that the city is eminently suitable for the erection of a remunerative electricity station. The Corporation already possess a suitable site near the Municipal Buildings, and taking this fact into consideration, the cost of the necessary building, plant, machinery, &c., for public lighting would be £8,000, and the annual up-keep charges, interest, &c., would be about £2,000. If, however, the Council wished to adopt a more comprehensive scheme, and undertake to supply current for private lighting, then the cost would be about £20,000, and the annual up-keep would be £3,000. If the latter scheme were adopted it was estimated that the revenue from the sale of current for private lighting would £3,125 per annum. This would leave a net profit of £125, besides lighting the main streets of the city free of cost. The Committee might also reasonably expect a certain demand for electric current in the day time for motive power purposes. The Committee have considered Mr. Smith's report, and they have come to the conclusion to recommend the Council to at once apply for a Provisional Order. The Committee further recommend that the applications of the Cork Gas Consumers' Company, the Cork Electric Light and Power Company and the Irish Electrical Supply Company for Provisional Orders be opposed. These recommendations were, after some discussion, adopted at the last meeting of the County Council.

COVENTRY.—The work of constructing and equipping the Coventry electric tramways is now practically complete, and it is anticipated that the cars will be running in about a fortnight's time. The line has been constructed for the overhead wire system, and the work of equipping the generating station at Foleshill has been carried out by the General Tramways Company.

DERBY.—The Chairman of the Provisional Committee for the promotion of the light (electric) railway from Derby to Ashbourne has issued a circular to the promoters, in which it is stated that

"the scheme has been enthusiastically received by the Ashbourne farmers and several gentlemen, who, thinking that it would benefit the agricultural community, and promote local interests generally, have promised to subscribe towards the expenses of obtaining Parliamentary powers, it being understood that in the event of the failure of the scheme any money beyond what is required for actual out-of-pocket expenses shall

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be returned to the subscribers proportionately; but if the Bill is passed into law, and a company incorporated thereunder, £1 shares in such company shall be allotted to each subscriber for every £1 subscribed. Further support, however, is needed to justify the Committee in proceeding with the application for the Bill."

DOCK LIGHTING.—The work of installing the electric light at the Tyne Dock for the North-Eastern Railway Company has just been completed. About 60 Crompton-Pochin arcs are used. The lamps are fixed on poles at a height of 30ft. from the ground, except on the coal jetties and at the dock entrances, where the height of the poles has been reduced to 23ft. The generating plant consists of three compound-wound Crompton dynamos driven by Marshall engines. The whole of the work has been carried out by Messrs. Crompton and Co.

EDINBURGH.—At the meeting of the Town Council on Tuesday last the Lord Provost's Committee recommended the cabling of various sections of the tramways as per plan submitted. The Lord Provost pointed out that the step proposed to be taken was a very important one. They had had numerous suggestions as to the adoption of electricity as a motive power, but they had never been approached by electrical engineers on the matter. That, he took it, showed that electricity was not regarded as a suitable motive power for Edinburgh. To the best of their knowledge the cabling system was the most suitable. The recommendation of the Committee was agreed to. Negotiations are in progress for the acquisition of the tramway lines from Waterloo-place to Jock's Lodge. The Edinburgh Street Tramways Company claim, it is understood, over £20,000 for the lines about to be acquired by the Council, but the actual sum to be paid is to be settled by arbitration. The Cleaning and Lighting Committee are to consider and report upon the advisability of extending the electric light mains from Waterloo-place to Abbey Hill.——It is stated that the Caledonian Railway Company, owing to complaints from the inhabitants in the neighbourhood of their Morrison-street depôt concerning the spray from the Lucigen oil lights, have decided to remove them and to substitute electric arc lights. The Company will at the same time instal the electric light at their goods yard in Lothian-road.

ELECTRIC PUMPING IN COLLIERIES.—An electric pumping plant has recently been installed in the Friedlicher Nachbar Colliery, Linden (Westphalia), Germany, which is capable of raising 1¼ cubic metres of water per minute to a height of 360ft. The generating plant is situated above ground, and includes a 75 H.P. steam engine, and a dynamo giving 80 amperes at 600 volts, while underground there is a 60 H.P. electric motor connected up to a triple-acting pump.

ELECTRIC TRACTION IN SOUTH AFRICA.—The Port Elizabeth tramways have been purchased by Mr. Henry Butters, of Cape Town, one of the conditions of the transfer being the introduction of a system of electric traction.

EMPIRE OF INDIA EXHIBITION LIGHTING.—The electric lighting of this Exhibition is uniformly described in the public Press as a most marked success. Certainly Messrs. Davey, Paxman and Co. are to be congratulated on the complete steadiness of the light, and Mr. Guy C. Fricker, who is in charge of the installation, is to be complimented upon the care bestowed on the installation and its efficient working. About 260 arcs and over 8,000 incandescents are used in the lighting, which has given the utmost satisfaction to the Exhibition authorities. The load is of an extremely varying character, the theatre frequently putting on or taking off nearly 100 H.P. repeatedly during the evening performance.

EVANTON (ROSS-SHIRE).—At the last meeting of the Parish Council a scheme for lighting the village of Evanton by electricity was brought forward by Mr. R. Macintyre, a member of the Council. Mr. Macintyre read a report as to cost., &c., which had been prepared by Mr. R. F. Yorke, electrical engineer, of Glasgow. It is proposed to utilise water power, and the initial expenditure would only amount to £320. The matter is to be further considered.

EXETER.—At the meeting of the City Council on Wednesday last a communication was read from the Board of Trade as to the conditions under which they would be prepared to consider the revocation of the Exeter Electric Light Company's Provisional Order, in view of the purchase of that Company's undertaking by the Council. The letter was referred to the Electric Lighting Committee for consideration and report.

FERMOY (IRELAND).—A special meeting of the Town Commissioners was held last week for the purpose of considering the report of their consulting engineer (Mr. F. J. Warden Stevens) on the question of lighting the town electrically. Mr. Stevens stated that he had surveyed the district and had taken into account the water power which would be at their disposal, and he had come to the conclusion that the Commissioners would experience no difficulty in establishing electricity works. An electric lighting scheme would certainly be far better and cheaper than gas, and he advised the Commissioners to apply for a Provisional Order. The Commissioners intend to advertise for schemes.

FULHAM (LONDON, S.W.).—A special meeting of the Electric Lighting Committee of the Vestry will be held on Thursday next for the purpose of selecting an electrical engineer to assist them in formulating an electric lighting scheme for the Parish.

GLOUCESTER.—A special meeting of the City Council will be held on the 12th instant. for the purpose of considering the advisability of applying for a Provisional Order. Recently a deputation, consisting of Messrs. George White (Managing Director of the Bristol and Gloucester Tramways Company), Kincaid and Devonshire, attended before a joint meeting of the Finance and Streets Committees of the Council, in order to explain the views of the Tramways Company as to the adoption of a combined electric lighting and traction scheme by the Council, and the lines on which the two bodies might co-operate in carrying it out. The consideration of the matter was adjourned in order that further information might be obtained prior to the special meeting of the Council.

GLOW LAMPS FOR THE BATTLE-FIELD.—It is stated to have been decided by the French military authorities to provide glow lamps with pocket batteries for the use of the members of the Ambulance Corps in place of the old-fashioned lanterns. The advantages of electric glow lamps for use on the field after a battle will be found fully set out in the *Daily Telegraph's* own inimitable style in the issue of that journal for October 26th.

HOSPITAL LIGHTING.—The newly-erected Royal Hospital for Sick Children at Edinburgh, which is to be formally opened by the Princess Beatrice this afternoon, is lighted throughout electrically.

INDUSTRIAL EXHIBITION OF BERLIN.—The preparations for the opening of this Exhibition next year are proceeding satisfactorily. £25,000 have been voted by the Committee of Works for the buildings and general organisation, and other large sums have been received by the organisers of the Exhibition. It is stated that no less than £170,000 is to be spent in street improvements in order to provide ready access to the Exhibition buildings. Three new electric railways are to be put down at an estimated cost of about £50,000, and a similar sum is to be spent upon the extension of the metropolitan and Circular railway in the city. A full success for the enterprise is anticipated, and from reports to hand it would appear that the Empire City is bestirring itself to secure this success. Side shows will include Old Berlin, Cairo, a panorama of the Alps, and other similar spectacles.

KETTERING.—The Electric Light Committee have been for some time past collecting information as to the cost of lighting a part of this town by electricity. The Committee have just presented their report to the Council, and they recommend that application be at once made for a Provisional Order. The Committee estimate that the cost of a scheme for lighting the proposed compulsory area, including the supply of current for an equivalent of 2,500 8 c.p. incandescents, would be about £9,500.

KINGSTON-ON-THAMES.—Some time ago the Town Council wrote to the Maldens and Coombe District Council on the question of the introduction of the electric light, but the District Council replied that they were of opinion that the matter was not yet ripe for consideration. At the last meeting of the Kingston Town Council letters from some ratepayers in the Malden District were read protesting against the decision of their Council and asking if any arrangement could be made by which they could obtain electric current. The Native Guano Company also wrote stating that they were paying £71. 15s. 8d. per annum for gas, and that they were quite ready to spend a similar sum for lighting their works electrically. After discussion it was left to the chairman of the Electric Lighting Committee, the town clerk and the borough electrical engineer to make the best possible arrangement.

LECTURES.—Prof. J. A. Fleming delivered the second of a series of popular science lectures at the Town Hall, Portsmouth, last week, on the subject of "Electric Currents and Magnetism." The lecture was illustrated by experiments and gave great pleasure to a large audience.

LEEDS.—The Leeds Tramways Committee have decided to recommend that Dr. John Hopkinson be called in to advise them as to an experiment in electric traction being made. The Committee suggest that the overhead wires in Roundhay should be continued up to the Canal Gardens, the wires to be suspended from brackets placed upon poles in the centre of the road. It is also proposed to extend the wires in a similar manner along North-street and down Briggate to Boar-lane. The Committee further suggest the laying of a conduit from Boar-lane to the Yorkshire Bank, and that from this latter point the overhead wires should be continued to Kirkstall. If possible, central poles will be used along the Wellington-road. The Committee think that the experiment would afford a thorough test of the merits of electric traction, and also of the practicability of the overhead and conduit systems being worked in conjunction. The Committee's recommendations were adopted at yesterday's meeting of the Town Council.

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LEICESTER.—At the meeting of the Town Council on Tuesday Mr. Alderman Lennard, in moving the adoption of the Gas and Electric Lighting Committee's report, referred to a petition which had been presented from local electrical engineers and contractors regarding the course adopted by the Committee in supplying electric light fittings, &c. The Committee were, however, unable to recommend the Council to make any alteration in the present practice of the fittings department of their electric lighting undertaking. He claimed that the electrical department were only carrying out the policy adopted in the gas department for the past 12 or 13 years. He complained of anonymous letters in the local Press regarding the work of the department, in some of which statements quite at variance with the truth were permitted to appear. It was untrue to assert that the Committee had transgressed in any way their own rules by the substitution of finer gauges of wire than other contractors were allowed to use. He had investigated this point and had satisfied himself that there was no justification for such a statement. These and other similar statements were false. He was not an advocate for indiscriminate manufacture and trading by the Corporation, but where large interests like the gas and water departments were concerned, in which there was something like a million and a quarter of the ratepayers' money involved, and where, in fact, the success of the department to a very large extent depended upon the fittings which were used for consuming the commodities supplied, he held it to be the duty of the Corporation to keep that auxiliary work in its own hands. It was good for the community at large. They had never made a loss in connection with the supply of these fittings, which was proof that they had not cut prices. If the department had been a loss, then the local tradesmen would have a right to complain, as it would be an indication that work was being done at less than fair prices. Councillor Marshall did not complain so much of the Department doing this fitting work, but he took exception to the touting for business. He understood that the gas fitting department simply supplied fittings at request, and if this policy were carried out by the electrical department he thought no member of the Council could object to it. Councillor Billings denied that any undue canvassing had taken place. What had happened was that in obtaining customers for the supply of current, orders had been given to their canvassers for fittings. He believed the department was doing right in supplying the fittings and in that way contributing to the success of the Corporation's installations. Alderman Coleman, a member of the Electric Lighting Committee, considered that when they had manufactured the gas or electric current and had brought it to the consumers' door, their connections with the supply ended. Councillor Biggs complained of the circulars that had been issued by the electrical department, and considered this method of canvassing unfair. Alderman Lennard, in reply to the remarks of councillors, said that the real ground of complaint seemed to be that the representatives of the Corporation had canvassed and had to that extent departed from the old practice, but the fact was that at the time when canvassing for customers for electric current was going on, conversations with the canvassers naturally ensued, and the subject of the necessary fittings was then entered into and orders given to the Corporation employés. The report of the committee was ultimately approved.

LLANDUDNO.—The Llandudno Electric Lighting Company have decided to ask four electrical engineers to state their fees for preparing an exhaustive report on the electric lighting of the town. The District Council have already obtained a Provisional Order.

LLANELLY.—The Borough Council have offered to sell their Provisional Order to Messrs. J. C. Howell (Limited) for £200.

LONDON COUNTY COUNCIL.—At the meeting of the Council on Tuesday last the engineer (Mr. A. R. Binnie) was empowered to engage temporary assistance, in order to satisfactorily cope with the very large amount of work at present devolving on the electrical staff of his department. It was pointed out that this work has now become very heavy, owing to the very considerable extension of electric lighting work throughout the area under the Council's jurisdiction, especially in connection with inspections of electric light installations at theatres and music halls, the examination of proposals for loans to vestries and district boards for electric lighting purposes, and the lighting of the Blackwall Tunnel. It was reported by the Finance Committee that the Treasury had sanctioned the period of 53 years for the repayment of the loan of £5,150 to the Vestry of Islington for the purchase of land for extending their electric lighting station. The Technical Education Board reported that three new workshops had been erected at the Battersea Polytechnic, which would be used for instruction in, amongst other subjects, electrical engineering. They further stated that the South-West London Polytechnic, at Chelsea, erected at the cost of £25,000, had been opened, and that the building was lighted throughout by the electric light.

MANCHESTER.—The Town Council intend to apply for an extension of their present electric lighting area, but it is proposed to make only one portion of the work in connection with the extended area compulsory.

METROPOLITAN ASYLUMS BOARD.—At the meeting of the Board on Saturday last a report was presented by the Ambulance Committee on the subject of the wiring of the Brook Ambulance station and recommending that this work be given out in conjunction with the wiring of the Brook Hospital. It will be seen from our advertisement columns that the recommendation of the Ambulance Committee has been adopted. On the recommendation of the Brook Hospital Committee it was decided to approve the suggestion made by Prof. Kennedy, in preparing plans and specifications for the installation of the electric lighting of the hospital, to invite tenders for engines, dynamos, switchboards and batteries from a select list of firms. The wiring, &c., to be put to public tender. The following is the list of firms who are to be invited to send in tenders:—Messrs. Siemens Bros., Crompton and Co., Johnson and Phillips, J. H. Holmes and Co., Thomas Parker (Limited), British Thomson-Houston, W. H. Allen, Son and Co., Mather and Platt, Davey, Paxman and Co., Robey and Co., Marshall, Sons and Co., and the Electric Construction Company.

NEWCASTLE-ON-TYNE.—At the special meeting of the City Council on Monday the discussion on the report of the Town Improvement Committee was resumed. The principal features of the report are the recommendations that the Council should expend £127,000 in the construction of cable tramways to Byker and Scotswood, Westgate-hill and Arthur's-hill and Elswick-lane, worked from a power station proposed to be erected in Bath-lane. The Committeealso propose to grant a lease for 21 years to the present Tramway Company, whose lease of the existing tramways will expire in about four years. The conditions of the proposed lease were set out in our last issue, while the local objections to the report are: (1) the granting of a lease for so long a period as 21 years; (2) the proposal to treat only with the existing Company—it being contended that the right to work the tramways should be open for tender; (3) the non-inclusion of the Stanhope-street district in the scheme, and (4) it is contended that the Corporation should itself take powers to work the lines. A long debate ensued, in the course of which several speakers advocated the adoption of electric traction, but the Council eventually approved the report. It was, however, agreed that in the Council's Parliamentary Bill powers be sought to work the other sections of the lines by electricity or other motive power.

OLDHAM.—The Local Government Board have sanctioned the borrowing of a further sum of £15,000 for electric lighting purposes.

PROVISIONAL ORDER.—The Urban District Council of Cowes, Isle of Wight, gives the usual official notice of its intention to apply to the Board of Trade on or before December 21st next for a Provisional Order under the Electric Lighting Acts 1882 and 1888.

RATHMINES (DUBLIN).—At a special meeting of the Improvement Commissioners of Rathmines and Rathgar on Monday last it was decided to apply to the Board of Trade for a Provisional Order.

REDUCTION IN TELEGRAPH RATES.—The Direct United States Cable Company and the Western Union Telegraph Company announce a reduction of rates to Winona (Min.) U.S.A., from 1s. 5d. to 1s. 3d. per word, the reduction to come into force this day.

REUTER'S AGENCY.—The *City Press* (London) of October 30th contains an interesting account of the history of this undertaking, the occasion being the celebration of the golden wedding of Baron and Baroness de Reuter. The first principal office of the Agency was opened at the Royal Exchange in October, 1851, de Reuter, with Mr. F. J. Griffiths (who is still with the firm), being concerned in the early work of the Agency.

SERIOUS GAS EXPLOSION.—An alarming gas explosion occurred on Tuesday evening last in a densely-populated section of the Strand (London, W.C.) district. For some time past a leakage had been noticed, which finally filled the basement of a small house, and ultimately resulted in a disastrous explosion, causing the loss of a fireman's life and very serious injury to over thirty persons, in addition to considerable destruction of surrounding property. If this disaster had been due to electricity what would the gas journals not have said?

SMOKING CONCERT.—A smoking concert of the City Electric Athletic Club is to be held at the Mason's Hall Tavern, Basinghall-street, London, E.C., on Thursday, the 14th inst., for which an excellent programme has been prepared.

SOUTHAMPTON.—The Southampton Harbour Board, at their meeting on Tuesday, considered the report of their Electric Lighting Committee on the question of putting down an independent generating plant at a cost of £5,500. The Board have hitherto been taking current from the Southampton Electric Light and Power Company, and they proposed to erect an electricity station on the Town Quay, near the Harbour Offices. In reply to a question, the Town Clerk produced figures showing a saving in favour of the Corporation's electric supply station of £172 per annum.

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SOUTHPORT.—A long discussion on the tramways question arose at the meeting of the Town Council on Tuesday. Negotiations for the purchase of the undertaking of the Southport Tramways Company have been in progress for the past three years, and the Council, despairing of coming to an amicable arrangement on the subject, have now determined to petition the Board of Trade to fix a price at which they could take over the lines. It was, however, agreed to give the Tramway Company a month's grace, and the Tramways Committee have been empowered to retain expert witnesses on behalf of the Council. About three-quarters of a mile of the lines run beyond the borough boundary, and a question of interest outside the boundary arises with the adjacent local authority.

STAFFORD.—It has been decided to amalgamate the Gas and Electricity Committees of the Town Council. At the sitting of the Council on Wednesday last it was agreed, on the recommendation of the Committee, in order to reduce the cost of raising steam for driving the machinery in the gas and electricity departments, to lay down a steam main from the boiler houses in the two departments at a cost of about £200, it being stated that this arrangement would enable the electricity department to do with two stokers. It was also decided to extend the electric lighting mains as far as St. Paul's Church, Lichfield-road, at a cost of about £250.

STAPLETON.—The District Council have appointed a Committee to consider the question of lighting their district electrically.

STEALING AND RECEIVING.—Before Alderman Sir Stuart Knill, on Wednesday, at the Mansion House Police Court, two men, James Murray (a clerk), and George Fowler (an agent), were charged with stealing and receiving respectively during the last three months 365 incandescent electric lamps (valued at £22. 16s. 3d.) belonging to the General Electric Company, of Queen Victoria-street, E.C. On the 23rd ult. the Manager of the Company (Mr. Wilson) went to Farringdon-road, where the prisoner Fowler was offering for sale from a barrow some incandescent lamps bearing the Company's trade mark. Fowler said he had bought them from a man, who was subsequently identified as the prisoner Murray, at 3s. a dozen. Murray was a warehouse clerk in the Company's service, and he admitted taking the lamps from the warehouse a few at a time, and selling them to Fowler, who at first paid him 3s. and afterwards 2s. a dozen for them. It was stated that the lamps were worth 1s. 3d. each. The prisoners were committed for trial, Fowler being admitted to bail.

TELEPHONIC COMMUNICATION IN ARGENTINA.—The United River Plate Telephone Company are extending their system to the town of San Martin.

TELEPHONES FOR TELEGRAPH WORK.—In our report of the proceedings at the meeting of the shareholders of the Amazon Telegraph Company (Limited) it will be seen that the Chairman, Mr. W. S. Andrews, referred to the decision of the Directors to introduce the telephone with the object of establishing communication over the smaller cables owned by the Company, which would enable these lines to be worked without the employment of skilled labour. The telephones to be used are those manufactured by the Single Wire Multiple Telephone Signal Company, of London, under the patents of Collier and Brown, which were a short time back described in these columns, and which have recently been tested by the well-known firm of Messrs. Clarke, Ford and Taylor, engineers to the Amazon Company, and have been found, we understand, specially adapted for this class of work.

THEATRE LIGHTING.—Messrs. Vaughan and Brown (Limited), of Hatton Garden, E.C., have very successfully lighted the Lyric Theatre, at Bath, and the Empire Theatre, at Bristol. The work done by the firm includes electric lighting, gas fitting, and hot water work.——The Prince's Theatre, Bristol, is now lighted electrically. The work of wiring has been carried out by a local firm (Messrs F. W. Ball and Co.), and current is being obtained from the Corporation mains.

"THE AUTOCAR."—A new journal is to be published in London under the above title, in the interests, as its name denotes, of automobility. It has been suggested that some new and convenient name should be established by which the new automatic or motor-propelled horseless carriage may be known, and "Autocar" is the result of careful selection. Messrs. Iliffe and Son are the publishers of the new journal.

THE BERNE VOCABULARY.—The October issue of the Chamber of Commerce *Journal* returns to the discussion upon the defects of the Vocabulary recently published by the Berne Bureau, and refers to the large number of complaints from commercial and banking firms which have been received by Chambers of Commerce in various parts of the United Kingdom. The matter in the *Journal* occupies nearly three long columns, and includes a mass of words given in the Berne Vocabulary which should and must be excluded from any commercial code if errors of the most natural kind are to be avoided. One firm points out that out of 20,000 words ending with the letter "a" no less than 840 have only one letter difference from others, and if anything like this proportion are bad throughout the book, no less than 11,000 words out of a total of 256,000 must be eliminated as useless from this process alone; the work of elimination being, in addition, of a most laborious and worrying nature. It is pointed out that as there are twelve other causes which interfere with the safe use of words from the Vocabulary, its valuelessness to the coding community can at once be seen. According to the Chamber of Commerce *Journal*, it is clear that the officials of the Berne International Bureau have failed to grasp the importance of this matter or they must have sought assistance from experts in Great Britain and other countries. That it is possible to obtain this expert assistance and to compile a vocabulary equal to the occasion we have good reason to assert. To some extent the work has already been done, and seeing that the Berne authorities were given a free hand in the use of common names and other advantages, the Vocabulary should have been free from many of the serious blemishes which unquestionably are conspicuous in it. Doubtless, this important subject will receive close attention at the forthcoming conference at Buda Pesth.

THE ELECTRIC ATHLETIC ASSOCIATION.—The Postmaster General will distribute the prizes to the members of this Association at a conversazione in the Holborn Town Hall, Gray's Inn-road, London, W.C., on Friday, the 15th inst.

TRADE WITH JAPAN.—An extremely useful and well-compiled "Commercial Guide and Trade Directory" of Japan has just been issued by the Bouverie Press, of Temple-chambers, London, E.C., or copies can be obtained of Messrs. Kegan Paul and Co., Charing Cross-road, London, W. The information given is of a character calculated to be of much service to British commercial houses, who will, we think, for the first time find set out such information as the following: List of Agencies of Japanese Companies in England, Articles Exported and Imported into Japan, Japanese Chambers of Commerce, Japanese Trading and other Companies, Consulates, Consulator Regulations, Customs Tariffs, Government Department, Lists of Officials of the Imperial Government, Parliament, &c.; several useful Directories, Weights and Measures, Monetary System, Military and Naval Departments, &c., &c. The Bouverie Press are well known as publishers of *Daily Tenders and Contracts*, which gives, in two editions daily, a complete list of outstanding contracts open, and other similar information of great value to manufacturers and others.

WEST HARTLEPOOL.—Electric tramways are being constructed in this town. The overhead trolley system has been adopted, and the work is being carried out by the Electric Construction Company. It is expected that the cars will be running by the end of the year.

WOLVERHAMPTON.—Col. W. E. Ducat held a Local Government Board inquiry on Friday last into the application of the Town Council for sanction to borrow an additional sum of £5,000 for electric lighting purposes. The Town Clerk (Mr. Horatio Brevitt) said the present loan was required for extending the electric lighting area. The capacity of their present plant was an equivalent of 8,000 8 c.p. lamps, and, as they had 7,936 lamps already connected, they could not accept any more orders until their system had been extended. They now proposed to put down machinery capable of supplying current to an additional 3,000 8 c.p. lamps, and with this they hoped to be able to tide over the winter. Mr. Brevitt added that within the last day or two they had received an application for 140 lamps, and they anticipated such a demand from fresh customers that they would have to make further extensions in the spring. Mr. F. Harman Lewis (borough electrical engineer) also gave evidence in support of the proposal, to which no opposition was offered.

WORCESTER.—The question of the extension of the electric light mains to Barbourne-road and Shrubbery-avenue is to be considered by the Electricity Committee.

COMPANIES' MEETINGS AND REPORTS.

Eastern Extension, Australasia and China Telegraph Company (Limited).

The forty-fourth ordinary general meeting of this Company was held on Wednesday at Winchester House, Old Broad-street, Sir John Pender, G.C.M.G., M.P., presiding.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the minutes of the last general meeting, which were confirmed.

The CHAIRMAN: Ladies and gentlemen, before moving the adoption of the report, I will, as usual, make a few remarks on the proceedings of the Company during the last six months. The gross receipts for the half-year under review have amounted to £264,138, against £247,681 for the corresponding period of 1894, showing an increase of £16,457. This increase is almost entirely due to the heavy gold mining traffic that has so suddenly sprung up with Western Australia. A few years ago the whole telegraphic traffic of Western Australia represented only a fraction of the Australasian traffic—now it is nearly one-third of it; mining

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business is, however, very speculative, and it is imposaible to say whether the "boom" in Western Australia will continue or not. Meanwhile, the Western and South Australian Governments are improving and extending their land-line communications in order to efficiently deal with this abnormal traffic. The working expenses have amounted to £95,254, against £80,295 for the corresponding period of 1894, showing an increase of £14,959. Of this, £8,000 is due to heavier cable repairs during the past half-year than usual, and the balance to special station expenditure, such as new instruments, apparatus, electric lighting machinery, buildings, furniture, &c. The usual interim dividends at the rate of 5 per cent. per annum have been paid for the past half-year, amounting to £62,500; and the balance of revenue, £70,504, has been carried forward to the next account. As stated in the printed report, the fourth year of the working of the guarantee arrangement with the Australasian Governments resulted for the first time since it was entered into in a slight excess over the guaranteed figure. This, however, was solely due to the exceptionally heavy mining traffic already referred to. For the previous years the results were as follows:—For the first year there was a loss of £55,040, for the second year a loss of £43,558, and for the third year a loss of £12,384, making a total loss of £110.982, one-half of which was borne by the Governments and the other half by the Eastern Extension and its associated companies. During the half-year the maintenance ships have been, as usual, kept well employed on the various sections of the Company's extensive cable system, but the traffic has in no instance been interrupted owing to the cables being duplicated and in some cases triplicated. I have now given you pretty much the details of the last six months' working. There has not been anything very striking, but I think that in maintaining the dividend and in carrying forward a large sum to the next account we have done very well (hear, hear). I have just been looking over the remarks I addressed to you six months ago, and I find that were I to repeat them to-day they would not be out of place. I shall therefore not go largely into details to-day. There are a good many things floating in the air at the present moment, but until we know something more about them than we do at present, probably the less we say about them the better; but I can assure you of this—that we are closely watching all these matters, and that your interests will be vigilantly looked after whenever it may be necessary to take action. I may further assure you that your cables are, generally speaking, in good condition, and that the traffic is good. I also think that your dividend is a very good one as an interim distribution, and in conclusion you may take it from me that we are in a very satisfactory and prosperous position (hear, hear). I beg to move—

"*That the report and accounts of the Directors, now submitted, be received and adopted.*"

The Marquis of TWEEDDALE: I beg to second that.

The CHAIRMAN: If any gentleman desires to put any question I shall, as usual, be only too happy to answer it to the best of my ability.

Mr. SAMUEL SMITH inquired whether the investments forming the reserve fund were entered in the balance-sheet at cost price.

The SECRETARY replied in the affirmative. At page 10 of the report it was so stated.

The CHAIRMAN: I think it is a very nice statement to put before you as to our reserve fund (hear, hear).

Mr. SMITH acquiesced, and said he had been going to point out that, as the investments were taken at cost price, they showed a profit of something like £150,000.

The CHAIRMAN: We take no credit for that in the accounts.

Mr. SMITH: But it is a great gratification to know this.

The CHAIRMAN: Yes, it is. I am very proud to see such a reserve, because it is one which we could turn into cash at once if necessary.

In answer to a further remark by Mr. Smith relative to the expenses,

The CHAIRMAN said: Submarine cables are an uncertain property in regard to cost of repairs. We may have many repairs to-day, and possibly none again for some time to come. Of course, we have to meet these repairs, but, on the whole, I think our repairs are not excessive. I think it probable that we may look into this question of repairs, and place the matter before you in a different form. Instead of charging very much in one year, and perhaps a great deal less next year, we may perhaps be able to see our way to charge a fixed annual sum, and have what is called an equalised amount provided each year.

Mr. SMITH said his remarks were merely intended to elicit information. He took it that there had been an unusual expenditure for buildings, which was not likely to occur again.

The CHAIRMAN: We are going to build a handsome station at Hong Kong, which will cost us some money. We find as we go on that our staff increases, and we have to extend our accommodation. We have got a good service because we have good men, and we have to put them in as comfortable quarters as we can. In many cases we reduce our rent by building our own stations. He then put the motion and declared it carried unanimously.

Mr. JOHN NEWTON: I have much pleasure in proposing a vote of thanks to the Chairman and Directors for their services in the past half-year. I think that the Board may well be proud of the list of investments they show in their report. I do not suppose there is any other cable company that can show such a strong position. It is very gratifying to me to hear you, the Chairman of so strong a Company, enunciate the principle of charging an average sum for repairs. That will enable the shareholders to count with much greater certainty on equal dividends.

Mr. SAMUEL SMITH seconded the motion, which was carried unanimously.

The CHAIRMAN: I am not old enough to feel other than pleased when our shareholders congratulate us each six months. I think we are entitled to a little compliment from you, and I should feel disappointed if you did not pay it to us. When you do I assure you we appreciate it very much, because we desire to be always in touch with you. We also desire to maintain the dignity and position of our submarine telegraph system; and as long as it occupies the position it does at the present moment, not only the Directors, but those shareholders who have stood by us for so many years, ought to be proud of it (applause).

The proceedings then terminated.

Brazilian Submarine Telegraph Company (Limited).

The forty-fourth ordinary general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, on Wednesday, under the presidency of Sir John Pender, G.C.M.G., M.P.

The SECRETARY (Mr. Richard Collett) having read the notice convening the meeting, and the minutes of the last meeting, which were confirmed,

The CHAIRMAN said: As usual, gentlemen, I will go over the report and give you such additional information as will make the meeting interesting to you, and I hope I shall be able to show that it is satisfactory. The receipts for the half-year ended June 30, 1895, were £108,206; for the previous half-year they were £104,926, showing an increase of £3,280. The receipts from messages show an increase of £3,336, and those from miscellaneous receipts from interest, rents and transfer fees a decrease of £56, resulting in a net increase, as before stated, of £3,280. This increase results from growth in the telegraphic business with the West Coast of Africa, South Africa, and the West Coast of South America. Although we have carried a largely increased volume of traffic with Brazil and the River Plate Republics, we have not benefited much in money, but this is due to the fact that the exchange value of the milrei has averaged nearly a penny less, and that certain re-arrangements of, and reductions in, the rates came into operation during the half-year. The increase in traffic has, however, compensated for the loss that would otherwise have resulted from the reductions in the rates I have mentioned. As traffic grows, and circumstances permit, your Directors are pleased to find themselves able to lower the telegraph tariffs. I may take this opportunity of comparing some of the charges in operation when the word rates came into force with the tariff of to-day. For Pernambuco the rate was 9s. per word—it is now 3s. 6d.; for Rio de Janeiro the rate was 13s. 7d., for Uruguay 15s. 8d., and for Argentina 16s. 4d.—they are now 4s. 6d.; and for Chili and Peru the rates were respectively 21s. 4d. and 26s. 6d.—they are now 6s. 2d. I think that shows that while we have been progressing and doing a fairly good business, we have also had regard to those who are contributing to that business by giving them rates perhaps more largely reduced than could have been expected. Taking the expenditure side of the revenue account we find the total expenses chargeable against the half-year amounted to £21,129, which, compared with the previous half-year, viz., £36,772, shows a decrease of £15,643—due, I may say, to the absence of any heavy expenditure for repairs of cable, such as occurred during the previous half-year, when repairs cost £16,400. You will see that a great deal depends upon the amount we expend on the repairs of the cables. That is a quantity which we cannot at any time estimate, but I may say that when these repairs take place we always put in some new cable, and are always strengthening the old cable thereby. The general expenses in London and the working expenses at stations show decreases of £54 and £698 respectively. There is also a reduction of £1,641 in the service of the Debenture debt for interest and sinking fund. The expenditure contains two special items, viz., one of £1,172 for repairing and storing some 36 knots of cable recovered during the repairs near Pernambuco, brought home, put into good order, and made available for use again when required. The other is £1,181 special legal expenses incurred in settling a dispute involving a question of great importance, upon which the Directors were bound in your interests to obtain a judicial decision. Taking both receipts and expenses together, we have a profit of £82,086 for the half-year under review, compared with £61,822 for the preceding six months. This shows an increase of £20,264. To the profit for the half-year is added £4,324, the balance to credit of the revenue account brought forward from December 31, 1894, making a total of £86,410. Of this £30,000 has been transferred to the reserve. An interim quarterly dividend of 1½ per cent. was paid in June, amounting to £19,500. A similar dividend is now proposed, and also the payment of a bonus of 2s. per share, amounting together to £32,500. The balance of £4,410 is carried forward. The dividend proposed for the year is at the usual rate of 6 per cent. The bonus of 2s. equals 1 per cent.; therefore the total distribution is 7 per cent. for the year, or ½ per cent. more than was declared for the preceding year. Although the period we are dealing with was free from expenses for repairs, we have not been so fortunate in the current half-year, for on August 26th the St. Vincent-Pernambuco No. 1 cable was broken, about seven knots from St. Vincent. The repairing steamer "Mirror," of the Eastern Telegraph Company's fleet, was at once chartered, and she left Gibraltar on August 31st, arrived at St. Vincent on September 7th, completed the repair on the 9th, left St. Vincent on the 10th, and arrived at Gibraltar on September 17th. This, I am sure, you will consider a very expeditious and satisfactory piece of work. The cable was laid in 1874, and has therefore been submerged 21 years. After the repair it was found to be in excellent working order. I do not know that I can give you more encouraging words than these. It has been for a long time a question, What is the life of a submarine cable? Well, what with the repairs we make, the additions of new cable, and one thing and another, I think we can keep a cable alive for a very long time. That is satisfactory to you, because it shows that your property may continue longer than we expected; but we must not rely too much on that. We must have such a reserve as will enable us to meet any breakdown that may occur promptly and efficiently. The traffic between the West Coast of South

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America and Europe, passing *vid* the lines of the Pacific and European Telegraph Company, continues to grow in a satisfactory manner, and I anticipate that very shortly a dividend will be declared by that Company. In the meantime we are receiving our proportion of the charges for carrying this West Coast traffic, which, prior to the formation of the Pacific Company, did not transmit by our system. Gentlemen, I have given you, as you will see, a very careful statement of our affairs. I have put before you a thoroughly satisfactory statement, and I have shown you that in the midst of the uncertainties, by which we are more or less surrounded, we are progressing, and from the way we are doing our work we are likely to progress. We are not in the happy position that we should like to be in with the Brazilian Government. For the 20 years during which we continued as their concessionaire we conducted the work in a most satisfactory way—so satisfactorily that I do not know that Brazil would have occupied the position she does to-day had it not been for the submarine telegraphs, which brought her into close contact with every mercantile community in the world. I think they ought to remember that. They ought to remember that while the pioneer Company exists and shows that it reduces the rates in a way that ought to be thoroughly satisfactory to the Government, they require a little attention, and not to be treated in the way in which the Brazilian Government has treated us lately. Some of the Brazilian newspapers have done a great deal to abuse us, and, I am sorry to say I read in a Brazilian newspaper that the odium which they are throwing upon us, or trying to throw upon us, is in some measure due to the interested parties apparently connected with the Western Company. The fault which I find with some persons connected with that Company is that they might look more after the dividends and interests of their shareholders and less to other considerations; and I hope that the shareholders of the Western Company will take up this question in earnest. We are doing well. We can go on as we are; but when I see a Company which I think ought to be much more prosperous than it is I think that the sooner the two companies are more closely allied the better. That ought to be the business of the shareholders of the two companies. I am quite ready. They have told me they are quite ready; but they are subject to the power of purchase by the Brazilian Government. If that sale does not take place promptly I think it will be wise on the part of that Company to see that the difficulties which exist now are removed. I am desirous of acting in a fair, straightforward spirit with them. So far as matters between the Government and the Brazilian Company stand, they are as follows:—In May, 1894, the Company sent a special agent to Rio with propositions from the Company to the Government, under which it was hoped arrangements would be made to meet the views of the Brazilian Government and increase the traffic with the telegraph department, and consolidate the working of the cable companies, having every regard for the interests and rights of the public. For reasons stated at a previous meeting the agent had no opportunity of entering upon the negotiations. I believe during a two months' stay they granted him two hours' interview. Early in 1895 further representations were made to the Brazilian Minister in London, having for their object the removal of all misunderstandings and the making of arrangements for the future of international telegraphy, which should afford every possible advantage to the people of Brazil, combined with a fair return to the Government Telegraph Department and to the cable companies. Under such an arrangement we hoped that all interests would be fairly dealt with and the service improved. Early in June last, at the request of the Minister of Industry, &c., our representative in Brazil presented to the Minister the views of your Directors, with an assurance of our desire to bring about a closer working arrangement with the Telegraph Department, with financial advantages to that Department and due regard to the other interests involved. We have not yet received a reply from the Minister, but there has lately been published in an official print in Rio de Janeiro a report upon the question from the Director-General of Telegraphs. It is very long, and is in the hands of the translator to-day; but, so far as we have gone into it, it raises questions as to monopoly, our alliance with the Western and Brazilian Telegraph Company, and other points, all of which it was our hope would be arranged to the satisfaction of the Brazilian Government in the negotiations your Directors have sought to bring about, and which they still greatly desire may yet be entered into with the Minister. I think I have told you pretty much all now that I ought say, but there is one subject which is before the public, and with which some of the newspapers are also dealing—I refer to the question of the little island of Trinidad. When we found that the Brazilian Government would not deal with us—in fact, practically refused to deal with us—we had to look round and see how the other part of the coast could be dealt with, and how we could maintain our traffic there, which formed a very large portion of our traffic with South America. We have erected new lines between Buenos Ayres and Valparaiso, thus connecting our system with that on the West Coast of South America, and the Western and Brazilian Company were parties to the erection of those lines which we are working now, and very satisfactorily. We have a very large traffic in the River Plate and on the West Coast, and we have to maintain an efficient service there, which we are able to do under existing cable arrangements. We are bound to keep lines for that traffic open, and we had to look around for the best way to get to the Argentine and Chili without being interrupted in any manner. We then found that this little island was unoccupied. It had been claimed at different times by different nations. The Portuguese say that they had it, the Brazilians say that they had it, and England says that she had it, but at the present time this small island is only occupied, as far as we can learn, by landcrabs; there was not a human being on it. We found that it would be a most excellent place for our purpose—a place which, practically, Providence had provided for the submarine telegraph system. We asked our Government to look into it, and, if free and unoccupied, to take it, so that it might be used as a submarine telegraph station. We asked for it for no other purpose except in the cause of submarine telegraph progress; and it is our business, having so far established it successfully, to protect it. Brazil has made a political question of it, but they are not likely ever to use it if they had it to-morrow. Let them have the sovereignty of it, if they please, but let it be used by us or any other parties—for we do not ask for its exclusive use—who choose to lay down a submarine telegraph there. Let it be used and kept as a telegraph station. It never can be used for any other purpose. I am quite sure you will agree with me that, while nations have their rights, they also have their duties; and if the Brazilian Government will deal with us as the nations of Europe deal with us, we shall be perfectly satisfied to meet them on fair terms, and in meeting them on those fair terms we shall give enormous benefits to their trade and advantages to those who trade with them. I will now move—

"*That the report of the Directors and the accounts to June 30, 1895, now submitted, be approved and adopted; and that a dividend be now declared of 3s. per share, making, with the interim dividends already paid, a total dividend of 6 per cent. for the year, and also a bonus of 2s per share, making in the aggregate a distribution of 7 per cent. in respect of the profits for the year ended June 30, 1895, the said dividend and bonus to be respectively free of income tax.*"

Mr. FREDERICK YOULE: I have much pleasure in seconding the resolution.

The CHAIRMAN: Before I ask you to approve this I will ask any gentleman to make any remark if he desires to do so; but I will first refer to a letter from Mr. Thompson, who urges upon us the impolicy of largely increasing our reserve fund. Our reserve fund is our stand-by; and to reduce it for the reason that he states—that a large reserve tempts others to come in and do the work—would be most unwise. He gives as an illustration of his reason the South American Telegraph Company, which came into competition with us. I am quite sure from what I hear and know of the traffic that if the South American Company had the choice of doing the work again they would not do it. I think they have quite enough to do with cable competition, and I think they will find it better to stick to their manufacturing work. We are on perfectly friendly relations with them, but, as I told them, and as I now tell you, they have not improved the position of submarine telegraphy since they became a cable company. They make very good cables, and I should like to see them prosperous, but I cannot approve of the course they have been pursuing. We ought not only to maintain but also to increase our reserve fund. It is there, and it belongs to you. We are not using it. If the time comes and it has to be divided, you are the people who will get your share of it. Therefore let us maintain the position which I think we have made; at all events, let us maintain it until we see smooth seas around us. If anyone now desires to put a question to me before I submit the resolution I shall be pleased to answer him in the best of my ability.

Mr. MICHAEL THOMPSON inquired whether there was any agreement between the Western and Brazilian Company and this Company prohibiting the laying of a competing line.

The CHAIRMAN, in reply, stated that they had an agreement for forty years with the Western and Brazilian Company, but under that Company's concession the Brazilian Government had power to purchase the Company's cables. If the Brazilian Government got possession of the interests of the Western Company, the Brazilian Submarine Company would be face to face with the Brazilian Government, and would then cease to be in any way connected with the Western Company. Therefore the Brazilian Government, if they bought up the undertaking of the Western Company, would deal with the Brazilian Submarine Company, or they ought to do so. It was for that reason the Directors of the Brazilian Submarine Company sent out a special agent with propositions for arrangements such as other telegraph companies have with India, with France, and with Italy. These were all businesslike arrangements, but the Brazilian Government would not see them or listen to them, and sent the Company's agent back without having made one step of progress. However, the present Brazilian Government has not been in office long, and he thought they would yet negotiate with the Company, and they would find after all, that the Company ought to be dealt with in a fair and reasonable way. The Western and Brazilian Company could not lay a competing line, but on acquiring that Company's undertaking the Brazilian Government could lay such a line. For his own part, however, he did not believe that the Brazilian Government would buy up the interests of the Western Company. The people who wanted to bring about the purchase saw that unless they urged on the Brazilian Government to buy, money which they expected to flow into their pockets would not reach them.

The motion was then carried unanimously, and resolutions were afterwards passed re-electing the retiring Directors, Lord Sackville A. Cecil and the Duke de Loulé, and the auditors, Messrs. Deloitte, Dever, Griffiths and Co. and Messrs. Gane, Jackson and Jeffreys.

Mr. ROBERT TAYLOR then proposed a vote of thanks to the Chairman and Directors, whose services he warmly commended, and whom he congratulated for having such a list of investments forming the reserve fund.

Mr. GEORGE C. SCRUTTON seconded the motion, which was carried unanimously.

The CHAIRMAN, in reply, thanked the shareholders for the strong confidence which they had expressed in the Directors. He had spoken plainly, and some of his remarks would probably not be appreciated by those for whom they were intended; but the first consideration of his colleagues and himself had been to see that the interests of the shareholders were fairly and properly respected. Their Company had been a marked success, and he would always do his utmost to take care that they were dealt with as an honourable body, which had done an immense deal of good, not only for Brazil, but for every country where trade and commerce were carried on.

The proceedings then terminated.

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The Amazon Telegraph Company (Limited).

The first ordinary meeting of this Company was held yesterday at Winchester House, Old Broad-street, E.C., under the presidency of Mr. W. S. Andrews.

The SECRETARY (Mr. R. M. Cunningham) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, we have no report and no accounts to present. This is, as you know, simply a statutory meeting, just to let the shareholders know what progress is being made in what is, of course, practically, an entirely new undertaking, and therefore what I have to say will be pretty much in the nature of a catalogue. In the first place, with respect to the capital of the Company, it was £250,000, you will remember, in ordinary shares—25,000 Ordinary shares. We had applications for 30,250 shares; 25,000 shares were allotted unconditionally to applicants. Fortunately, the Company is in this position—that it has no other capital. There is no debenture capital, there is no Preference capital, and, therefore, whatever we may be fortunate enough to earn will be distributed among the shareholders alone. I am pleased to say that all the calls made have been paid up to the present time. The shares are now £5. 10s. paid, with the exception of 914 shares, which were all paid up in full. The shares, as you know, are of the nominal value of £10. Up to the present time—that is, up to yesterday—we are informed that 1,119 miles of cable have been manufactured, and it is expected that the total mileage will be completed by the end of November, or perhaps even a little earlier. All the apparatus is in hand, and the expedition, no doubt, will start shortly after the completion of the cable, and we may probably see our line in full working order pretty early next year. I think I ought to say a word as to the very satisfactory manner in which all the works have been executed by Messrs. Siemens, so far as we have gone. I have no doubt that that satisfactory work will be continued to the end of the chapter, and that as far as our plant goes we shall have a very first-rate cable. We shall have the best and most modern apparatus, and, therefore, the concern ought to work to a profitable end. The contractors and the Company's representatives and engineers have been up the river Amazon for the purpose of surveying the route, fixing the points at which the cable is to be landed, and arranging for the building of huts or small establishments for the offices and quarters, as far as possible, of the clerks employed. Therefore, every care has been taken well beforehand of the conditions under which the thing is to be worked. We expect to have this report shortly. We have not received it at present—we have simply heard that it is coming, but we expect to have it in the course of, I suppose, a fortnight, and then we shall be in a better position even than we are now to gauge the date at which the line will be finally completed; but it will be, at all events, as I have said, early in the coming year. There is only one other point which I have to mention. I daresay some of the shareholders have been looking out for a Stock Exchange quotation. We applied in the usual course for it, but there has been delay, owing to the concession having to be sent out to Rio for the attestation of the British Consul to certain signatures. That was one of the requirements of the Stock Exchange, and we were very happy to comply with it. The only thing we regretted was that it would interpose a little delay in the granting of a quotation. Otherwise everything is in order, and as soon as these papers get back we shall fulfil the necessary formalities, and your quotation will no doubt be forthwith granted. I think there is no other matter I have to detain you with. You are all business men, and no doubt you will be glad to go. Unless any gentleman likes to offer any remarks the meeting is at an end. There are no resolutions to be passed.

A brief discussion followed, and,

The CHAIRMAN, in reply, said: Before Mr. Griffith arrived I had mentioned that we anticipated the completion of the line early in the new year. As far as we have information at the office, it points to an earlier completion and opening of the line than we had ventured to anticipate. That is a favourable element, as far as it goes. With respect to the earliest dividend and dividends during construction, as the learned gentleman knows perfectly well—better than I, I imagine—a Company like ours is under the Joint Stock Companies Act, and has not a special Act enabling it to pay dividends out of the capital subscribed during construction. It, therefore, cannot pay anything until the earnings of the Company enable it to do so.

Mr. GRIFFITH: Could you not do so out of the subsidy?

The CHAIRMAN: We have not got the subsidy yet. With respect to the Stock Exchange quotation, I do not think I need say anything further. With regard to the traffic, we have not the reports, which are on the way, and which our worthy secretary tells us we shall receive in about a fortnight, but there is nothing of any discouraging character, so far as we know, to interfere with our our prosperity. With respect to the observation of Mr. Quilter as to the strides made by Brazil, it is perfectly true that Brazil is making great strides. There ought to be a very much quieter and more satisfactory feeling in Brazil, and that state of mind ought to lead to increased business and increased prosperity. You all, however, know that there has been a little something thrown across the path that has interfered with and thrown exchange rather backward than forward, and that is one of the points which makes prosperous and unprosperous companies. We may cite the Western and Brazilian and the Brazilian Submarine companies; with a low exchange their revenue is less. It does not affect us, but it does affect trade and commerce. This has rather thrown that back again. Then there is the excited state of political feeling, and the Brazilians are immensely excited over the rock of Trinidad. That, with the fear of something desperate occurring, has rather caused a stagnation or temporary pause in the advance which you were quite right in saying was taking place. We have sent our engineers and others to go carefully over this line because of the peculiarity of it and the newness of the endeavour to establish a communication of such great length in what we call a river. At the same time, as you know, the Amazon, where our line terminates—that is at Manaos, some thousand and odd miles up the river—is ten miles broad. When the flood season is on, its width is so large that the waters on the river are very little affected. There is not that amount of disturbance and flood that you would expect, from the simple reason of the gradual flow which the water takes over the low-lying lands around, and during that season the river is not 10 miles, but about 30 miles, broad. It is called out there the Mediterranean of South America, so it is not a river in the ordinary sense. There is one little bit of it—little relatively to the enormous length of the whole—where it is more like a river. It divides into three rivers, where the big Amazon comes into the Para. Otherwise this enormous width is all the way up. As far as we know at present, our engineers have found nothing of an adverse character at all. We should have heard of it if they had. We are told that this report is coming, but we should have been informed had there been anything to interfere with or render less promising the laying of this cable, and the result as regards its expected future. We had several reports—all of them favourable. None seemed to anticipate any difficulty, after investigating the charts, in the laying of this cable. We are, therefore, led to hope, seeing the careful way in which everything has been done, and the care taken in laying out the construction of the whole scheme, that the future ought to be prosperous. We hope so. We are all shareholders in it, as you know. A question was asked whether the subsidy would begin to be paid on the completion of the cable—the opening of the lines—or whether it would not be paid for 12 months after. We are advised that it becomes payable as soon as we can report that the lines are laid and open for business, and from the date of the contract, so it will go back. Our representative in Brazil is making inquiries with respect to the employment of native Brazilians, who, properly trained, are skilful telegraphists, and also as regards the best means of communication. It is singular that Mr. Quilter should have hit upon it, but we have already ordered several telephones with the object of establishing communication, which it is reported we can effect over the smaller lines, and which would then be worked without the application of skilled labour. Anyone can talk through a telephone, and carry out the instructions put upon it. We have therefore already taken this matter in hand, and the instruments are being made.

On the motion of Mr. GRIFFITH, seconded by Mr. QUILTER, a vote of thanks to the Chairman and Directors brought the meeting to a close.

Monte Video Telephone Company (Limited).

The annual general meeting of this Company was held yesterday (Thursday) at Winchester House, London, E.C., Mr. Herbert Ward (Chairman of the Company) presiding.

The SECRETARY (Mr. E. M. Reiss) read the notice convening the meeting.

The CHAIRMAN said: The position, as shown by the accounts, compares favourably with that of last year, in spite of one or two troubles which have befallen us during the past twelve months, troubles to which a telephone business like ours is peculiarly liable, and which serve to retard that progress which would otherwise be made. One of these troubles is damage to our plant by storms. In the early months of this year Monte Video was visited by many storms, and our wires and posts were much damaged. On March 25th, during a heavy thunderstorm, the main post, with its many cross arms, on the roof of our central building, was struck by lightning, and all the wires coming out of the central office were severed, and communication with subscribers was for a time totally disconnected. A word of praise is emphatically due to our general manager in this matter, for, by his alertness and energy, and by keeping men at work night and day, the damage was repaired within five days. The activity displayed in restoring communication with subscribers added in fact to the local prestige of the Company, and quite counteracted the harm which was feared in the first instance would be done to the Company's business. The loss sustained by this lightning accident was entirely recovered from the fire insurance company, who settled our claim very promptly, so that this accident has not added to our working expenses, but I may mention this event as one showing the dangers we are always open to, and which are naturally beyond our control. Another matter, however, which has helped to increase our maintenance charges is the constant changing of posts on the roofs of houses and buildings, owing chiefly to caprice on the part of the property owners. This is a matter of peculiar difficulty to which our manager is always giving his attention. It is owing to these causes that our working expenses are some £800 more than last year. Another trouble was loss of subscribers. Our monthly returns show that throughout the year our losses have been fairly made up by new subscribers gained, and had it not been for the unfortunate loss of the police department, who subscribed to 49 of our instruments, our present number of subscribers would be about equal to the number at this time last year. The local opposition company, however, through political influence on the occasion of the change of ministry last winter, succeeded in taking this police service from us. This opposition company has no multiple board, and cannot, therefore, give such efficient service as our own company, and we are already advised that the police bureau are very dissatisfied and are threatening to return to us. Notwithstanding this loss our total receipts from subscribers are only £157 less than last year. In view of this loss and of there being no increased revenue to apparently justify the capital outlay for the year of £985, the Directors have considered it right to use a portion of the depreciation fund, created for the purpose, to cover this item of expenditure. I would next like to mention that Mr. Sanford, one of your Directors, being just now engaged on business in the River Plate, has been able to visit our head office in Monte Video, and is in constant communication with our manager. The advantage of having a member of the Board at headquarters is obvious. Mr. Sanford is thus able

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to personally consult with Mr. Harispurn, our local agent and attorney, and to dispose of questions promptly, to the great assistance of the manager, not only temporarily, but as regards the future conduct of the Company's business. Now, on the other side of the picture we show a new item of income of £187 in the shape of interest on our investments, which, moreover, stand at yesterday's closing middle prices at a capital appreciation of nearly 8 per cent. In other words, securities which are taken in our balance sheet at their cost price of £8,693 would, if sold to-day, realise about £9,300. While adding substantially to our reserve fund, and carrying forward a larger sum than a year ago we are able to maintain the dividend of 4 per cent. declared last year on the Preference shares, so that in spite of the little troubles I have explained to you I think you will agree that the position, as revealed by the accounts, is a satisfactory one, and is even stronger than at this time last year. I now formally move :—

"That the report and accounts as presented be received and adopted."

Mr. F. W. JONES seconded the resolution, and it was agreed to without discussion.

The CHAIRMAN then moved

"That a dividend at the rate of 4 per cent. per annum on the Preference share capital of the Company be declared for the year ending July 31, 1895, and that the same be paid forthwith."

Mr. E. F. POWERS seconded, and it was carried.

On the motion of the CHAIRMAN, seconded by Mr. H. SMITH, Mr. C. H. Sanford, the retiring Director, was re-elected ; and Messrs. Gerard Van de Lind and Son were re-appointed auditors.

A vote of thanks to the Chairman terminated the proceedings.

NEW COMPANIES, STATUTORY RETURNS, &c.

ACETYLENE ILLUMINATING COMPANY (LIMITED).—The statutory return to September 19th has been filed. The nominal capital is £21,000, in £1 shares, and 4,000 of these have been subscribed for and allotted. A call of 2s. 6d. per share has been made.

AURORA ELECTRIC LIGHTING AND DISTRIBUTION COMPANY (LIMITED).—The annual return to October 9th has been filed. 5,935 shares have been taken up out of a capital of £25,000, in £1 shares, and 5,000 have been issued as fully paid. The full amount has been paid on the remainder.

BUENOS AYRES ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to June 11th, has just been filed. The nominal capital is £100,000, divided into 9,986 Ordinary shares of £10 each, and 70 Founders' shares of £2 each. All the latter have been subscribed for, but nothing has been called thereon.

BICKLEAND COMPANY (LIMITED).—The annual return of this Company, made up to October 2nd, has just been filed. The capital of £50,000 is divided into £10 shares ; 2,030 of these have been taken up, and 1,000 have been issued as fully paid. The full amount has been called on the remainder, resulting in the payment of £10,223, and leaving £77 in arrears.

CONNOLLY BROS. (LIMITED).—The statutory return to October 11th has been filed. Out of a capital of £20,000, in £5 shares, seven have been subscribed for and allotted. The full amount has been called and paid.

ELECTRIC CONSTRUCTION COMPANY (LIMITED).—The annual return to September 26th has been filed. The nominal capital is £400,000, in 150,000 Ordinary and 50,000 £7 per Cent. Cumulative Preference shares of £2 each. 110,000 Ordinary and 16,343 Preference shares have been taken up, and all the Ordinary and 13,145 of the Preference have been issued as fully paid. The full amount has been called and paid on the remaining 3,198 Preference shares.

CITY NOTES.

MEMORANDA—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 31d. per oz. (Oct. 31st). Consols (2¾ per cent.) 106⅞—107⅛ for money, 106⅛—107 1/16 for account ; 2½ per cent. 104¾—105 (Oct. 31st). Stock Exchange Settling Days : Consols, Nov. 6th ; Stocks and Shares Continuation Day, Nov. 12th ; Ticket Day, Nov. 13th ; Pay Day, Nov. 14th ; Mining Share Carry-Over Day, Nov. 11th.

ANGLO-FRENCH (COLONIAL) MINING TRUST (LIMITED).—At the statutory meeting of this Company on Monday last the Chairman (Mr. James Burnett) announced that the Directors had secured an interest in the Ward Electrical Car Company. He said that there was no doubt that electricity would be the motive power of the future, and he thought the time was not far distant when the streets of London would be without horses. He had been informed that the drawback to electric cars in the past had been their weight, but he believed that Mr. Ward had now overcome this difficulty, and he was prepared to put on the streets 'buses and carriages that would run even lighter than the ordinary horse cars. There seems to be a smack of ancient history in this report, more particularly as the Chairman talks of 50 per cent. dividends in the near future. Surely this has been previously prognosticated.

BRITISH ELECTRICAL MANUFACTURING AND ENGINEERING COMPANY (LIMITED).—As stated in our last issue, a company has been formed under the above title. It will be an amalgamation of the St. Martin's Electrical Manufacturing Company and the manufacturing departments of Messrs. Laing, Wharton and Down, of New Bond-street, London. Mr. C. L. Barker has been appointed consulting engineer to the new Company, and the vendor, Mr. T. Duncan Dundas, has been appointed manager. £12,500 (£2,500 in cash, £1,000 in debenures, and the balance in fully-paid shares) is the purchase price fixed.

CASTNER-KELLNER ALKALI COMPANY (LIMITED).—Letters of allotment in the recent issue of shares in this Company have, we learn, been posted.

CENTRAL CHILI COPPER COMPANY (LIMITED).—The Directors of this Company invite tenders for about 5,000 Six per Cent. Accumulative Priority shares of £1 each, at a price not below par. The subscription is invited from existing shareholders, and if not taken up by them the Directors will proceed to allotment on the 11th inst. upon applications already in hand for the whole amount. The present issue is made in consequence of the satisfactory reports from the Manager in Chili, upon which the Directors propose to take steps to increase the output of the mines by further developing and putting down additional machinery, &c.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended October 27th were £977, against £948 in the corresponding week of 1894, an increase of £29. The total receipts for the half-year amount to £14,678, against £14,811 for the corresponding period of 1894.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—A drawing of 381 Five per Cent. Mortgage Debentures of this Company will take place at the offices, Winchester House, Old Broad-street, E.C., on Friday, the 15th inst., at noon. The drawn debentures will be paid off on January 1st next, and due notice of the numbers will be given.

ELECTRIC TRACTION IN ITALY.—A Company, entitled the Unione Italiana Tramways Elettrici, has just been formed in Genoa. The capital of the Company is £120,000.

ELMORE'S PATENT COPPER DEPOSITING COMPANY (LIMITED).—The Directors of this Company report that the profit on the last year's manufacturing account is £4,557, and after writing off the Company's general and trading expenses, the trading account shows a net profit of £2,253 carried to the credit of profit and loss, as against a loss of £6,858 in the previous year. This improvement has been effected without any increase in the Company's working capital, out of which £5,202 has had to be spent in necessary additions to plant and buildings. The additions to plant are described as specially valuable, and are working satisfactorily. The orders received have increased from 706 in the preceding year to 1,531 in the present year, whilst the deliveries to customers have been nearly four times greater in volume and practically three times larger in value, notwithstanding that the average selling price has been over £12 per ton lower. Prices are, however, again ruling higher. The working expenses show a great decrease with the increase in the business done ; in fact, the rate of manufacturing cost has fallen by over 50 per cent. The profit and loss account shows a net profit for the year of £480. The business is described in the report as having now reached a stage when further capital can be reasonably asked for and profitably employed in its extension. The shareholders will therefore be asked at the meeting held to-day to increase the Board's borrowing powers, giving them power to borrow, as may be required, up to £100,000, and the debentures proposed to be issued will, in the first place, be formally offered to the shareholders. It is also proposed to reduce the ordinary share capital from £2 to £1 per share.

GROSSE LEIPZIGER STRASSENBAHN-GESELLSCHAFT.—A Company with this title has just been formed in Leipzig for the purpose of taking over the undertaking of the present English Tramway Company of Leipzig. The Company, which has a capital of £225,000, has been promoted by some German banks and the Gesellschaft für Elektrische Unternehmungen, propose to extend the present lines and equip the entire system electrically.

GUILDFORD ELECTRICITY SUPPLY COMPANY (LIMITED).—It is stated that sufficient capital has now been subscribed to float this Company, and that the shares applied for will be immediately allotted. Mr. W. J. Perkins has been appointed secretary of the Company.

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).—The Board of Directors of this Company have declared an interim dividend, for the half-year ended June 30th last, at the rate of 5 per cent. per annum, free of income tax. The dividend is now payable.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 27th ult. amounted to £1,075. The amount for the corresponding week last year was £901 ; increase, £174.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—The transfer register of this Company will be closed from this day (Friday) to Friday next inclusive, to prepare for the payment of an interim dividend.

SOCIETE GENERALE BELGE D'ENTREPRISES ELECTRIQUES.—A Company bearing this title, and having a nominal capital of 6,000,000fr., has just been formed in Brussels. Though the Company will carry on a general electrical business, special attention is to be devoted to the exploitation of traction enterprises.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have ordered 17,139 "A" shares (Nos. 01 to 017,139) of the Edison and Swan United Electric Light Company (Limited), to be quoted in the official list

VICTORIA ELECTRIC RAILWAY AND LIGHTING COMPANY (LIMITED).—A meeting of the debenture-holders of this Company will be held at 8, Austin Friars, London, E.C., on Wednesday next, the 6th inst., at 2 o'clock.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ending October 25, 1895, after deducting 17 per cent. of the gross receipts payable to the London-Platino Brazilian Telegraph Company (Limited), were £3,203.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Oct. 18.		Price Wednesday, Oct 30.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 26.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS.								
£1,012,820	Stock	10 0	Anglo-American	45	47	44	45	5 0 0	Jan., Apr., July, Oct.	46	45½
£2,993,540	Stock	20 0	Do. Preferred	84	85	85	86	5 4 8	" "	84½	84
£2,993,540	Stock	5/0	Do. Deferred	7½	7⅝	6½	7½	..	..	..	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	102	105	102	105	3 17 1	January and July	103⅜	..
130,000	£10	3/0	Brazilian Submarine	14	14⅜	14	14½	4 9 8	Mar., June, Oct., Dec.	14⅜	14½
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111	115	111	115	4 8 4	June and December	..	..
10,000,000	$100	3 ⅜	Commercial Cable Capital Stock	164	168	164	168	4 3 7	Jan., Apr., July, Oct.	..	..
16,000	10	3/0	Cuba Submarine	13	14	13	14	5 14 4	February and August	13½	..
6,000	10	10%	Do. Preference 10 per Cent.	21½	21⅝	20½	21½	4 13 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	4	5	4	5	4 0 0	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10	10½	10	10½	4 5 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104⅞	107⅞	104⅞	107⅞	4 5 4	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877	8⅞	9⅛	8⅞	9⅛	4 6 6	Jan., Apr., July, Oct.	9	..
400,000	10	2/6	Eastern	17⅜	17⅝	17	17⅛	3 15 4	" "	17⅜	17½
70,000	10	6%	Do. 6 per Cent. Preference	18	18⅛	18	18⅛	3 4 10	" "	18½	..
£1,297,887	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock ..xd	129	131	127	130	3 1 7	May and November	130½	129½
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 11 11	February & August	..	..
250,000	10	2/6	Eastern Extension	18	18½	17⅞	18⅛	4 2 2	Jan., Apr., July, Oct.	18⅜	18
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128	131	128	131	3 1 7	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	107	103	107	4 15 0	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	107	103	107	4 5 0	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108	111	108	111	3 12 9	February & August	108½	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	114⅞	117⅞	114⅞	117⅞	3 9 7	May and November	114	114
180,227	10	1/8	Globe Telegraph and Trust	10⅛	10⅜	10	10⅛	4 0 6	Jan., Apr., July, Oct.	..	..
180,042	10	6%	Do. 6 per Cent. Preference	17	17⅛	16⅞	17⅛	3 10 1	" "	..	..
150,000	10	5 0	Great Northern	21⅜	22⅛	21⅜	22⅛	3 16 3	Jan., April, and July	..	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	103	106	104	107	4 14 4	March & September	104	105½
17,000	25	12,6	Indo-European	50	53	48	51	4 18 0	May and November	50½	..
37,548	10	..	London Platino-Brazilian	..	..	..	..	..	" "	..	..
£[illegible],000	100	6%	* Do. 6 per Cent. Debentures	106	110	108	110	5 10 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	109	112	109	112	3 12 3	" "	..	..
11,839	8	4/0	Reuter's	5½	6½	5½	6½		April and October	5½	..
3,881	£100 Cert.	3/0	*Submarine Cables Trust 6 per Cent.	127	132	127	132	4 0 11	" "	..	..
15,609	10	2/0	West African Telegraph	5½	6½	5½	6½		January and July	6	6
£233,300	100	5%	* Do. 5 per Cent. Debentures (red.)	104	107	104	107	4 14 4	March & September	..	..
80,000	10	2/0	West Coast of America	1½	2	1½	2	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	100	105	100	105	7 16 1	June and December	100½	..
88,321	10	6d.	West India and Panama	⅜	1½	⅜	1½	..	..	1 1/16	1 1/16
34,568	10	6%	Do. 6 per Cent. 1st Preference	10½	10⅝	10⅜	10⅝	5 14 8	May and November	10½	10⅜
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½	9½	8½	9½	5 13 4	" "	9 5/16	..
£30,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	111	1'4	111	114	4 9 1	June and December	114	..
64,242	15	6/0	Western and Brazilian	10½	10⅝	10⅛	10⅜	4 8 8	May and November	10⅜	10⅛
33,129	7½	4/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	7	..	—	..	..
33,129	7½	1/6	Do. 5 per Cent. Deferred	3½	4¼	3½	4	..	..	4 1/16	3 15/16
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103	107	104	107	5 13 9	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103	107	103	107	5 13 9	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	118	118	118	118	6 2 3	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100	103	100	103	5 17 8	March & September	..	..
			TELEPHONES.								
44,000	5	2/6	Chili Telephone (fully paid)	3½	4	3½	4	..	..	..	..
224,350	10/0	1½d.	Consolidated Telephone Const. & Maintenance	1 1/16	1 3/16	1 1/16	1 3/16	..	May and November	..	..
171,504	£1	8-215	Oriental Telephone and Electric (fully paid)	⅞	1 1/16	⅞	1 1/16	..	Yearly	1 1/16	..
484,597	5	2/6	National	6⅛	6⅝	6	6½	4 0 0	June and December	6 1/16	6 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16	18	16	18	3 6 8	" "	17⅛	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15	16	15½	16½	3 12 9	" "	15⅞	16⅛
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6½	6⅝	6½	6⅝	3 16 11	—	6 1/16	6⅛
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	106	108	106	108	3 5 7	January and July	107⅛	106⅜
58,000	5	3/0	United River Plate	2⅞	3⅛	2⅞	3⅛	..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	92	97	92	97	5 5 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	5/0	City of London Electric Lighting (fully paid)	13	14	13	14	1 14 6	—	13½	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15	18	15½	16½	3 12 9	—	16½	15½
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	133	137	133	137	3 13 11	June and December	..	..
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	—	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½	5⅝	6½	6⅝	..	—	5⅝	—
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	—	..	..
8,322	£5	..	House-to-House Electric	—	—	—	—	..	—	—	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	—	—	—	—	..	—	—	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	..	..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞	8½	7⅞	8½	..	—	..	..
111,000	5	..	London Electric Supply	..	..	..	..	..	—	..	—
49,900	£10	6/0	Metropolitan Electric Supply (fully paid)	11½	11⅝	11	11½	2 12 2	—	11⅝	11½
150,000	Stock	4½%	* Do. 4½% Debs.	117	119	117	120	3 15 11	June and December	1.5½	..
6,452	£10	2/0	Notting Hill Electric	8½	9½	8½	9½	..	—	9½	9½
..	..	..	Rand Electric	1/16	1/16 prem	⅛	⅛ prem	..	—	..	..
19,980	£5	2/0	St. James and Pall Mall	8½	8⅝	8½	8⅝	..	—	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	9	10	9	10	3 10 0	—	9½	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8⅜	9	8¼	8⅜	3 2 10	—	8⅛	8½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	8	1/6	Brush Electrical Engineering	1½	1⅝	1½	1⅝	3 11 8	—	1 1/16	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2	2⅛	2	2⅛	5 6 8	—	2 1/16	2
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112	115	112	115	3 18 9	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1½	2⅛	1½	2⅛	..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1⅝	2⅛	1⅝	2⅛	..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104	107	104	107	4 5 4	..	..	..
£50,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	—	—	—	—	..	..	—	..
110,000	2	..	Electric Construction	⅜	⅝	⅜	1	..	..	⅜	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2	2⅛	2	2⅛	5 11 0	..	—	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜	1	⅜	⅝	..	..	1 1/16	1 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	⅜	⅝	⅜	⅝	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	19	20	19	20	3 15 0	February & August	19½	19½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	100	102	100	102	4 8 5	March & September	..	..
15,995	£10	..	International Okonite Ordinary	..	..	..	..	..	—	—	..
16,000	£10	..	Do. 8 per Cent. Preference	—	—	—	—	..	December and June	—	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	⅜	⅝	⅜	⅝	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	43	45	43	45	4 0 0	March and July	44½	43½
£150,000	100	5%	* Do. 5 per Cent. Bonds	104	107	104	107	4 15 0	January and July	..	..
57,014	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	..	..	..	..	..	—	—	..
41,098	£5	..	Do. Preference (fully paid)	..	..	..	..	..	—	—	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	14½	14⅝	14	14½	4 2 9	..	14½	14½
£80,000	10	7/0	Do. 7 per Cent. Preference	15⅞	16⅛	16⅛	16½	4 4 10	—	..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	110	110	107	110	4 2 5	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1½%	City and South London Railway	33	40	40	43	2 19 6	May and November	39	33
7,650	10	5%	Do. 5% Perpetual Preference	14½	15½	14⅜	15½	3 5 8	—	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	184	186	182	184	2 14 9	May and November	..	..
37,500	£10	2½%	Liverpool Overhead Railway	11⅜	11⅝	11 1/16	12 1/16	1 17 4	—	—	—
14,000	10	5%	Do. 5% Preference	15	15⅜	15	15⅜	3 4 9	—	..	—
1[illegible],000	Stock	4%	Do. 4% Debenture	112	114	112	114	3 10 2	January and July	—	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

At the last meeting of the Hull Corporation Electric Lighting Committee a Report by the late Borough Electrical Engineer was presented, in which a change over to the now fashionable 220-volt lamp system was emphatically recommended. It was ultimately decided that Mr. GIBBINGS' Report should be entered on the minutes and its consideration deferred until after the forthcoming Board of Trade Conference.

In the case of extensions, and where one is working under Orders dating back as far as 1883, the 220-volt lamp idea need meet with no difficulty worth mentioning. But when we come to apply the idea to existing networks or to make the alteration under more modern Orders, several difficulties arise. Apart from the question of the durability of 220-volt lamps, there is the question: Who is to pay for the first batch? Mr. GIBBINGS proposes to settle this matter in right regal style by giving all his customers new lamps for old, and he estimates that after allowing for the money derived from the sale of the discarded 110-volt lamps, the change-over can be effected at a net cost to the Corporation of £1,500.

MR. GIBBINGS' "short way" is undoubtedly just, and where only some 15,000 lamps are concerned it is financially quite feasible. It would, however, be a somewhat expensive method in the case of concerns having, as many of the London companies have, 80,000 to 100,000 lamps connected. The remedy is evidently better suited to small rapidly-growing concerns than to large well-developed slowly-expanding businesses; more feeders would probably prove the better plan in the latter case. The Board of Trade also will, no doubt, have something to say in the matter wherever the electric supply is being carried on under a modern Order. It will be interesting to see whether that august Department will subscribe to the dogma of the infallibility of 110-volt switches and cut-outs when exposed to double the pressure allowed for.

THE decision which the Leicester Town Council came to last week to continue their electric light fitting business was a very natural one under the circumstances. No one is anxious to forego a lucrative trade, and least of all when the arguments brought forward against it are contradictory and irrelevant, and when it is possible to make out a very plausible, not to say forcible, case. Private trading by a municipality may be opposed on principle or on the ground that the work done is bad. At Leicester the local wiring firms merely deprecated municipal competition on purely personal grounds. As to the allegation that the Corporation did not adhere to its own wiring rules and took undue advantage of its position to secure wiring orders, these were satisfactorily disposed of by Alderman LENNARD in the course of his lengthy speech.

WE ourselves are, and ever have been, in favour of restricting municipalisation within the narrowest possible limits, on the ground that jobbery will inevitably creep in, and that the emulation of municipalities is not, in plain business matters, an adequate substitute for the competition of companies. At the same time, the electric lighting business once embarked on, the wiring business, especially in provincial towns, is an almost inevitable sequel. As Alderman LENNARD put it, "the success of the department to a very large extent depended upon the kind of fittings which were used," and the kind of fittings which would in all probability be used by small local firms is better imagined than described. Gas concerns certainly do gas-fitting better than the average local firm, and the same no doubt holds good for electric lighting. An obvious and, we think, effective way to secure good wiring and avoid the disadvantages of municipal trading would be to warn every intending consumer that his wiring will have to conform to standard, to fix that standard reasonably high, and to rigidly enforce the regulations by means of a small and competent staff of well-paid inspectors.

THE Birmingham Town Council were recently bold enough to grant provisional permission to the Birmingham Central Tramways Company to work the Nechells section of their network on the overhead trolley system. On Monday the ratepayers of the district concerned met in their might. The trolley and its appurtenances do not certainly possess "the fatal gift of beauty," but what modern "improvement" does? We can, however, imagine many a worse disfigurement than a line of steel poles with "ornamental" brackets, and then, as one of the speakers remarked at the meeting in question, "as for defacing property, some of it was of such a character that the more it was defaced the more it would be improved." No; the trolley in all its original hideousness was not to be tolerated; but it has now cast off much of the crudity of its early

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youth, and its progress will most certainly not be long retarded by mere selfish arguments, such as were used at the Duddeston Ward Hall. In the early days of steam railways, landowners thought they had won a famous victory when they kept the accursed thing away from their property. In 1895, frontagers are playing the same part in regard to electric street railways. To-day many a landowner bitterly regrets his famous victory; to-morrow many a houseowner will do so likewise.

THAT it is sometimes, if not always, economical to use condensers for steam plant in electric supply stations is shown by the statements of Mr. WILLIAM CROSS in his Paper on "The Surface Condensing Plant at the Newcastle and District Company's Electric Light Works," an abstract of which appears in another column. This condensing plant has been running since 1892; and though troubles were experienced at first, these were easily overcome; and the plant has been successfully worked on a series of six-months' runs without stoppage and practically without attention. Paying for coal at the same rate as before, the expense per unit for coal has fallen nearly 50 per cent., and that of water about 70 per cent., since the introduction of the condenser. And though it is probable that a number of other causes have also influenced these results, and the share in them which is due to the condenser may not be quite determinate, the improvements are large enough to warrant the deduction that a considerable economy in coal and water has arisen directly from the use of the condenser. We could have wished, however, that Mr. CROSS had been able to make a closer statement of the benefits directly arising from this addition to the generating plant. One would like to know what was the additional capital outlay, and how much is annually spent on repairs, &c. With these supplementary data it would be possible for an engineer to arrive at a far more accurate estimate of the advantage he might expect to derive from a condenser than could possibly be obtained from a mere statement of the savings in coal and water, savings which it is very well known are almost sure to be made.

MR. BRADLEY'S Paper on "Phasing Transformers," an abstract of which appears in this week's issue, presents several points of interest. The apparatus possesses no motive parts, and transforms an ordinary alternating current into a current suitable for alternating motors. The method adopted for making the phase of the induced currents independent of the load is instructive, and the inventor seems to have attained considerable success in the construction of condensers, since he has apparently made one of 2·4 microfarads capacity, capable of withstanding the alternating pressure of 3,000 volts, and occupying the space of a cube whose side is only 4in. long. Nothing, however, is said about efficiency. For a ½ horse-power motor the condenser above mentioned is needed, the pressure being 1,000 volts and the frequency 140. Under these circumstances, assuming an ordinary power factor for the condenser, this would absorb quite 50 watts, or nearly 15 per cent. of the output of the motor. Nor would this percentage diminish with larger power motors, and for currents whose frequency is 70 instead of 140 the percentage would be doubled. Moreover, there are the losses in the *two* specially-wound transformers to consider, besides those in the motor itself. These considerations partially explain, and we hope only partially, the fact that for the ½ horse-power motor a 75 kilowatt dynamo was used.

Telephonic Communication in Madagascar.—A line of telephone was completed and put in operation on the 1st inst. between Tamatave and Tananarivo.

The Hargreaves-Bird Electrolytic Cell.—Owing to pressure on our space, we have been compelled to hold over until our next issue a lengthy letter on the Hargreaves-Bird electrolytic cell, which has been sent us by Mr. Hargreaves.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Cadiz-Teneriffe	Sept. 25, 1895.	.....
Maranharn-Para	Oct. 10, 1895.	Nov. 4, 1895.
Bonny Cameroons	Oct. 30, 1895.	Nov. 5, 1895.

The Vienna Elektrotechnische Verein.—The *Zeitschrift für Elektrotechnik* of Vienna, in its issue of November 1st, states that the Archduke Carl Ludwig of Austria has consented, in accordance with the wish of the Vienna Elektrotechnische Verein, to become the patron of that institution.

Horseless Carriages.—No less than three "syndicates" with horseless carriage titles have been registered within the last week. These are the Automotive Syndicate (Limited), the English Automobile Horseless Carriage Syndicate (Limited), and the Horseless Carriage and Motor Cycle Company (Limited). Clearly the horseless carriage is to be boomed and the horse carriage is doomed.

Personal.—It has been decided by the friends of Mr. W. T. Ansell, traffic manager of the Eastern Telegraph Company, to commemorate the fiftieth anniversary of his entry to the telegraph service (of which service he is the *doyen*) by inviting him to a dinner at the Holborn Restaurant, London, on Thursday next, on which occasion a presentation will be made to Mr. Ansell as a souvenir of the event. Mr. J. Denison Pender will occupy the chair.

Vacant Appointment.—The professorship of applied physics and electrical engineering at Heriot-Watt College, Edinburgh, has become vacant, and the Governors will receive applications for the post not later than November 22nd. The duties will commence on January 1st next. The salary is £400 per annum. Particulars can be obtained from the Principal of the College, 20, York-place, Edinburgh. Some further particulars will be found in our advertisement columns.

Board of Trade Revised Regulations.—A Conference between the Board of Trade and the objectors to the revised "REGULATIONS AND CONDITIONS FOR SECURING THE SAFETY OF THE PUBLIC AND FOR ENSURING A PROPER AND SUFFICIENT SUPPLY OF ELECTRICAL ENERGY" will be held at 11 o'clock on Tuesday, November 19th. As the number of objectors is somewhat large, the meeting will in all probability take place at the Westminster Town Hall, Sir Courtenay Boyle presiding.

Institution of Electrical Engineers.—The Institution of Civil Engineers have kindly consented to permit the meetings of the Electrical Engineers to be held in their new building, but inasmuch as there is some doubt as to whether the building will be sufficiently advanced to allow of the use of its lecture hall on the 14th inst., the Council of the Institution of Electrical Engineers have decided to postpone the opening of their Session until the 28th inst.——The Annual Dinner of the Institution will take place at the Freemasons' Tavern on Friday, November 29th.

Galvanometers on Board Ship.—Who ever has heard of the ordinary Thomson astatic galvanometer being used at sea? We learn, however, that on a recent cable-laying expedition with which Mr. H. W. Sullivan was associated the final tests before submersion of the various lengths of cable on board were made with one of these instruments with excellent results. At the time the ship was anchored some miles distant from the

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land in perfectly calm water, and save for an occasional oscillation of a few scale divisions, due to the otherwise imperceptible ground swell, the readings were steady throughout. During the tests all the machinery on board was stopped. This probably is the first instance on record of the "astatic" being practically used on the ocean.

Lightning.—By signals observed from the coastguard look-out at St. David's on Thursday last week, it was seen that assistance from the mainland was required on the Bishop Lighthouse, seven miles off. A boat set off through the heavy sea to render assistance. It was found that the building had been struck by lightning, the electric discharge shattering everything in its course, and causing great consternation to the three men stationed on the rock, one of whom had a narrow escape. Fortunately the lantern and fog-signal apparatus were uninjured. The damage within the tower and living rooms, however, was considerable. From time to time representations have been made that both the Smalls and Bishop lighthouses should be connected with each other and the mainland by telephone, and those who have taken interest in the matter are hopeful now of achieving their object.

Hull.—At a meeting of the Hull Corporation Electric Lighting Committee held last week, a report from the late engineer, Mr. A. H. Gibbings, was presented. In this report Mr. Gibbings recommended the adoption of a house pressure of 220 volts in place of the existing pressure of 110 volts. The actual cost of changing over at the present time, or at least within the next twelve months, would be roughly about £1,500. The Chairman said that the only question was whether the Board of Trade would allow them to use the system. The actual cost of the alteration would be £3,362. 13s. 9d, but it was estimated by the engineer that there would be a return from sale of re-placed lamps, and an increased number of customers, which would leave the actual cost of the complete alteration at £1,525. 1s. 2d. It was ultimately resolved that the report be entered on the minutes, and its consideration deferred pending the coming conference with the Board of Trade.

The Rating of Fuse Wires.—In a Paper on "The Rating and Behaviour of Fuse Wires," read by Messrs. Stine, Gaytes and Freeman before the American Institute of Electrical Engineers, the authors describe a series of experiments, by which they are led to the following conclusions: (1) Covered fuses are more sensitive than open ones. (2) Fuse wire should be rated for its carrying capacity for the ordinary lengths employed. (2*a*) When fusing a circuit the distance between the terminals should be considered. (3) On important circuits fuses should be frequently renewed. (4) The inertia of a fuse for high currents must be considered when protecting special devices. (5) Fuses should be operated under normal conditions to insure certainty of results. (6) Fuses up to 5 amperes should be at least 1½in. long, ½in. to be added for each increment of 5 amperes capacity. (7) Round fuse wire should not be employed in excess of 30 amperes capacity. For higher currents flat ribbons exceeding 4in. in length should be employed.

Disturbances Caused by Tramway Earth Returns.—At the meeting of the Elektrotechnischer Verein of Berlin a few days ago, at which the Secretary of State, Herr von Stephan, acted as chairman, an important statement was made by Dr. Frölich, on behalf of Messrs. Siemens and Halske, with regard to the disturbance likely to be caused to the Reichsanstalt by the use of the earth return on the proposed Berlin-Charlottenburg electric tramway. As will be remembered, Prof. Kohlrausch, at a former meeting of the Verein, objected to the use of the earth return on the line in question on the ground that stray currents caused an enormous disturbance of the delicate measuring and testing instruments at the Reichsanstalt (see *The Electrician* of June 21st last, Vol. XXXV., p. 248). He also pointed out the way in which the Reichsanstalt could be made to withdraw its opposition. Dr. Frölich now states that means appear to have been found to render the earth currents innocuous. These currents, Dr. Frölich argues, are not stray currents, but pass from the rails through the earth to the generator in curves which can be accurately ascertained. Such determinations of the curves have been made in the Siemens laboratory on large models, and latterly on the Dresden electric tramway the accuracy of the method was tested and found trustworthy. A reliable method has, therefore, been found for ascertaining the exact course of the earth return current. It is proposed to connect metal conductors at certain intervals to the rails, and to lay these in the direction of the earth return current curve. Buildings for which special protection is desired are to be encircled by a number of wires, which may be joined to a cable the position of which will be fixed by the direction of the curve, previously determined. The capital cost of compensation circuits of this kind will not, it is said, be very considerable; but, of course, attention must be paid to the action of them, and also frequent tests must be made, as the varying value of the earth return current depends to a certain extent on weather and season, and will thus influence the direction of the curve. These conditions have been met by the adoption of regulating resistances placed in each compensation circuit. It is hoped that in using this system all objections to the use of the earth return in tramway work will be overcome, and disturbances reduced to a minimum.

Carborundum.—In a Paper published in the *School of Mines Quarterly* (Columbia College, U.S.A., No. 16, p. 73-79) Mr. J. A. Mathews gives a description of some works which have been started for the manufacture of carborundum by the aid of electricity. The process is carried on in a furnace, the walls of which are built of vitrified bricks upon a masonry foundation 3ft. wide by 8ft. long. Carbon electrodes 1ft. long by 2in. in diameter, and which may be as many as nine in number, project from the end walls. The carbons of one end are separated from those of the other by a distance of 5ft. to 5½ft. For a fuller description of the furnace we must refer our readers to English patent 17,911, 1892. The charge, which is a mixture of four parts of coke ground to an impalpable powder, with five of good glass sand, and one or two of salt, fills the furnace, except the region between the electrodes, where is laid a core of loose carbon. Electrolytic action is prevented by the use of an alternating current. The current is passed for about eight hours, and the furnace cooled, when a hollow cylindrical mass of carbon crystals, 4in. or 5in. thick, is found surrounding the carbon core, whilst a thin layer of soft greasy-feeling graphite separates the carbon from the carborundum, beyond which is a thin layer of light-coloured, amorphous carborundum, and beyond this again a portion of the charge, which is unaltered, with the exception that the salt has been fused. The raw product is crushed in a pan by hard steel rollers, boiled for a week in dilute sulphuric acid to remove iron and sodium silicate, sifted, and the finest powders graded by the length of time they are found to float upon water when stirred up therewith. The carborundum is now fit for use as a polishing powder, or can be formed into grindstones. Carborundum crystallises in the hexagonal system, and the crystals vary in size from a fraction of a millimetre to 3mm. in their largest dimensions. They have a specific gravity of 3 12, and the colour, which is probably due to the small percentage of impurities—viz, Fe_2O_3, Al_2O_3, CaO, MgO, &c.—varies from greenish to yellow and sapphire-blue. It has not yet been determined which is the harder, the diamond or carborundum, the brittleness of the crystals of the latter causing a difficulty in ascertaining the point. Carborundum is not suitable for the first rough treatment of the diamond, but it is used successfully in the polishing process. Analysis gives for it the formula SiC, the reaction of its formation being represented as $SiO_2 + 3C = SiC + 2CO$. It is unaltered by any of the ordinary mineral acids, and is unaffected by any heat short of that of the electric arc. For a further description of its chemical properties, and of the methods employed in the analysis of carborundum, we must refer our readers to the original memoir. The author states that carborundum appears to be suitable for most abrasive purposes, and there is especially a large application for it in grinding and cutting glass, the same amount of material doing much more work and acting more quickly than any abrasive now used. Wheels made from carborundum are used in grinding the necks of the Westinghouse incandescent electric globes and unless the wheels grind from 12 to 15 times as many globes as the emery wheels formerly used, they are returned marked "Not good."

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ELECTROMAGNETIC THEORY.—LXXVII.*

BY OLIVER HEAVISIDE.

(*Continued from page 807, Vol. XXXV.*)

§ 303. In the other way of simplifying the general determinantal equation described at the close of § 298, we reduce it to the form (109), which indicates that we have the set of normal systems corresponding to $sl=(n-\frac{1}{2})\pi$, and in addition, the set corresponding to $(Z_0q)^2=R^2$. So (100), the solution for a point charge, is reduced to

$$V_1=\frac{(R\sin+Z_0s\cos)sy\,.\,(R\cos+Z_0s\sin)s(l-x)}{(q^2Z_0^2-R^2)\cos sl}\frac{sQ}{S}, \qquad (138)$$

showing the potential at x on the right of y due to Q initially at y itself. Let $V=U+W$, where U is the regular part, and W the extra part. Then by the expansion theorem (30), we obtain

$$U=\frac{2Q}{Sl}\Sigma\epsilon^{pt}\frac{(R\sin+Z_0s\cos)sy\,.(R\sin+Z_0s\cos)sx}{R^2+(Z_0s)^2}, \qquad (139)$$

subject to $\cos sl=0$. And, by the same process, we find

$$W=-\frac{Q}{S}\Sigma\epsilon^{pt}\frac{q\epsilon^{q(x+y-l)}}{\left(1+\frac{2p}{Z_0}\frac{dZ_0}{dp}\right)\cosh ql}, \qquad (140)$$

ranging over the roots of $R^2=(Z_0q)^2$. The sum of U and W is the expression for the potential at time t on either side of the source.

As an example, take $Z_0=R_0$, a mere resistance. Then there is just one extra q, of value $R/R_0=h$, say. To balance the resistance R_0 at $x=0$, there is a permittance of amount $-S/h$ at $x=l$.

Now, if we put $Q/S=1$, and $t=0$, in $U+W$, it represents u, the appropriate unit impulsive function. It need not be written out, as its form is obvious. Integrating the product of u and $f(y)$ with respect to y therefore expands $f(x)$ in the normal functions in question. In particular, if $f(x)=1$, we obtain the expansion

$$1=-\frac{\epsilon^{hx}(1\epsilon^{-hl})}{\cosh hl}+\frac{2}{l}\Sigma\left(\frac{h}{s}\pm1\right)\frac{(h\sin+s\cos)sx}{h^2+s^2}, \qquad (141)$$

in which the + sign is to be used in the odd terms, and the − in the evens. Introducing the time factors, as usual, shows what the initial uniform state changes to later on.

The expansion (141) may be verified by the conjugate property of the normal systems. Remember that there is one terminal condenser. So, assuming

$$1=A_0\epsilon^{hx}+\Sigma A(h\sin+s\cos)sx, \qquad (142)$$

we must have the identity

$$S\int_0^l\epsilon^{hx}dx+S_1\epsilon^{hl}\times0=A_0\left\{S\int_0^l\epsilon^{2hx}dx+S_1\epsilon^{2hl}\right\}, \qquad (143)$$

which gives A_0, and also

$$S\int wdx+S_1h\sin sl\times0=A\left\{S\int w^2dx+S_1h^2\sin^2sl\right\}, \qquad (144)$$

which finds A. Here w stands for the general normal function in (142). The 0 which occurs stands for the initial potential of the terminal condenser. S_1 is its permittance, $=-S/h$. Carrying out (143), (144), we shall arrive at the coefficients in (141), and verify that expansion.

An interesting modification may be mentioned. Put a real condenser at A, and a negative resistance at B. Say $Z_0=(S_0p)^{-1}$, which makes the one extra q be $h=S/S_0$. Then, instead of the above-used unit impulsive function, we shall find that

$$u=\frac{he^{h(x+y-l)}}{\cosh hl}+\frac{2}{l}\Sigma\frac{(s\sin-h\cos)sx\,.\,(s\sin-h\cos)sy}{h^2+s^2} \qquad (145)$$

is the proper one to use.

§ 304. Returning to the more interesting case in which $Z_0=-Z_1$, treated in § 299, where (115) shows the proper unit impulsive function, let Z_0 be L_0p, indicating an inductance coil without resistance. The determinantal equation of the extras is a cubic, and the assumption of no resistance makes it manageable. Thus, (106) shows that

$$p^3=\frac{R}{SL_0^2}=g^3, \text{ say,} \qquad (146)$$

finds the three extra p's—that is, $p=g$, g_1, and g_2, where

$$g_1=g(-\tfrac{1}{2}+i\sqrt{\tfrac{3}{4}}), \qquad g_2=g(-\tfrac{1}{2}-i\sqrt{\tfrac{3}{4}}).$$

Also, in virtue of (146), we may write R/L_0p for q. So, by (115), the part of the unit impulsive function depending upon the extras is given by

$$\frac{R}{SL_0g}\frac{\epsilon^{Rz/L_0g}}{\text{shin}\frac{Rl}{L_0g}}+(\text{same with } g_1)+(\text{same with } g_2). \qquad (147)$$

The time factors to be introduced later are ϵ^{gt}, ϵ^{g_1t}, ϵ^{g_2t}. The part of u depending on the regulars is given by the first line in (115), omitting the $1/l$ term, however, because there is terminal earth connection.

Of the three terms in (147) only the first increases with the time. The two others unite to make a real function indicating oscillatory subsidence, but it is of a complicated mixed kind, because it depends on two inductances separated by the permittance of the cable. The full development need not be given.

§ 305. The same extra functions are, of course, concerned when the source is an impressed force. For example, let it be e at $x=0$. Equation (59), § 291, shows the V that results. Put $Z_0=-Z_1$ in it. Then

$$V=\frac{\{\sin-(Z_0s/R)\cos\}s(l-x)}{\{1+(Z_0s/R)^2\}\sin sl}e \qquad (148)$$

gives V in terms of e.

Specialise, by making $Z_0=R_0$, a resistance. Then

$$V=h\frac{(h\sin-s\cos)s(l-x)}{(h^2+s^2)\sin sl}e, \qquad (149)$$

where h denotes R/R_0.

Put $s=0$ to get the part independent of the time, and then develop by the expansion theorem (30), as in previous cases. The result is

$$V=e\left(1-\frac{x}{l}-\frac{1}{hl}\right)+\frac{e\epsilon^{h(x-l)}}{\text{shin}\,hl}-\Sigma\frac{2he}{sl}\frac{(h\sin+s\cos)sx}{h^2+s^2}, \qquad (150)$$

without the time factors. That is, it is the initial state, representing $V=0$ everywhere between $x=0$ and l, and at the terminals as well. This is because there is terminal resistance. In the summation, we have $sl=n\pi$.

We may verify the result by the conjugate property. Assume that

$$\frac{e}{hl}-e\left(1-\frac{x}{l}\right)=A_0\epsilon^{hx}+\Sigma A(h\sin+s\cos)sx \qquad (151)$$

Multiply by ϵ^{hx} and integrate along the cable to find A_0. Multiply by $(h\sin+s\cos)sx$ and integrate to find A. The results are as in (150).

I give this case for the sake of a result which will be useful a little later. It is got by differentiating (150) to x. We obtain

$$\frac{\epsilon^{h(l-x)}}{\text{shin}\,hl}=\frac{1}{hl}+2\Sigma\frac{(hl\cos+sl\sin)sx}{(hl)^2+(sl)^2}, \qquad (152)$$

which will be used in another problem.

§ 306. It will be seen from the preceding that the subject of abnormal Fourier series is quite a large one. We find that we require to use series that look like Fourier series, inasmuch as the wave lengths are the same as in real Fourier series, but that the complete set of normal functions includes extra functions of the type ϵ^{hx}, where h is a constant, real or complex, as the case may be, the number of such functions depending upon the terminal conditions. These abnormal series are merely special cases of the general series got previously by leaving Z_0 and Z_1 independent of one another. If any one of the electrical constants involved in these operators, which constants are real and positive in real problems, be made negative, we introduce something abnormal, because there is a reversal of Ohm's law, or of the law of displacement, or of induction, in some part of the electrical system concerned, and, as a

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PHOTOGRAPHS OF THE ELECTRIC ARC.

The accompanying illustrations are the outcome of some photographs of the electric arc taken by Prof. J. Violle, and were exhibited by him at the Easter Exhibition of the Société Française de Physique. Having shown by previous experiments (*Comptes Rendus*, Vol. CXV., p. 1273, and *Journal de Physique*, Vol. II., p. 545, 1893) that the brilliancy of the crater was the same for currents between 10 and 400 amperes, Prof. Violle was anxious to make sure that it was the same with currents of 1,000 and 1,200 amperes. It was found to be rigorously constant. The photographs were taken very quickly with the objective "*fortement diaphragmé*," so that the blacks of the negative were far from saturated, an essential condition for accurate photometric comparisons. The two arcs—one of 1,000 amperes and the other of 10 amperes—were photographed one after the other on the same plate, which was afterwards developed all over in exactly the same manner.

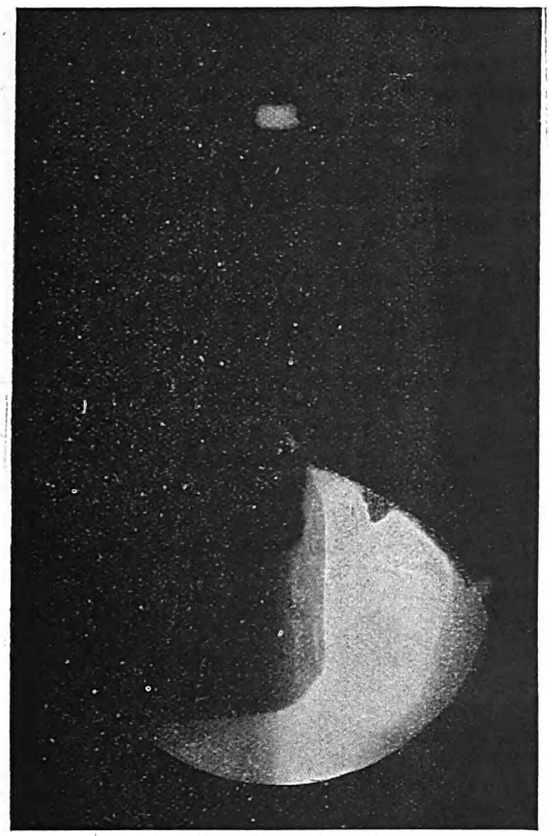

FIG. 1.—White Light, June 21, 1894.
10 amperes, 110 volts.
1,000 amperes, 80 volts.

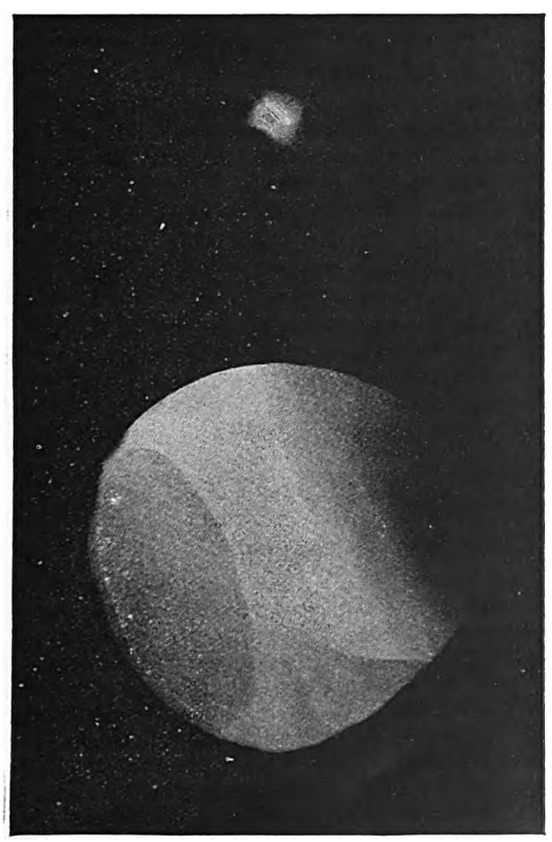

FIG. 2.—White Light, June 23, 1894.
10 amperes, 112 volts
1,000 amperes, 75 volts.

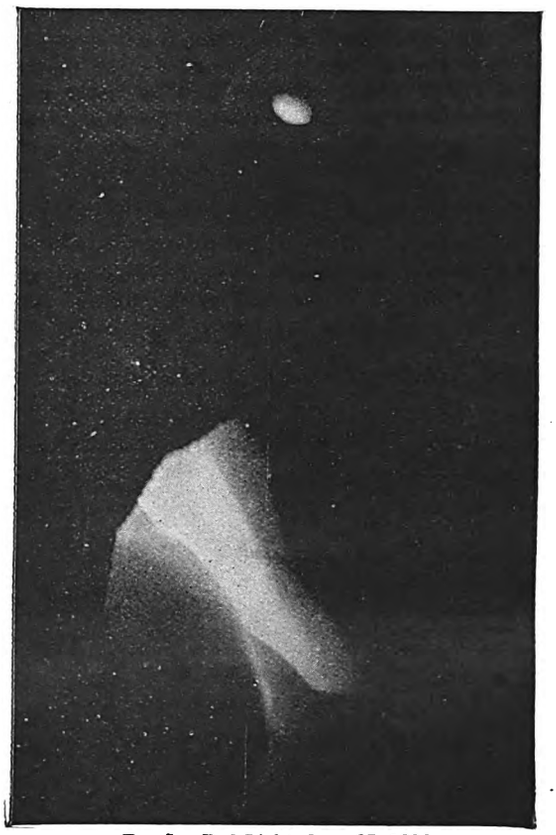

FIG. 3.—Red Light, June 23, 1894.
10 amperes, 115 volts.
1,000 amperes, 75 volts.

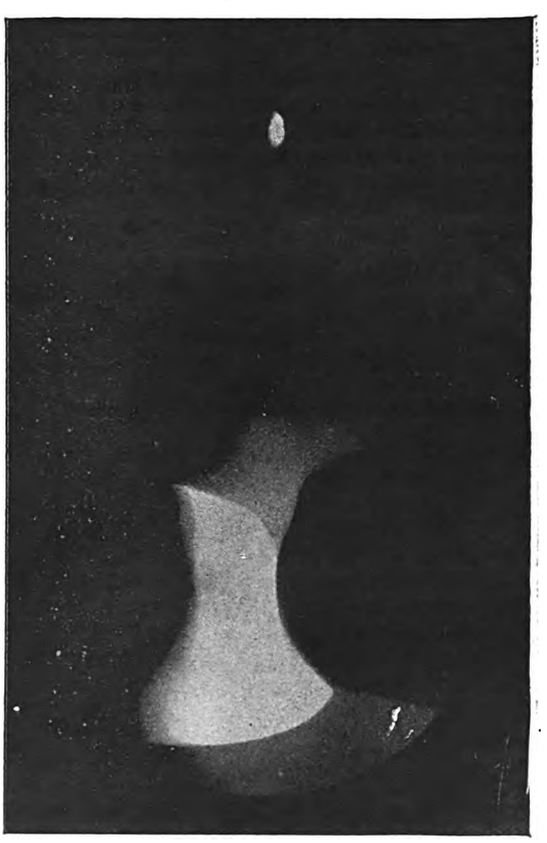

FIG. 4.—Green Light, July 7, 1894.
10 amperes, 110 volts.
1,000 amperes, 75 volts.

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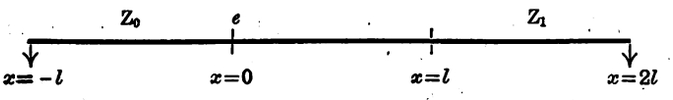
result, time functions, as ϵ^{pt}, occur in which p is positive. Some cases of this kind were considered by me in 1882, and earlier ("Electrical Papers," Vol. I.). The peculiarity of the cases above treated lies in the simplicity produced by reducing the wave lengths of the regular normal functions to be the same as in the original Fourier series. I think I have given sufficient information to enable any competent person to follow up the matter in more detail if it is thought to be desirable. It is obvious that the methods of the professedly rigorous mathematicians are sadly lacking in demonstrativeness as well as in comprehensiveness.

But it would be out of place to elaborate further in this work. I will therefore conclude the present remarks on abnormal series with the consideration of a very singular case indeed. In none of the previous cases did we cause the terminals to be nodes of the regular normal functions, or make $V=0$ terminally in them. In the following we shall do this.

Go back to (59), § 191, and make $Z_0=-Z_1$. This produces (148) above. So far it expresses V due to e at $x=0$ with any terminal Z_0, provided there is its negative at $x=l$.

Next, let
$$Z_0=\frac{R}{s}\tan sl. \tag{153}$$

This says that Z_0 is a cable identical with the one in question, or equivalent thereto, earthed at its end. We have therefore

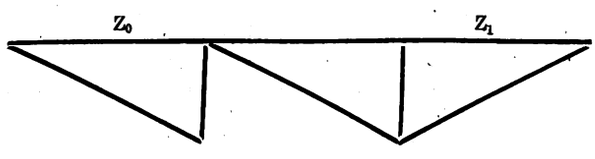


three cables in sequence, two of which are alike, extending from $-l$ to $+l$, with a negative cable added from $x=l$ to $2l$, that is, a cable in which the permittance and resistance are negative, without other change. This arrangement being in equilibrium, e is started and maintained constant. It is of little consequence to follow up the later effects. It is just at the beginning that we require the behaviour, so as to obtain the proper expansion of the initial state. The condition (153) reduces (148) to the very simple result
$$V=-\frac{\sin sx}{\tan sl}e, \tag{154}$$

which makes V permanently zero at $x=0$. This is highly anomalous. Expand (154) by the expansion theorem. The result is apparently
$$V=-\frac{ex}{l}-\Sigma\frac{2e}{sl}\sin sx\,\epsilon^{pt}, \tag{155}$$

where $\sin sl=0$. Now this is incorrect, because the initial state is $-e$, according to (155). There is something missing.

But there is some sense in it. For it makes the final current be $C=e/Rl$. By continuity, this, if existent, should be the current through all three cables. The corresponding state of potential is then as in the figure.



The zero potential at $x=0$ is accounted for. We may corroborate this by calculating the rise of potential in the cable Z_0 due to e, regarding the rest as a mere terminal arrangement. It will be found that the resistance operator of the two cables from $x=0$ to $2l$, reckoned at $x=0$, is zero, which is equivalent to a short circuit, so far as the cable Z_0 is concerned. So e establishes V in the Z_0 cable just as if there were an earth on the other side (the right side) of e.

After this partial explanation return to (154) and (155), where the state of the middle cable is in question. The resistance operator to the right is zero, but then the potential at $x=0$ is zero, so there is compensation. According to (155) a complete normal system of potential would consist of $\sin sx$ from $x=-l$ up to $x=l$, combined with $-\sin sx$ from $x=l$ up to $2l$. But it is easily to be seen that we cannot expand an arbitrary function in terms of these systems alone. For instance, let $V=f(x)$ (any function) from 0 to l, zero from 0 to $-l$, and $V=f(2l-x)$ from l to $2l$. The energy is zero, so the result of expansion by quadratures is zero.

It is certain that (155) is incomplete. And, in fact, we may ask, where are the abnormal functions necessitated by the negativeness of resistance and permittance in Z_1? The answer is to be found by seeing how $\tan sl$ in (154) arose. It represents $\sec sl\times\sin sl$, and $\sec sl=0$ is the equation belonging to the extra functions. But the roots of $\sec sl$, infinite in number, are at infinity. The normal functions to correspond are therefore unmanageable from being ungetatable. Their influence, however, is in full operation. For the failure of (155) proves that the sum of the whole of the missing functions required to make it represent the initial state truly is e. That is, we should have, initially,
$$0=e-\frac{x}{l}e-\Sigma\frac{2e}{sl}\sin sx, \tag{156}$$

where the first e is the sum of the missing terms.

§ 307. But to make this conclusion plainer, we should bring the roots at infinity to a measurable distance (like the abolition of that fraud 4π which has been purblindly inserted in the electrical equations), so that we can manipulate them. Take, then,
$$Z_0=\frac{R_0}{s_0}\tan s_0l_0, \tag{157}$$

instead of (153). The cable Z_0 is no longer an exact or equivalent copy of the middle one. Then (148) makes
$$V=\frac{(\sin-c^{-1}\tan s_0l_0\cos)s(l-x)}{(1+c^{-2}\tan^2s_0l_0)\sin sl}e, \tag{158}$$

instead of (154). Here $c=Rs_0/R_0s$ or $(RS_0/R_0S)^{\frac{1}{2}}$. The abnormal roots are now finite.

Let $V=U+W$, U being the part of V depending upon $\sin sl=0$, and W the extra part. Develop U in the usual way by the expansion theorem. We get (with $t=0$)
$$U=e\left(1-\frac{x}{l}-\frac{1}{cf}\right)-\Sigma\frac{\sin sx+c^{-1}\tan f^{-1}sl\cos sx}{\frac{1}{2}sl(1+c^{-2}\tan^2f^{-1}sl)}, \tag{159}$$

where f is the constant $(RSl^2/R_0S_0l_0^2)^{\frac{1}{2}}$. This U evidently reduces to the right member of (154) when $c=1, f=1$.

The development of W requires more care. The extra roots are given by
$$\tan^2s_0l_0=-c^2; \quad \text{or} \quad \text{than}^2q_0l_0=c^2. \tag{160}$$

Whether we take c or $-c$ to be than q_0l_0 is indifferent, provided we work consistently. Say, then, that
$$\text{than}\,q_0l_0=c, \tag{161}$$

or, which is the same,
$$\epsilon^{2q_0l_0}=\frac{1+c}{1-c}=g^2, \text{ say,} \tag{162}$$

which makes
$$q_0l_0=\lambda+in\pi, \quad \text{if} \quad \lambda=\log g, \tag{163}$$

provided c is less than 1. But if c is >1, then
$$q_0l_0=\lambda+i(n-\tfrac{1}{2})\pi \tag{164}$$

instead, where λ is the same real constant. The form assumed by W when expanded is, therefore, quite different in the two cases. At the point $c=1$ there is a jump, and special care is required.

Let us use (167), with $c<1$. Then
$$p\frac{d}{dp}\tan^2s_0l_0=-s_0l_0\tan s_0l_0\,.\,(1+\tan^2s_0l_0)$$
$$=-q_0l_0c(1-c^2). \tag{165}$$

The application of the expansion theorem to (158), so far as the extras are concerned, therefore makes
$$W=\Sigma\frac{2ce\epsilon^{qx}}{q_0l_0(1-c^2)(\epsilon^{2ql}-1)}. \tag{166}$$

In this, the relation between q and q_0 is $ql=fq_0l_0$, and in (163) n has to receive all integral values, positive and negative, including zero. The nth term of (165) pairs with the $-n$th to make a real function. But, owing to the exponential function in the denominator of (166), the resultant takes a

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rather complicated form, which need not be given. It is sufficient for our purpose to see that if f is an integer, the denominator simplifies. We then get

$$W = \frac{2ce}{1-c^2}\frac{1}{g^{2f}-1}\Sigma\frac{\epsilon^{qx}}{q_0 l_0}; \qquad (167)$$

that is, by (163),

$$W = \frac{2ce}{1-c^2}\frac{\epsilon^{\lambda fx/l}}{g^{2f}-1}\left\{\frac{1}{\lambda}+2\Sigma\frac{(\lambda\cos+n\pi\sin)n\pi fx/l}{\lambda^2+(n\pi)^2}\right\}, \qquad (168)$$

where the summation is with respect to n, which has all positive integral values from 1 to ∞.

Comparing the last equation with (156), we see that hl becomes λ and x becomes fx. The quantity in the big brackets in (168) is therefore

$$\frac{\epsilon^{\lambda(1-xf/l)}}{\text{shin}\,\lambda}, \quad \text{or} \quad \frac{1+c}{c}\epsilon^{-\lambda xf/l}, \qquad (169)$$

by (163). This reduces W to

$$W = \frac{2e}{1-c}\cdot\frac{1}{g^{2f}-1}, \qquad (170)$$

provided f is an integer.

Let it be 1, *i.e.*, $RSl^2 = R_0S_0l_0^2$, then

$$W = \frac{e}{c}. \qquad (171)$$

Finally, $c=1$ makes $W=e$, as was to be proved.

We have proved that in the singular case of identity or equivalence between the terminal cable Z_0 and the middle one, when the extra normal functions apparently go out of existence, by the roots of the determinantal equation becoming infinite, they are nevertheless virtually existent, and must be allowed for in the expansion of the initial state.

In the more general case, in which there is not the equivalence mentioned, no such straining of the expansion theorem is needed. For instance, W in (168) may be tested in other cases in which f is integral, and be found to represent the negative of the U in (159). There is, therefore, no reason to doubt the equivalence of $-U$ with the more general form W in (166).

(To be continued.)

THE ELECTRIC ARC.

BY HERTHA AYRTON.

(Continued from page 748, Vol. XXXV.)

The Resistance Employed to Steady an Arc.

It is now possible to consider the influence on the arc of the E.M.F. of the generator, and of the resistance placed in circuit outside the arc. This may be done in two ways, graphically by means of Fig. 46, the curves in which are a reproduction of those in Fig. 33, with certain additions; and analytically by examining equation (4) (p. 420, *The Electrician*, July 26th) in conjunction with an equation expressing the relation between the E.M.F. of the generator, the P.D. between the ends of the carbons, the outside resistance in circuit, and the current flowing.

Since equation (4) applies only to silent arcs, it will be better to deal first with silent arcs by both methods, the graphical and the analytical, and then to take up the discussion of hissing arcs.

We might consider what would happen when any one of the four possible variables, the E.M.F. of the generator, the outside resistance, the current, or the length of the arc, was kept constant, and the rest varied; but for the present it will be sufficient to take the most important case, that of a generator of constant E.M.F. For this case applies to all mains supplying current at a constant P.D., since current flowing at a constant P.D. between the mains, when there is a certain fixed minimum resistance in the arc circuit, is practically the same thing as current supplied by a generator of constant E.M.F.

The graphical method is, perhaps, the easier to follow, and will therefore be taken first. Let P (Fig. 46) be a point on the axis of P.D. such that its distance from the axis of current represents the E.M.F. in volts of the generator supplying the current, and let P Q be a line parallel to the axis of current, so that the distance of any point on P Q from the axis of current will represent the E.M.F. of the generator, if it is constant for all currents. Then, if R_1 be a point on one of the curves, the distance between R_1 and the axis of current will represent the P.D. in volts used in sending the current through the arc, and R_1 S, the distance between R_1 and P Q, will represent the P.D. employed in sending the current through the outside resistance. Also, since P S represents the current flowing when that outside resistance is in circuit, the ratio of S R_1 to S P, which is tan R_1 P Q, represents this outside resistance.

If, then, with the given generator supplying the current, any line be drawn from P making an angle Q P R with P Q, and cutting the curves at various points, the positions of those points will represent the relation between P.D. and current in arcs all having the same outside resistance in circuit—namely, that represented by the tangent of the angle R P Q. We may, then, for convenience sake, call such lines as P R_1 Y resistance lines.

There are three possible ways of altering the conditions of the arc when the E.M.F. of the generator is kept constant, viz.:—

(1) The external resistance may be kept constant, and the length of the arc varied.

(2) The length of the arc may be kept constant, and the external resistance varied.

(3) Both the external resistance and the length of the arc may be varied together.

In the first case, since everything is constant except the length of the arc, lengthening the arc *must* mean increasing the resistance in the whole circuit, and consequently a diminution of current must follow on it. Similarly, shortening the arc must mean a diminution of the total resistance in circuit, and therefore an increase of current must follow on it.

In the second case, since everything is constant except the external resistance, increasing this must increase the total resistance in circuit, and therefore must diminish the current; while diminishing the external resistance must cause a diminution in the total resistance in circuit, and therefore must cause an increase in the current.

In the third case, the current may be made to vary in any manner that is desired, or to remain constant, by suitable variations of the external resistance and the length of the arc. But the sum of the effects of the variation of each of these must be the same as if each had been varied separately while the other was kept constant, so long as one of the variations does not cause the arc to be extinguished, thus making it impossible for the other to take effect after it.

While the external resistance can really be kept absolutely constant, the length of the arc cannot, for it is quite impossible, either automatically or by hand, to keep the carbons moving towards each other at exactly the same rate at which they burn away. Consequently what is *called* keeping the length of arc constant is really allowing it to become slightly longer than the desired length, and then bringing the carbons together till it is slightly shorter, so that the curve connecting time and length of arc when the length of arc was supposed to be constant, would be a zig-zag, not a straight line.

Similarly, what is called a constant current is not really constant, for it is impossible to lengthen or shorten the arc, and at the same time alter the resistance by exactly the right amount to keep the current constant. Hence there is a continual increase and decrease of current above and below the supposed constant value. Nevertheless it is possible to keep both length of arc and current constant within certain limits, which may be made very narrow by careful experimenting.

If we follow one of the resistance lines, P R_1 Y for instance, we shall see what happens when the external resistance is kept constant, and the length of the arc varied.

The first thing that strikes one about this line is that the curves for silent arcs above a certain length—viz., 6mm.—are not cut by it at all; that the curve for this length is touched by the line, while those for shorter lengths of arc are cut by it in two points, or would be cut in two points, if hissing did not intervene and terminate the curve. The two points at which

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the line P R_1 Y cuts each of the curves for lengths of arc less than 6mm. are closer together the nearer the length of the arc is to 6mm., and we may consider that it really cuts the 6mm. curve at two points which are coincident. The fact of its not cutting the curves for longer arcs at all shows that no arc of greater length than 6mm. can be maintained by a generator with the given constant E.M.F. when a resistance represented by tan R_1 P Q is in circuit; in other words, 6mm. is the maximum length of arc that can be maintained under the given conditions of generator and external resistance.

The fact of the resistance lines cutting each of the curves that they meet at two points makes it appear as if, with a generator of constant E.M.F., and a constant resistance in circuit external to the arc, two widely different currents might be sent through two arcs of the same length. That is, apparently, under two precisely similar sets of conditions, two entirely different things may happen. This is, of course, absurd. Either the conditions cannot be precisely similar, or if they are, the two different currents cannot permanently flow. By tracing the course of events from the moment the arc is struck it is possible to find out which of these two hypotheses is justified by facts.

We know from experience that immediately after striking the arc, in the ordinary way, the current flowing is comparatively large, since the length of the arc is very small, and that if we lengthen the arc without altering the resistance in circuit, we diminish the current. Hence it is evident that if we want to follow the course of events after striking the arc, we must follow the line P R_1 Y from right to left, because in going from right to left it cuts the curve for each successive length of arc in points which show that the current diminishes as the length of the arc increases. For instance, following P R_1 Y (which corresponds with an E.M.F. of 68·88 volts and a resistance of 1·05 ohms) from right to left, we see that when the arc is 4mm. in length the current is about 18 amperes, when it is 5mm. the current is about 14 amperes, and when it is 6mm. the current is a little over 8 amperes. The right-hand points of intersection of the resistance lines with the curves are, then, those we are accustomed to find after striking an arc, and we know, therefore, that they are possible. Can the left-hand points also be obtained when the E.M.F. of the generator and the outside resistance are the same as for the right-hand points? is the question now to be answered.

In going from right to left along the line P R_1 Y, everything is perfectly easy till the arc is 6mm. in length, that is, till the resistance line is a tangent to the curve connecting P.D. and current. When this point is reached, however, trouble arises, for, since 6mm. has been shown to be the maximum length of arc that it is possible to maintain with the given resistance in circuit, and since the tendency of the arc is to lengthen, unless the carbons are brought nearer together at the very moment they have become 6mm. apart, the arc will be extinguished.

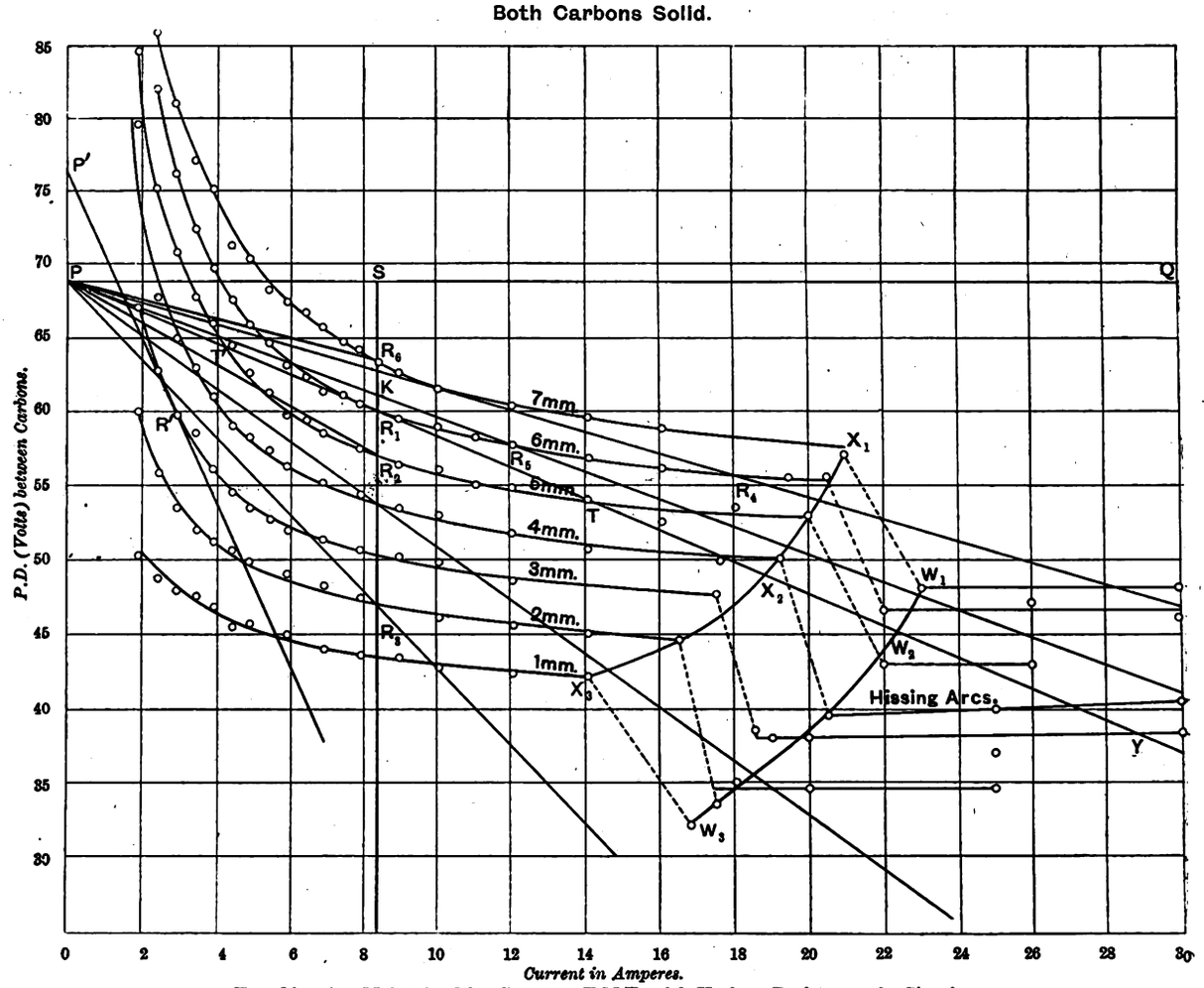

FIG. 46.—Arc Maintained by Constant E.M.F. with Various Resistances in Circuit.

It would, of course, be very difficult, if not impossible, to bring the carbons nearer together at the precise moment when their distance apart was 6mm., but supposing that done, the question arises, which course would the point of intersection of the resistance line and the curve for the shorter arc take; would it move to the right or to the left, should we get a right-hand or a left-hand point of intersection between the resistance line and the curve; or, in other words, would the current increase or diminish? There is not much difficulty in answering that question. It has already been pointed out that, if everything else remains unchanged, shortening the arc can have only one result: it must lessen the total resistance in circuit, and therefore lead to an increase of current.

Hence the point R_1 will move to the *right* when the arc is shortened, and it is thus evident that it is not possible to obtain a left-hand point of intersection between the resistance line and the curve by keeping the external resistance constant and varying the length of the arc.

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It still might be possible, however, to get to a left-hand point of intersection by varying the external resistance and keeping the arc at a constant length. Let us see. We may suppose that the arc has been struck, that its length has been increased from zero to 6mm., and that a silent arc is being maintained with a current of about 20 amperes flowing. If the length of the arc be now kept constant the resistance will have to be increased, in order that we may pass along the curve for a silent arc of 6mm. As the resistance is increased the current will diminish, and the points of intersection between the resistance lines and the curve will be right-hand points, such as R_4 and R_5, till the resistance is represented by tan $R_1 P Q$, and the resistance line is a tangent to the curve.

When that moment is reached the resistance has of course gained its maximum value for a 6mm. arc, for if the angle $R_1 P Q$ were still further increased, the line $R_1 P$ would not meet the 6mm. curve at all. Hence, at this point, the arc could no longer be allowed to become even slightly longer than 6mm. before shortening it, as had hitherto been done, for it would go out directly its length exceeded 6mm.

Thus, the resistance must be diminished the moment the arc is 6mm. long, and the question again arises, Which way would the point R_1 go—to the right or the left? Would the current increase or diminish when the external resistance was diminished? This question is readily answered. We know that diminishing the resistance, and leaving all else unchanged, can only cause a diminution in the total resistance in circuit, and hence an *increase* of current, which will give us over again points on the curve to the *right* of R_1. It is, therefore, impossible to obtain the left-hand points of intersection between the resistance lines and the curves by varying the external resistance and keeping the length of the arc constant.

It remains only now to see if these points can be obtained by varying both the external resistance and the length of the arc at the same moment, and this seems the most plausible method of all. It seems so possible, when the resistance line is just about to become a tangent to the curve, to suddenly diminish the resistance and lengthen the arc at the same moment, so as to pass quickly through the critical point, and arrive safely at a left-hand point of intersection on the other side of it.

That this idea is fallacious is, however, easily proved by referring to three conclusions that have already been shown to be true. With a generator of constant E.M.F. to supply the current—

(1) Changing both the length of the arc and the resistance together can only have the same effect as changing each separately in quick succession, if the order of change be such that one does not extinguish the arc before the other can take effect.

(2) Changing the length of the arc alone can give only right-hand points of intersection between the resistance lines and the curves.

(3) Changing the resistance alone can give only right-hand points of intersection between the resistance lines and the curves.

From these three facts it follows that it is impossible to obtain left-hand points of intersection between the resistance lines and the curves by altering the external resistance and the length of the arc simultaneously, and it follows that there is no possible way of varying the conditions of the arc in such a manner as to obtain left-hand points of intersection between the resistance lines and the curves connecting P.D. and current.

Hence no points can be obtained on the curves connecting P.D. and current farther to the left than those which form the points of contact between the curves and the tangents drawn to the curves from that point on the axis of P.D. which indicates the E.M.F. of the generator.

The question arises, then, How can these left-hand points be obtained at all; how *were* they obtained? They were obtained as *right-hand points*, by using a generator with a much larger E.M.F. than that indicated by the position of P. It is, of course, obvious that all the points on the curves that are higher up than the line P Q must have been obtained with a generator of larger E.M.F. than that indicated by P; but what this investigation shows is that some of the points that are much lower down in the figure than the line P Q must also have had a generator of higher E.M.F. to produce them. The point for 2 amperes, for instance, on the 2mm. curve, although corresponding with a P.D. of only 58·5 volts, must have been found with a larger E.M.F. than 69 volts, which is indicated by the position of P, for the tangent from P to the 2mm. curve touches the curve at a point indicating a current of between 2 and 3 amperes.

On referring to Fig. 46, it is seen that a left-hand point of intersection of a resistance line and a curve—for example, the left-hand point T', where the resistance line $R_1 P$ meets the 5mm. curve—has the following property: If the E.M.F. of the generator be kept constant, and also the length of the arc, an *increase* of the resistance of the circuit corresponds with an *increase* of the current. Now, this is exactly the condition of the unstable solution that is obtained when a series dynamo, running at fixed speed, is in series with a set of accumulators of fixed E.M.F., the total resistance in circuit being also fixed.

For in such a case, as Dr. J. Hopkinson showed some years ago, there are three distinct values of the current possible, two of these corresponding with the dynamo charging the cells, while the third, which is very large and is negative, is produced when the magnetisation of the dynamo has been reversed, and the dynamo is helping the cells to discharge. Now, the smaller of the two positive charging currents is *unstable*, for it *increases* in value with an *increase* of the resistance in circuit, so that on the slightest change in the speed of the dynamo, or in the resistance in circuit, this unstable current is suddenly changed into the larger charging current, or into the very much larger discharging current.

Further, just as I have shown that a left-hand point in Fig. 46 may, for the same current and length of arc, be changed into a right-hand one by increasing the E.M.F. of the generator and the resistance in circuit, so it may be shown that Dr. Hopkinson's unstable point may, for the same current and the same set of accumulators, be changed into a stable solution by raising the speed of the series dynamo and increasing the resistance in circuit.

The impossibility of obtaining small currents without having a comparatively large E.M.F. in the generator and a large external resistance, explains a very puzzling circumstance that occurred in carrying out the experiments of which the curves in Fig. 46 are the result—one which many other experimenters must have noticed before me.

There were two dynamos at the Central Technical College, either of which it was convenient for me to use; one of these produced about 120 volts, and the other about 150 volts on open circuit. The first ran much more steadily than the second, which was driven by a single-cylinder engine; the former was, therefore, much better to employ in a general way; when, however, it was used for small currents and long arcs, the arc behaved in the most tricky manner, going out again and again for no apparent cause.

The reason of this is now obvious. The curves for long arcs are so nearly vertical in the parts for small currents, that the tangents to those curves at any of the points indicating small currents are very nearly parallel to the axis of P.D., and therefore intersect it very high up. It is this point of intersection, however, that determines the smallest E.M.F. that it is possible to have in the generator, and the smallest resistance that it is possible to have in the circuit, in order that a given current shall flow through a given length of arc. Thus, although, for the smallest current and longest arc I used, a P.D. of only about 86 volts was required for the arc itself, yet an E.M.F. of considerably over 120 volts was needed in the generator to enable the arc to be maintained at all with the given small current flowing. The remainder of this large E.M.F. had to be wasted in sending the current through the large resistance that it was absolutely necessary to have in circuit.

On page 401 of *The Electrician* for February 1st I showed that the resistance added to an arc lamp on a constant-pressure circuit fulfilled two distinct functions. The one, which was already well known, was to prevent an enormous current flowing when the arc was first struck, the second, which I do not think had been previously pointed out, was to render it possible for a solenoid placed in series with the arc to regulate its length. We now see, however, that *this resistance fulfils a third and entirely different function, for without some resistance being placed in the circuit external to the arc it is impossible to maintain a silent arc at all.*

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Hence the resistance placed in series with an arc lamp "to steady the arc," as it is commonly said, fulfils the all-important function of making a silent arc possible.

In fact, an arc possesses this very curious property, hitherto unpublished, and indeed not thoroughly realised by myself until this summer, viz.: that, although a certain current of, say, A amperes flowing steadily through an arc of, say, l millimetres in length corresponds with a P.D. of, say, V volts between the carbons, the mere maintenance of this very P.D. of V volts between the very same carbons with the very same arc, of length l millimetres, is not a sufficient condition to ensure that the current of A amperes shall continue to flow.

As an example of this peculiarity, I may refer to the difficulty, alluded to on page 472 of *The Electrician* for February 15th, which I met with when experimenting on arcs with constant P.Ds. An examination of Fig. 46 shows that when, for example, a current of 11 amperes is steadily flowing through an arc 5mm. long, formed with solid carbons 11mm. and 9mm. in diameter, the P.D. between them is 55 volts. It might, therefore, be imagined that this current could be sent through such an arc with a dynamo compounded and run at such a speed as to maintain exactly 55 volts between the carbons with no resistance inserted between the dynamo and the carbons. Or it might be thought that this steady current of 11 amperes could be sent through this arc by means of, say, 29 accumulators when such a small resistance was inserted in the circuit that, with a current of 11 amperes, the accumulators maintained a P.D. of 55 volts between the carbons.

But when I tried this, and similar experiments of keeping the P.D. between the carbons constant, the arc always either went out, or the magnetic cut-out, set to open at 30 amperes, broke the circuit. The explanation of this is now clear, for what I was really endeavouring to obtain was a silent arc with a fairly *small* current, and a *small* resistance in circuit external to the arc; in other words, I was trying to obtain the *left*-hand point of intersection between the 5mm. curve and the resistance line, and this, as I have proved in the present communication, is impossible, a fact, however, which I did not realise ten months ago. Indeed, with a set of accumulators having an E.M.F. of about 58 volts and a small resistance in circuit, the only current that could flow steadily through a 5mm. arc between the carbons in question was a very large one far greater than 30 amperes. The value of this current would be known if we could find the intersection of the resistance line with the hissing part of the 5mm. curve at a point far off the figure to the right.

What has not, I think, been hitherto recognised, is the fact that, *in order that a given current may be maintained flowing through a given length of arc, there must be a minimum external resistance in the circuit which is independent of the E.M.F. of the generator.*

For example, whatever be the nature of the generator, the *least* resistance that can be placed in the circuit to send a steady current of 11 amperes through a 5mm. arc is that given by the tangent to the 5mm. curve at the point corresponding with 11 amperes. And on drawing this tangent to the 5mm. curve in Fig. 46, which was obtained, it must be remembered, with *both* carbons solid, we find that it corresponds with a resistance of 0·64 ohm.

This minimum resistance determines the minimum E.M.F. in the generator for each current and length of arc; for example, on continuing the resistance line just referred to for the 11-ampere 5mm. arc we find that it cuts the axis of P.D. at 62 volts. Hence a resistance exceeding 0·64 ohm must necessarily be placed in the circuit, and the E.M.F. employed must exceed 62 volts, although the arc requires a P.D. of only 55 volts. Similarly, although we see from Fig. 46 that a 12-ampere 3mm. arc requires a P.D. of only a little less than 49 volts, the preceding reasoning tells us that, with the solid carbons used, two such arcs could not be run in series off the ordinary constant-pressure 100-volt electric lighting mains, even if the supply pressure were kept absolutely constant at 100 volts. Or again, two 10-ampere 4mm. arcs could not be run in series off 110 volts constant-pressure mains, although each arc requires less than 53 volts with the solid carbons I used.

A resistance exceeding a certain minimum must in all cases be placed in the circuit to render it possible for the required current to flow, and this minimum resistance was so great for an arc of 7mm. and current of 2·5 amperes with the solid carbons I used that it made the minimum E.M.F. required more than half as large again as the P.D. used in sending the current through the arc itself, for I have calculated that the minimum E.M.F. was about 139 volts, while the P.D. needed by the arc was only 86 volts, as has been mentioned.

It may be seen from Fig. 46 that the compulsory minimum resistance outside the arc is greater—

(1) the greater the length of the arc,
(2) the smaller the current.

But the apparent resistance of the arc also increases with the length of the arc, and is greater the smaller the current, so that we arrive at this very curious fact: *When a silent arc is being maintained the smallest resistance that it is possible to have in the circuit external to the arc is greater the greater the apparent resistance of the arc.*

(To be continued.)

STREET LIGHTING BY ARC LAMPS.*

BY ANDRE BLONDEL.

(Continued from page 15.)

We ought not, then, to seek to make the illumination produced by a source, uniform, excepting on the condition that we leave a certain minimum quantity of superabundant light at the foot of the lanterns. We may consider it as necessary at these points to obtain an illumination of 10 lux, which permits reading easily, and we should give up the idea of uniform illumination unless we can give this relatively high illumination everywhere. Should the production of light be cheap enough for one to realise mean illuminations of 8 to 10 lux, one might seek for uniform illumination, but still it is necessary to remark that this uniformity should not be applied but to the resultant illumination of many lanterns and not necessarily to the individual illumination of each of them. It is to be feared, besides, that inconveniences will present themselves from the point of view of optical illusions that may be produced. Let us suppose, for instance, that the source has the form of a uniformly illuminated luminous sphere, which is approximately the case with diffusing globes, the luminous intensity produced in each direction being equal to the product of the apparent surface by its intrinsic brillancy, or following the same law of augmentation as I—that is to say, proportionally to $\cos^3 a$. We should then have sources of light which would appear more brilliant at a distance than close to.[21] This fact would completely upset the public, who would no longer be able to appreciate distances or understand the enfeeblement of the brilliancy of the globes when looked at closely.[22] Besides, if the illumination of the road is uniform—that is to say, I $\cos^3 a$ constant—the vertical illumination of cabs and passengers would increase proportionately to $\tan a$—that is to say, proportionately to the distance; which would produce a most strange effect. For all these reasons I believe that the desideratum of individual uniform horizontal illumination is perhaps Utopian, and, at any rate, the moment has not yet come to seek to realise it. In the present circumstances the most that we may demand in this way from the law of the distribution of each source is uniformity of the vertical illumination produced outside a cone formed by the rays at 45deg., while keeping to the interior of this cone the more or less superabundant light. Such a law of distribution is represented by curve II. of Fig. 16, which has for equation $I_\alpha \cos^2 a \sin a = \text{constant}$, from the angle of 45deg. Under these conditions we can be sure that a passenger, or an object that moves along a line joining two lanterns, will remain illuminated in

* From *Le Génie Civil.* Translated by Mr. John Heaketh.

[21] This is evident if the image on the retina is not a point, for the illumination is then proportional to the brilliancy of the object. When the image on the retina is reduced so far as to become a point, the quantity of light received by it varies proportionally to I_α, and in the inverse ratio of the distance from the eye to the object—that is to say, proportionally to $\cos^2 a$. As we suppose $I_\alpha \cos^3 a$ constant, we see that the apparent brilliancy increases proportionally to $\frac{1}{\cos a}$.

[22] It must not, however, be forgotten that the public, to appreciate any system of lighting, much more readily look at the globe than the ground, and believe all is perfect when the luminous source appears blinding. Although I mention this singular fashion of judging the things which I shall criticise later, it is not in the least necessary to take account of it in practice.

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the most constantly uniform manner possible. It is very interesting to compare on this figure the three photometric curves corresponding to the uniformity of the one or the other of three illuminations. These three curves have been drawn with the assistance of the results of the calculations shown in Table IV., obtained on the supposition that it was desired to realise a light of 100 pyrs in the direction of the vertical. We thus see that for the vertical illumination a much less rapid increase of the intensity with the obliquity of the rays is involved than in the case of the two others.

TABLE IV.—*Table of Photometric Curves obtaining Uniform Illumination on a Horizontal Plane.*

Angular direction. a	I. Normal illumination. $Ia = \frac{100}{\cos^2 a}$	II. Vertical illumination. $Ia = \frac{100}{\cos^2 a \sin a}$	III. Horizontal illumination. $Ia = \frac{100}{\cos^3 a}$
0	100 pyrs	∞	100 pyrs
7°30′	101	730 pyrs	102
15°	106	113	110
22°30′	107	306	126
30°	133	266	153
37°30′	158	260	199
45°	200	282	282
52°30′	269	340	443
60°	400	461	800
67°30′	683	739	1,862
71°34′	1,002	1,057	3,174
75°	1,494	1,542	6,069
80°	3,322	3,378	19,200
90°	∞	∞	∞

We must not forget, besides, that beyond a certain distance we should in all cases renounce uniformity of illumination, so as to escape losing too much light by absorption of the rays sent to a distance. On the other hand, we cannot limit, for instance, by the aid of reflectors the rays in a direction below that of the horizon, for if we did this the lanterns of a street or a boulevard would not be visible, except at a very short distance, while it is absolutely necessary that the greatest number possible should be seen simultaneously, so as to obtain a good effect of perspective; but as it is not necessary that they should play an appreciable lighting part, we may reduce to a very small value the intensity of the rays sent towards the horizon. The best theoretical curve of the individual distribution in a word will take the form OABCD (Fig. 16) which blends with the curve of equal vertical illumination in the middle, and with a circle at the angle of 45, where the illumination is superabundant. None of the sources of light actually in use agree, even roughly, with this desideratum. It cannot even be realised, excepting by optical devices, to which I shall refer later. I shall examine, to begin with, the indirect methods of *uniformisation* which may admit of the bad distribution of actual source being palliated—that is to say, choice of a favourable height and a convenient distribution of the lamps; and we shall see later how we may bring into use the rays sent above the horizon, of which we do not at this moment take account.

HEIGHTS OF LAMPS.

The sources of light actually employed, and in particular the electric arc with or without globes, all present in their polar curves a critical direction corresponding to a relative maximum illumination.[23] The consequence is that we make the illumination produced by each lantern uniform at the same time that we increase its minimum value by augmenting the height. The clause of a contract which imposes a certain minimum horizontal illumination leads, then, to the employment of greater elevations if we consider it alone, more especially in the case where arcs under clear globes are employed. It is to the too exclusive consideration of this minimum, without doubt, as much as to the desire to shun dazzling effects, to which it is necessary to attribute the infatuation that people had, in the early days of electric lighting, for very high lanterns. These have more especially been in favour in the United States,[24] where they have attained a height of 30 metres and more. In Europe they have been used but little; I only, for instance, think at Milan. In France we have never regarded this system with favour, and though in 1888 M. Eiffel proposed to illuminate the capital by great lighthouses placed on towers 300 metres high, conveniently spread about, his idea has not been taken seriously by competent authorities. The only example we have had of high lanterns in Paris—in La Place du Carrousel—was sufficient to make both the public and the engineers forsake them. The great pillars—25 metres in height—which are fixed on this square are, happily, very soon to disappear. In short, the uniformity of horizontal illumination is not attained under these conditions, excepting at the price of the following inconveniences: Firstly, a part only of the flux emitted below the lamp falls on the roadway and the bottoms of the houses; the rest is sent too high to serve for anything else but to draw shadows on the surrounding buildings. Secondly, the least haze or mist absorbs an enormous number of rays before they reach the ground. This last reason has been sufficient to force the Belgian State railways to lower the porches of the railway station of Schaerbeck (Nord), of which the lamps became useless in case of fog.[25] Thirdly, even in the absence of mist and in streets without trees and straight, where one can consider as useful all the lower hemispherical flux, the total surface illuminated increases with the height, and in consequence the mean illumination, calculated in the manner indicated before, diminishes. It is the same *à fortiori* for the maximum illumination. We tend, then, towards uniformity, but the uniformity of mediocrity. We may show this more clearly by a consideration of Figs. 18 and 19. These represent the values of the horizontal illumination on the

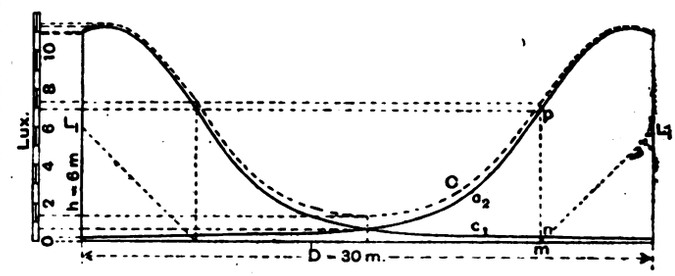

FIG. 18.—Two 10-ampere continuous-current arcs, under opal globes placed 6 metres high.

ground between two equal lights, of which the law of distribution is known. Fig. 18 applies to arc lamps of 10 amperes under opaline globes placed at a height of 6 metres, and Fig. 19 to the same lanterns placed at double that height (12 metres). The distance between them remaining the same, D equals 30 metres. Fourthly, the reduction of the useful effect is far more important still in that which concerns the vertical illumination, for the more one raises the lanterns the more they tend to badly illuminate the promenaders. It is to this effect that we must attribute the greater part of the bad apparent illumination realised on the Place du Carrousel, and this itself will be sufficient to proscribe high pillars They are not useful except for the lighting of yards, railways, or of docks, where it is necessary to escape the effects of contrasts. I have, however, sometimes praised the employment of very high lanterns on certain public places,[26] and this disposition may be justified in the case where it is a narrow place completely

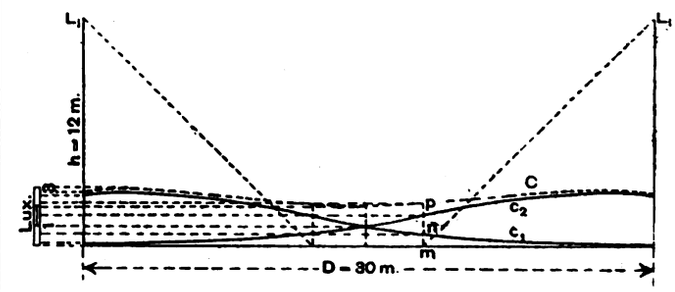

FIG. 19.—Two 10-ampere continuous-current arcs under opal globes, placed 12 metres high.

FIGS. 18 and 19.—Comparison between the illumination obtained between two lamps when their height varies, the distance between remaining constant. C_1, C_2 = Curves of horizontal illumination produced by each lamp individually. C = Curve of resultant illumination.

surrounded by high houses.[27] The light which strikes the façades is not then altogether lost, but to a great extent reflected. It is no longer the same where the space is very large and incompletely closed. The example of the Carrousel which I have quoted proves this sufficiently. I also believe that in this case there was a

[23] We shall see examples of this in curves to be given later.

[24] Notably at Detroit, Alleghany, Cleveland, Los Angeles, &c., where the "pillars" are veritable towers, carrying many lamps, from whence is derived the expression "tower-lighting."

[25] Weissenbruch, *loc. cit.*

[26] M. Palaz notably, gives 10 to 20 metres as heights for arcs of 10 to 18 amperes.

[27] This case arose at Brussels, where M. Wybauw was able to very satisfactorily light La Grande Place by two lanterns suspended at 15 metres high.

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TABLE V.—*Data of some Street Arc Lighting Plants in Europe and America.*

Cities.	Kind of current.	Globe.	Current in amperes.	Mean width of streets in metres.	Mean distance from post to post in metres.	Mean height of lamps in metres.	Total number of arcs.
Paris, Grand Boulevards	Continuous	Opaline	10	35	40 to 60	5·95	313
„ Clichy Avenue	„	„	10	25	50	4·45 to 4·95	
Toulouse	„	„	10	14 to 15	50 to 70	7	222
St. Petersburg, Newski Prospect	„	Roughened	11 and 12	50 to 60	40 to 70	10·50	80
Milan	„	Opaline	4·5, 6, 10, 15 and 20	8 to 30	40 to 60	9	341
Hamburg, Jungferstieg	„	„	8	16	25 to 30	8	68
Berlin, Unter-den-Linden	„	„	14-15	16	41 (2 rows) 60 (1 row)	8	185
„ Leipzigerstrasse	„	„	14-15	16	60 (1 row)	8	
Berne	„	„	12	15 to 20	60 to 80	9	42
Munich	„	„	5 and 10	15 to 25	50	8 and 10	780
London, City	„	Small opal globe in clear glass lantern	10	...	...	6·50	479 (City 340)
Londonderry	„	Opaline	10	15 to 25	70 to 100	7·60	170
Glasgow	„	„	10	...	40 to 55	5·20	101
New York, avenues	„	Clear glass	10 to 11	30	78	6·10	2,621
„ cross streets	„	„	10 to 11	18	90		
Chicago	„	„	9·6 to 10	20, 22·5, 24·5, 30	60 to 100	...	1,486
Atlanta	„	„	10	9 to 30	23 to 30	7·60 to 12	416
Le Havre	Alternating	Opaline	12 to 15	30 to 45	70 to 80	4·50, 5·50, 7·50	77
Clermont-Ferraud	„	„	12 and 20	...	35	6	15
Zurich, Quai du Lac	„	„	18	30 to 40	60	7	53
Cologne	„	„	10	7 to 10	45 to 60	7	13
Blackpool	Continuous and rectified	„	10 and 10·5	25	45 to 50	7·6	185
Bristol	Continuous	„	10	15 to 30	40 to 50	6·70	97
	Alternating	„	13			3·65	
Yarmouth	Continuous	„	10	...	...	6·70	60
	Alternating	„	15	...	...		
Portsmouth	Rectified	„	12	...	80	7·60	100

I am particularly indebted for these interesting returns to the goodness of the engineers, Messrs. Monmerqué, Quintin, De Joukovsky, C. Cervi, Vermehren, Kirschner, Rothenbach, Uppenborn, J. Christie, W. Arnot, McCormick, J. P. Barrett, J. Harper, Fevrier, Dalichampt, Irly, J. Hesketh, H. F. Proctor, A. W. Ranken, and E. Price, to whom I wish here to express my sincere thanks.

reason for lowering the lanterns, without, however, descending below 8 or 10 metres and getting off by losing in uniformity. Besides, as we have seen higher up, the employment of opaline globes favours this. I have been able to see an example of this in the beautiful Newsky Perspective at St. Petersburg, but the height of 10·70 metres adopted on this road is the maximum admissible from the æsthetic point of view, and would not be justified on our straight boulevards. We gain equally in employing lower lanterns by a greater facility in up-keep when the lamps are fixed. Thus actually the height of 10 metres is not exceeded in public ways even abroad, as the figures of Table V., taken in Germany, Italy, &c., show. We see that in France we have long since adopted lower heights than the mean—heights which, however, appear good in their effect.[28]

In Paris, on the boulevards, the lanterns are 4·95 metres, or 5·95 metres with very variable distances from 25 to 50 metres. The current is 10 amperes. On the Avenue Clichy, much less lighted, the heights are 4·95 metres to 4·45 metres, with the same current and distances of 50 metres.

With the lamps actually in use—that is to say, with arc lamps in opaline globes—these small heights tend, it is true, to reduce the value of the minimum horizontal illumination. M. H. Maréchal has shown in particular that in the Avenue de Clichy the minimum illumination of the roadway falls from 0·37 lux to 0·18 lux only by the mere substitution of lamp-posts of 4·45 metres for those of 4·95 metres, which result is shown in the diagram of comparative illuminations, Figs. 20 and 21. But this peculiarity does not apply so much to the vertical illumination. We may besides reduce it either by artificially modifying the law of distribution of the rays of the actual lamps by the methods indicated later, or by distributing the lanterns in a more appropriate manner. In any case actual experience seems to establish empirically that it is necessary to confine oneself within the limits of 5 to 10 metres; 6 and 7 metres are the heights most common in France. If at Munich they have been able to adopt the higher limit of 10 metres it is only because the avenues are certainly smaller and not planted with trees, and because they employ movable lamps.

DISTRIBUTION OF LAMPS.

The method of distribution of electric lamps naturally depends on the length, importance, and the traffic on the roads to be lighted. First, if the length is not very considerable, the most advantageous solution, and the best from all points of view, consists in placing the lanterns on the axial line. This is the disposition most generally used to-day. Berlin, Milan, Havre, Toulouse, Nantes, Munich, Cologne, Vienna,[29] &c., and even Paris on part of the great boulevards, furnish beautiful examples of this. If we remember that in the interval between two lanterns the individual illuminations are added together, we see that in general we may adopt for lamp-posts a distance between them at least equal to the width of the street, unless the illumination at n falls below the value allowable upon the footpaths at a and b (Fig 22.). To roughly proportion the power of the lamps to the width of the streets it is sufficient, then, after having been given the maximum height of the lanterns, to choose a strength of current such that the horizontal illumination calculated for the point a from the curve of horizontal illuminations of the arc under its globe, shall attain the fixed minimum value, then to distribute the other lamps at such distances that the same horizontal and vertical illuminations shall be attained or exceeded at the points $n\,n'$. The illumination at $a\,b$ will be then a little higher than the limit. This rule, which is the most rational, can evidently not be followed when the street is too narrow, and when one has to consider the question of expense. For the smaller streets 25 metres may be regarded as a minimum below which we scarcely go as a general rule. Besides, in the case of narrow streets, the diffusion by the frontage plays a very important part, and renders an exact arrangement of the distances between the lanterns useless.

In the case where no refuges exist in the centre of the roadway, and where recourse cannot be had to suspension by chains, we are forced to adopt a solution much inferior to the preceding one, and to arrange the lanterns zig-zag alternately on each footway (Fig. 23). The minimum illumination will then be at a point about the middle of the distance A C, and the distance may be regulated according to the minimum illumination sought to be obtained. The quantity of light distributed remains almost the same as in the preceding case, but it is not so well utilised.

The fronts of the houses send back a part (0·2 to 0·5) of that which they receive; but if we take an avenue which is planted we may, on the contrary, consider as almost altogether lost the light

[28] This choice depends principally upon the way in which the cleaning is done. The use of a ladder naturally limits the height.

[29] A singular arrangement of lamps has been tried at Vienna, in the employment of two lamps hung from the same chain. This solution appears to have little to recommend it from any point of view, and it does not appear to me to be one which will be imitated.

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received by the trees situated in the immediate proximity of the lamps, although it does contribute in a certain degree, however, to the general effect by making the trees better distinguishable. This distribution has been adopted in a great number of cities in Europe and America—in Paris, in the Avenue de Clichy; in very important streets, such as the Rue Royale in Paris, Unter-den-Linden in Berlin, &c.

In certain cases where an intense illumination is desired we may be brought to unite the two distributions into the *quincunx* form by adding lanterns on the refuges to those on the edges. This is

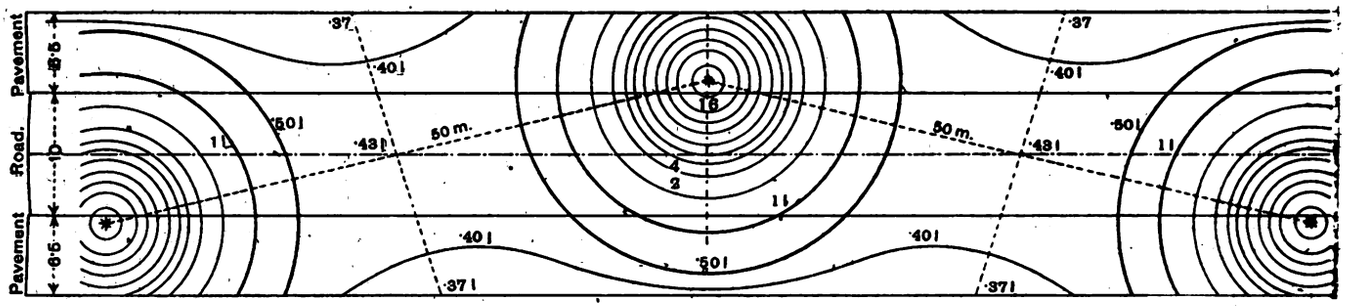

FIG. 20.—Plan of illumination with 10-ampere continuous-current arcs under opal globes, Avenue de Clichy. Height of lamps 4·95 metres. (Figure taken from *L'Eclairage à Paris* by M. H. Maréchal.)

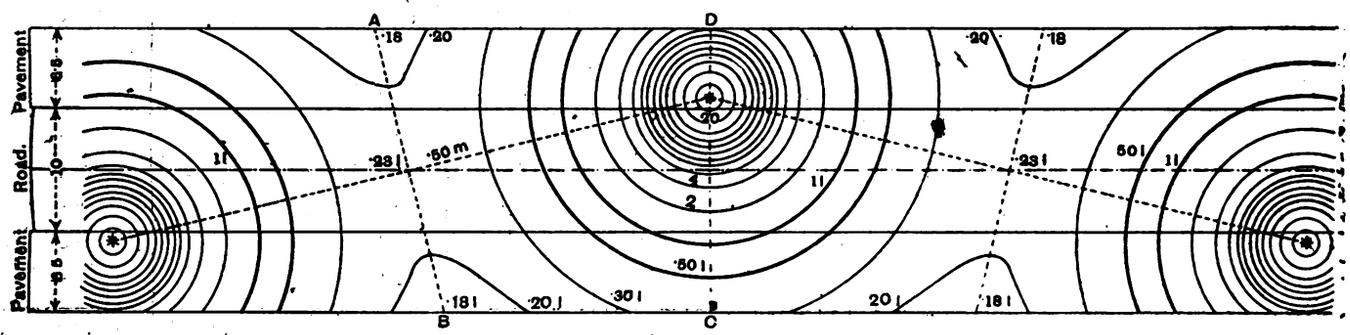

FIG. 21.—Plan of illumination with 10-ampere continuous-current arcs under opal globes, Avenue de Clichy. Height of lamps 4·45 metres. (Figure taken from *L'Eclairage à Paris* by M. H. Maréchal.)

Berlin, in the Leipzigerstrasse; in New York, in all the streets excepting the Fifth-avenue.[30]

In wide streets we can obtain a much better distribution for an equal expense of energy by reducing the current to one-half, and doubling the number of lamps, as is shown in Fig. 24. The triangular arrangement is not to be recommended, except in narrow streets, and when we cannot have recourse to transversal suspension.

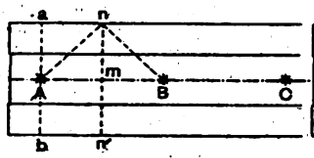

FIG. 22.—Distribution of lamps in straight line in the axis of a street. (Grand Boulevards: Section Edison).

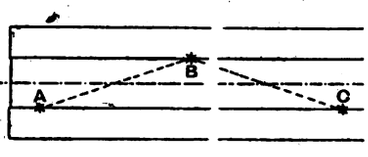

FIG. 23.—Distribution of lamps in triangle, alternately on each footpath (Avenue de Clichy).

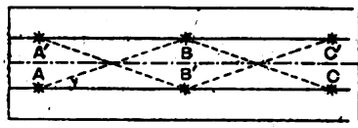

FIG. 24.—Distribution of lamps in rectangle on the two footpaths.

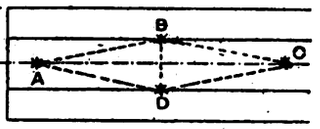

FIG. 25.—Distribution of lamps in *quincunx*, according the mixed system of the Grand Boulevards (Section Popp).

As in general it has been the practice up to the present to use lamps taking 10 amperes and over, the distribution shown in Fig. 24—that is, in rectangle—is not yet applicable, excepting to the distribution adopted in Paris on the main boulevards (Section Popp, Fig. 25), and also in a slightly different form in La Rue Royale (Fig. 26), where the illumination on the roadway, according to M. Maréchal, obtains the extremely high mean value of 3·40 lux. The distribution in *quincunx* lends itself particularly well to the illumination of large squares or gardens. When the

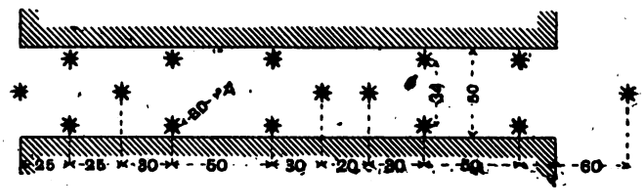

FIG. 26.—Distribution of Lamps in the Rue Royale.

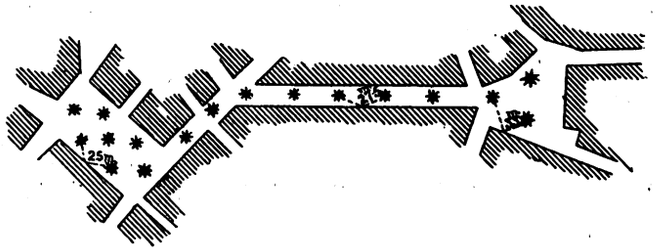

FIG. 27.—Scheme of Distribution of Electric Lamps for the Publi Lighting of the town of Lille.

scheme elaborated by MM. Gavelle, Mougy, and Robard, of which we reproduce the plan here in Fig. 27, is completed, we shall see an interesting and very successful example in the illumination of La Grand Place at Lille. In New York all the Fifth-avenue is illuminated in this manner with double lanterns. It is one of the finest examples of lighting by arcs; but this arrangement, which greatly multiplies the number of lamps, has been up to the present quite the exception.

(To be continued.)

[30] In this last city, the arrangement of houses into "blocks" in a perfectly regular chequered pattern has allowed an absolutely uniform method of distribution to be adopted. The avenues lighted are 30 metres wide, and are crossed every 60 metres by transverse streets 18 metres wide. In the avenues, the lamps are placed at the crossings, and alternatively on the right and left footpaths. In the transverse streets the length of the blocks of houses varies from 18 metres to 23 metres, and the lamps are spaced about every 90 metres.

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PHASING TRANSFORMERS.*

BY CHARLES S. BRADLEY.

The polyphase motor is so good as to need but very little, if any, improvement. One of the important links to round out the art seems to be the phasing transformer, so that we can take a single-phase alternating current and convert it into polyphase of any desired number.

I have chosen for my work the conversion of single-phase to three-phase, because the three-phase motors which we have been able to construct give us very much less trouble than the two-phase. In a series of experiments I have found that the two-phase motor would run at a number of speeds, especially when supplied with current from a phasing transformer. I supposed the trouble arose from harmonics, but of this I am not certain. The three-phase motor never has given us any of this trouble. These experiments, however, were carried out before the transformers had been refined,

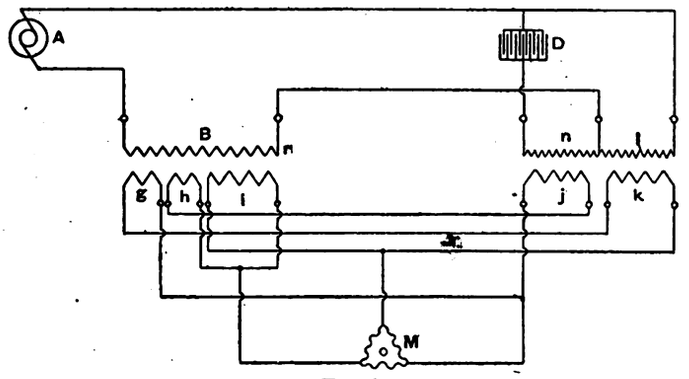

FIG. 1.

and, now that we are getting more perfect results, I think it is very probable that we could return to the two-phase motor, and get much better results than when first tried.

The following is a description of an arrangement of condensers and cores to produce polyphase and single-phase alternating currents. Many different arrangements of condensers and inductances have been tried, and all have failed to keep their phases at a working relation, except the one I am about to describe.

A diagram of the phasing transformer and connections with the generator and motor will be found in Fig. 1, A being the generator, B the simple section of the transformer, D the condenser, and M the motor; r, primary of the simple section of the transformer; n and l, primary of the compound section; g, h and i, secondaries of the simple section of the transformer, and j and k, secondaries of the compound section. The primary of the simple section of the transformer is in series with the compound section and condenser.

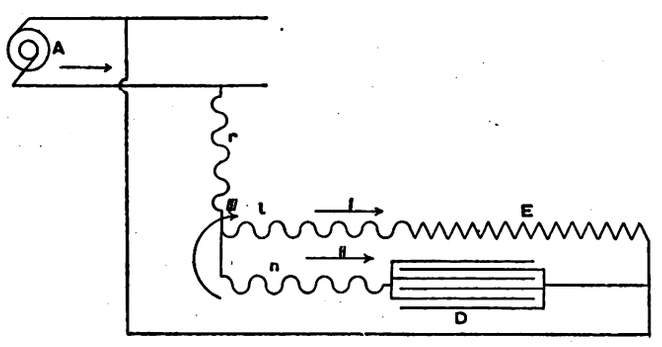

FIG. 2.

By the proper adjustment of capacity and inductance, the magnetic flux in the core of the compound section is approximately 90deg. in phase behind the simple section; then, in order to get three phases from the two, I resort to resultants in the secondaries: g and k constitute one phase, h and j a second, and i the third.

The essence of this invention rests in the arrangement of the compound section of the transformer and condenser. There are, undoubtedly, several ways of explaining the theories involved in this device, and most people would prefer the mathematical description, but, as I did not hit upon the invention by that method, I shall follow in the explanation the same method of reasoning as I used to arrive at the result.

* Abstract of a Paper read before the American Institute of Electrical Engineers, New York, September 25th.

In order to explain the theory involved in this, refer to Fig. 2, in which A is the generator, E the inductance, D a condenser or capacity; l and n represent the leads to the inductance E and to the capacity D. If the generator is generating an electromotive force in the direction of the arrow (Fig. 2) a current will flow through the lead l and the inductance E, as represented by the arrow I., and through n into D, in the direction of the arrow II. During the rise of the electromotive force through the machine from zero to the top of the wave, the current will flow in parallel into or through the inductance E and the capacity D. As soon as the wave of the electromotive force commences to decline the condenser will begin to discharge, and the current flowing from it will be in the direction of the arrow III, Fig. 2. Also, at the same time, the inductance will discharge its energy by a current in the direction of arrow III., so that the current represented by arrow III. is delayed by 90deg. Thus we see that the current represented by arrow III. will be lagging in its time period considerably behind that in the lead r. Now, if we wind the lead l and the lead n upon an iron core, as shown in Fig. 3, in opposite directions, and of the same number of turns, and have the inductance E bear a proper relation to the capacity D, so that the currents represented by arrow I. and arrow II. shall be equal, no magnetic flux will be produced in the

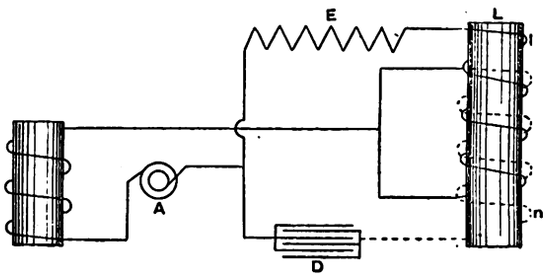

FIG 3.

core during the rise of the potential of the machine, but during the fall of the electromotive force of the machine and during the discharge of the inductance and condenser which is represented by arrow III. (Fig. 2), the currents flowing through n and l will be in series and flowing in the same direction; consequently, the magnetic flux will be approximately 90deg. later than it would be if charged directly from the machine.

I have represented in Fig. 2 a section of lead by r, and it will now be clearly seen that the current in the lead r will have a phase difference from the combined or resultant phases in the leads l and n. Furthermore, a current in the lead r will be in lead of the electromotive force of the machine, because the inductance and the condenser, previously described, cut off the flow of the current before the machine has reached the zero point, and when the lead r is placed upon an iron core, as shown in Fig. 3, it has a tendency to lag, which counterbalances the lead and leaves the main-line current somewhere near the phase with the electromotive force of the generator.

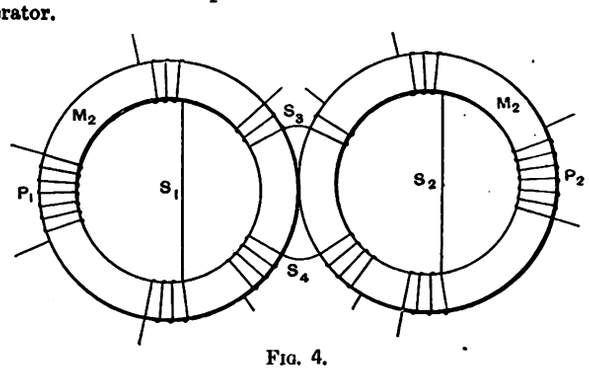

FIG. 4.

Refer now to Fig. 3, where the leads l and n are wound in opposite directions, and completely interlaced upon the iron core L. The lead r is here wound upon the second iron core, which constitutes the primary of the simple section of the transformer as shown at B, Fig. 1. In reducing to practice and applying the transformer to an induction motor, we find that the inductance E can be dispensed with, as the apparent inductance produced by the motor furnishes all the lag necessary; and it will be noted that in Fig. 1 the extra inductance which we used in our first experiments is left out of the combination. The lead from the simple section of the transformer, it will be noted, goes to the centre of the compound section. This diagram does not represent the true condition of the compound section, for the winding n and l are together, or, as before mentioned, interlaced upon the core. The magnetic flux in the two sectior of the transformer are approximately 90deg. apart.

D

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The secondaries are, therefore, wound each partially upon the two cores, so that the three resultant phases may be produced from two, this being in accordance with Mr. Fred. S. Hunting's invention for changing two phases to three. For the description of this I will quote Mr. Hunting's own words, and the plan is in Fig. 4.

"If P_1 and P_2 represent two primary circuits supplied respectively with alternating currents differing in phase, or disposed in any other suitable manner so that the fluctuating magnetic impulses developed in the cores M_1 and M_2 differ in time, then the secondary currents developed in circuits S_1 and S_2 will differ in time period. If other circuits, as S_3 and S_4, be so arranged that part of their convolutions will enclose one magnetic core and part another, there will be developed in these circuits a resultant current due to the combined action of both magnetic cores, and this current may be given any desired degree of phase displacement with reference to the current in primary coils P_1 and P_2, accordingly as the number of convolutions surrounding the respective cores are varied. For example, if, as shown in circuit S_4, an equal number of convolutions is placed around each core, then there will be developed in circuit S_4 a resultant current having its phase half-way between the phase of current in coils P_1 and P_2. If the number of convolutions on the two cores vary in the proportion of three to two, and be joined together as indicated by the coils S_3, the resulting current produced by these coils will be closer in phase to the current flowing in P_1 providing the larger number of convolutions be placed as indicated in the diagram upon the magnetic core controlled by coil P_1. Thus, by varying the relative proportions of the two coils inclosing the two magnetic circuits, a resulting current of any desired phase displacement with reference to the phase of coils P_1 and P_2 may be developed. It will thus be seen that by means of two magnetic circuits or cores in which magneto-motive forces differing in phase are developed, we may produce any

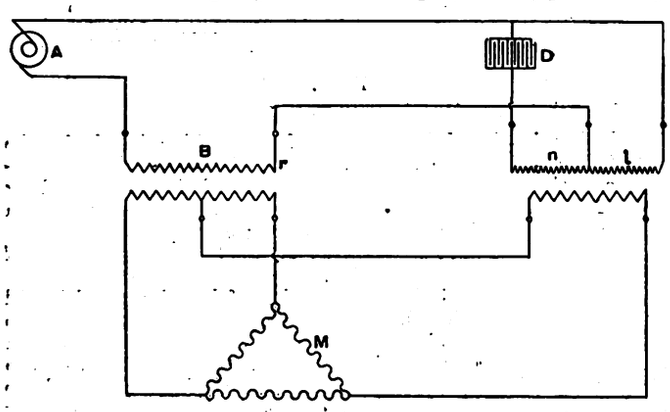


FIG. 5.

desired number of currents of differing phase, and may produce a definite degree of phase displacement, and the resultant current may in any case be shifted closer to the phase of magneto-motive force in either core by increasing the inductive influence of said core upon the circuit carrying the resultant current. In the organisation shown in the diagram we will have four secondary currents developed from the primary coils P_1 and P_2, and assuming that the currents flowing through these coils differ in phase, all of said secondary currents will differ in phase."

Mr. Scott's invention for changing two phases to three may also be used, and is shown in Fig. 5. Making the resultants in this manner by means of the secondary windings contributes also to steadiness of phasing. If desired, two secondaries having a proper two-phase relation may be used on the motor.

The experimental work, in which I have been greatly assisted by Messrs. Hulse and Chapman, has occupied a long time, and has passed through a great many stages. The results represent a great deal of patience, and we have chased the phases from zero to 180deg., back and forth, until there is a well-worn path between these two points, but finally we have a set of beautiful results. This motor gives powerful starting torque, and it gives me pleasure to show it to you here in operation.

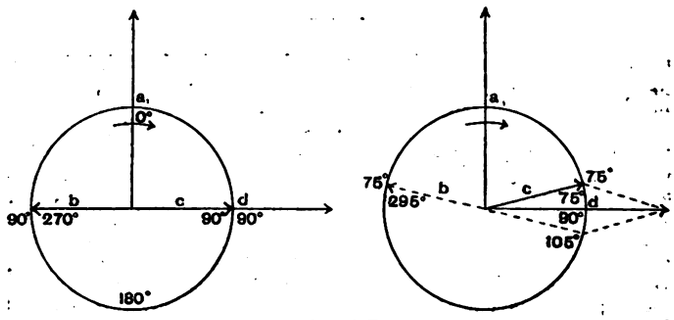
I want to bring to your attention one feature of the compound coil used in combination with the condenser, which will be found in Figs. 6 and 7. If we suppose a direction of motion, as shown by the arrow and the current in the condenser branch, leads by 90deg., which is represented at b, and the current in the inductance branch lags by 90deg., as indicated at c, and the wires carrying these currents are wound in opposite directions upon the core, we shall have a resultant current which is represented by extension d. Increase of load changes the phase relation of the individual branches, but not the resultant secondary, and this is explained by reference to Fig. 7, where a 75deg. lead and a 75deg. lag are represented by the respective branches, and as the branches are wound in opposite directions we find that when b is turned over it becomes a lag of 105deg., and the resultant of 75deg. and 105deg. again produces 90deg. lag, and the value again represented by the extension d; the value of the current is slightly less, but its resultant phase is the same as is represented in Fig. 6. This explains the steadiness of phasing which we are able to obtain.

The power factor is found to be very good, it being 82 per cent. even at light loads, and the probability is that we shall have very much better results upon larger-sized transformers.

The condenser in this combination fills two very important functions, first assists in the phasing and second prevents the lag upon the line. This arrangement does not prevent the idle currents flowing in the motor circuits and the secondaries of the phasing transformer, and we find in small motors with the high period of 140 cycles that the apparent energy in the motor circuits is sometimes two and one-half times the apparent energy in the main line. The capacity of condenser for a one-half horse-power motor when 1,000 volts are supplied to the transformer is about 2·4 microfarads. Our condenser for this size, without connections, occupies a space of a cube four inches on each side, and capable of enduring 3,000 volts, or a factor of safety of four, as the voltage on the condenser is about 700. Of course, it will be understood by those familiar with the designs of induction motors that it is impossible to design a small motor with small power factor, as the air-gap necessary for mechanical construction has to be so large in proportion to the size of the motor.

Many attempts have been made by placing the condenser in direct connection with motors to produce rotary fields, but have so far been attended with little success. As the trade requires the motor to be of comparatively low voltage, which calls for a large capacity in the condenser, and as the output of the condenser of a given capacity is proportional to the square of the voltage, it will be seen how advantageous it is to place the condenser in combination with the primary of the step-down transformer.

The curves obtained of the electromotive force and current were were all of true sine form. The current for this work was obtained



FIGS. 6 and 7.

from a 75-kilowatt Slattery alternating machine. This machine has a surface winding on the armature, and, therefore, gives practically a sine wave. Just what the transformer may do on all the various dynamos that are in the market, giving all sorts of complex waves, it is difficult to say with our present experience, but so far as we know now, the transformer tends to smooth out all the irregularities.

While the principal use for this device at present seems to be the application of polyphase motors to single-phase lighting systems, many new ones undoubtedly will be found. It may seem bold to think of applying this to long-distance trolley railroads, but I am hoping to have it done. It is much more simple to have one trolley wire with track return than to have two trolley wires, which would be required by the direct application of polyphase systems. A large amount of power requires either a large current or high voltage, in order that the resistance of contact of whatever device is used to make connection to line need not be too great. As viewed at present, it seems as if the alternating current must be used for this work. If so, and unless the traffic is extremely frequent, it will take many more transformers, if they be placed along the line, than if the transformation is made upon the car or locomotive, because the transformers along the line having no trains or cars near them would be idle. If the voltage is stepped down on the car or locomotive, it is just as economical to do it by the phasing transformer, with the exception of the added weight of condensers, which for a 1,200 H.P. locomotive will be about two tons, and this is not of consequence on so large a power.

A brief description of the motor may be in order, although it does not belong strictly to this subject. We met with much difficulty in developing a motor for so high a periodicity as 140 cycles. It is necessary to keep the density so low, and it is always such a temptation to try to get all the power from a given piece of apparatus, that they are always heating much more than they should. With a large number of poles and slots, we found that any use of wide bars in the armature was out of the question, for

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the eddying currents in the copper were too serious. *We also looked for difficulties which we never found.* At times we thought the heating was due to higher harmonics produced from the phasing transformer; but the fact is we never found any, unless it was in the experiments upon the two-phase motor. The rotary field of the motor is the exterior or stationary part, the secondary constituting the armature. The armature is composed of two sections, or practically two armatures end to end upon the same shaft, one of the armatures having a low-resistance winding, and the other a comparatively high resistance; the field is placed over a high resistance for starting, and shifted by means of a lever over the low resistance, when it has nearly attained speed. Of course this arrangement is for securing the starting up of the motor, and has nothing to do with the phasing transformer, and the motor might haverings for connecting the starting resistance to the armature and operate quite as well. The sliding of the field gave trouble, as the air-gap has to be small, and the play at the sides allowed the armature to strike against the field, and when a tight fit was made, which would work easily when cold, it would stick fast when the motor rose in temperature; the writer therefore decided to give it quite a clearance at these points, and give it a guide at the bottom of the field. This being central and comparatively thin, the expansion is not sufficient to cause sticking.

THE SURFACE CONDENSING PLANT AT THE NEWCASTLE AND DISTRICT COMPANY'S ELECTRIC LIGHT WORKS, NEWCASTLE-ON-TYNE.*

BY WILLIAM CROSS.

In 1892 the Newcastle and District Electric Lighting Company (Limited) decided to put down an independent surface condensing plant for the purpose of economising the consumption of steam, and as this plant differs to some extent with ordinary practice a short description may prove of interest.

The generating plant for which the above was designed consisted of two Parson turbo-motors, each of which, when running at full load and at 4,500 revolutions per minute, gave about 250 effective horse-power. These motors were supplied with steam at 140lb. pressure. The motors are designed to expand the steam about 150 times, thus giving a theoretical terminal pressure of 1lb. It was therefore obvious that an air-pump of ordinary construction could not maintain a vacuum nearly perfect enough to be of any service.

The situation was a somewhat difficult one, the point at which the condensing plant had to be fixed being 90 yards and the floor level 36ft. above low water springs in the river Tyne, which was the only available source from whence the water necessary for condensation could be obtained. It was, moreover, a point of special importance that the plant should be capable of running continuously for very long periods without stoppages for repairs or adjustments. The surface condenser was required to have 1,500 sq. ft. of cooling surface, and the pumps, &c., had to be made of suitable size for dealing with plant of such capacity. Owing to the height the condensing water would have to be lifted and the great length of the suction pipe, it was considered desirable to keep the condenser and pumps as low down as possible, and in view of the continuous running required, to keep the engine on the floor level, so as to be well in view and easily accessible.

The tandem compound pumping engine is carried on beams over the top of the shaft, whilst the condenser and pump are placed at the bottom, the pumps being connected to the rocking beam of the engine with wooden spear rods. The shaft is 10ft. in diameter, and from the bottom of it a drift 260ft. long, and of a cross-section of 4ft. 6in. by 4ft. 6in. is driven to the river, which it meets at about low-water level. Down the drift run two cast-iron pipes, each 12in. in diameter, one being the suction and one the return. These pipes are continued well into the river, the suction pipe being fitted at the end with a short length of flexible hose, with wind-bore and float so arranged as always to keep the extreme end well clear of the mud.

The surface condenser is 4ft. 6in. in diameter and 9ft. 8½in. long between tube plates, and contains 790 brass tubes ¾in. in diameter, giving a cooling surface of 1,512 sq. ft. The exhaust steam is brought to the condenser by light galvanised wrought-iron pipes, about 2ft. in diameter.

The engine is a tandem compound, on Kingdom's system, designed to run constantly at 60 revolutions per minute, having two cylinders 6½in. and 11½in. by 9in. stroke. There is no intermediate gland, a corrugated piston rod working through a long bush being used instead. There is only one slide valve, which is cast hollow, the exhaust from the high pressure passing through the back of the valve and into the low pressure; there is, therefore, only the slide spindle gland exposed to high-pressure steam, a point of importance in view of the long runs required. On the upstroke the corrugations of the rod constantly entering the bush tend to check any leakage of steam, and this they effect most completely, whilst on the down stroke the bottom of the high pressure and the top of the low pressure are in connection through the slide valve, and any leakage past the rod is a matter of unimportance. The rocking levers are double-ended, and are connected to the cross-head by links in the usual manner; the outer end of the levers drive the circulating pump of 1ft. 6in. stroke. Nearer to the fulcrum is attached the spear rod of the cold water pump, which is 9¼in. stroke, and at the inner end of the lever is the air pump spear rod, of 1ft. 6in. stroke. There are two flywheels on each end of the crank shaft, so that all strains are symmetrically distributed. The engine is controlled by a Tangye governor, but this is only intended to come into play in case of a spear rod breaking or a pump missing its water. The cold water pump is an ordinary ram pump, 4in. by 9¼in. stroke, taking the water delivered by the air pump, and delivers against a head of about 50ft. into a feed-water tank in the boiler room. It is driven by a light spear rod made of wrought-iron tube.

The circulating pump is double-acting on the constant-pressure system, which has the advantage of diminishing the number of valves required, and doing away with any valves in the bucket. This pump is 1ft 6in stroke, the bucket being 1ft 2in, and the ram 10in. in diameter; it is estimated to deliver 550 gallons of water per minute at 60 double strokes. The valves are of the ordinary india-rubber disc pattern, and are arranged so as to be very easy of access. The pump draws only on the upstroke; on the down stroke it delivers all the water to the top or ram side, but that as the ram is one-half the area of the bucket, one-half of the water is displaced and delivered into the condenser; on the succeeding upstroke the second half is delivered. The delivery is therefore practically constant, whilst the suction is intermittent. The velocity of water through the valves is 5ft. 6in. and in the suction pipe 3ft. 6in. per second. To prevent the shocks in the suction pipe, due to the intermittent flow, an air vessel of 11·25 cubic feet capacity was fitted. The water, after being forced through the tubes of the condenser passes back to the river through the second or exhaust 12in. pipe already mentioned, the effect of this being that the head is balanced by the suction of the delivery, and the work on the pumps very considerably reduced. As already mentioned, so high a vacuum was required that an air pump of ordinary construction could not be expected to deal with it, and one of special construction had to be constructed.

In an ordinary air pump the clearances are so large as compared with the volume swept by the piston that at very high vacuums the vapour is never compressed sufficiently to attain the atmospheric pressure *plus* that required to lift the valves, consequently on the next outstroke the vapour simply expands again and fills the barrel without any suction having taken place. It was therefore decided to break up the compression of the vapour into stages, so that the compression in any one cylinder would be but small, and the difficulty mentioned would not arise.

Having now briefly described the plant, it only remains to give the general results. A few difficulties were experienced at the first, but these were easily overcome, and the plant has been working continuously ever since. It generally runs for about six months on end without stopping, and practically without attention of any kind. Though only a part of the plant works into the condenser, the results so far have been very satisfactory. The cost of coal (at the same price per ton) per Board of Trade unit has dropped nearly 50 per cent., and the cost of water about 70 per cent., as taken over six similar and consecutive months in each case, a saving sufficient to pay the whole cost of installation in about three years, and this result would have been still more favourable had it not been for the unavoidable expense of the shaft and drift. Surely these figures are worthy of the attention of the owners of the numberless high-pressure non-condensing engines in this district, and who are in most cases much more favourably placed as regards site and facilities for obtaining condensing water than in the present case.

* Abstract of Paper read before the North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, November 8th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read:—(1) "The Magnetic Field of any Cylindrical or Plane Coil," by W. H. Everett. (2) "The Latent Heat of Volatilisation of Benzene," by Mr. Griffiths and Miss Marshall. (3) "The Comparison of Latent Heats of Volatilisation," by Prof. Ramsay and Miss Marshall.

TUESDAY, November 12th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Address by Sir Benjamin Baker, the President, and presentation of medals, premiums and prizes awarded at the close of last Session.

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The Electrician.

The Oldest Electrical Journal (1861—1878.)

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SPECIAL NOTICES.

With this week's number of "THE ELECTRICIAN" is issued (Gratis) a Supplement Sheet of "Photographs of the Electric Arc." Complaints of non-receipt should be promptly made to the Publisher.

Last week's number of "THE ELECTRICIAN" commenced Vol. XXXVI. and contained (Gratis) the Index to Vol. XXXV.

ELECTRIC *v.* GAS MOTORS AT BRIGHTON.

To propel a girder-built vehicle weighing some 60 tons, and running on four submerged rails, at a velocity of about six miles an hour, through a depth of some 15ft. of sea water in an indeterminate state of agitation, will be a unique feat of engineering. So original, indeed, is the principle that, although the Brighton and Rottingdean Seashore Electric Tramroad Company purpose to put it into execution, they confess to the vaguest ideas as to the amount of power which will be required. According to their present plans, it is intended to equip the aforesaid 60-ton car with two 30 H.P. electric motors, and it is believed that these will suffice. At the same time, it is admitted that the data to determine this provision of power are of the most meagre nature. Though it may be impossible to state the maximum which will be required, it is not altogether difficult to fix a minimum limit. Two 30 H.P. motors will be sufficient, we think, only if each motor is capable of developing very much more than its rated power for a considerable time—perhaps, indeed, for the whole run. Ordinary tramcars running on well-conditioned rails require at least 1 H.P. per ton of gross load, and this provision is often exceeded, even on tracks where there are no stiff gradients or curves. With rails and wheels almost constantly submerged in sea water, and in altogether an indeterminate condition beneath many feet of saline fluid, with a girder stage drawn rapidly through a considerable depth of water, and with the stress which must arise from the currents and waves

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impeding the vehicle, we should be disposed to estimate that a minimum of 80 H.P. would be required, and it would not surprise us if onoccasion the power should exceed double that figure.

It was intended at first to run this perambulatory pier by power supplied from a secondary battery. Whether or no this was feasible from an engineering point of view, it is not surprising that Mr. MAGNUS VOLK, the plucky promoter of this extraordinary scheme, together with those associated with him, should have come to regard the use of storage batteries as being commercially impossible. There is no good in demonstrating an engineering possibility if it is an assured commercial failure; so Mr. VOLK decided to abandon batteries, and to supply his vehicle with power by means of a trolley. As will be seen in another column, this decision has met with severe opposition from the Brighton Town Council. Plenty of objections were raised. It was urged that the trolley poles would be a danger to boats; that the wires would obstruct the "beautiful view"; and the general objections were advanced that the submerged rails would be a stumbling block to bathers; that the chalky "rock" in which the foundations of the line are laid might go the way of the sand on which a foolish man once builded his house; and that Brighton might be left with an ugly mixture of abandoned poles and wires if the scheme by any chance resulted in failure.

The Borough Electrical Engineer, having been requested to advise the Town Council in this matter, expressed himself in favour of the use of gas engines and compressed gas, whilst admitting the advantages of the trolley system. Now, gas-driven cars have nowhere become an established success, unless where cars of quite moderate weight are used. In this country they have more than once been tried, and in every case have been abandoned after a few weeks, or at most months, of experimental running. There are seemingly endless difficulties with them. In a vehicle moving through the sea, there would be perhaps no lack of jacket water; but the gas engine, even on cars not exceeding one-tenth of the weight of the proposed Brighton vehicle, has proved itself unequal to the development of a good starting effort—an especially necessary provision in this case—and unable to tackle in a satisfactory manner the variations of load and the changes and reversals of speed. The gas engine must be kept continually running at a fairly even rate, and all manipulation of the car must be done through the agency of gearing. Clearly, this type of motor is quite unsuited to the requirements of Mr. VOLK's novel and ponderous car.

But to what do the objections to the trolley system really amount? It has been said that bathers may be troubled by the hidden submerged rails. Will not, then, a line of trolley poles serve excellently well as a warning of the lurking danger? The outcry is also made that boats may be capsized by the poles. In daylight the poles will be visible, and at night it is not likely that strangers will venture to land at the base of a precipitous cliff. A pier or a groyne would be far more dangerous; and if the existence of pier lights is urged as a safeguard, we may add that such lights are not impossible on a line of trolley poles. With the prospects of success of this novel tramway we are not now concerned, nor with the general construction of the line and its remarkable car. But, conceding for the sake of argument that everything else about the system is in order, we have every confidence in recommending the use of the trolley for this particular job. Any element of structural weakness, commercial failure, or injury to the amenities of the Brighton foreshore, which this tramway may chance to develop, need not, we feel sure, arise from the use of the trolley system.

REVIEWS.

Armature Windings of Electric Machines. By H. F. PARSHALL and H. M. HOBART. (New York: D. Van Nostrand Company. 1895. London: "The Electrician" Printing and Publishing Company.)

Except the prehistoric Dredge this is the largest book electricians have ever had published for their benefit. The authors state at the outset that "it was concluded the only feature of the multipolar dynamo requiring special study was that of the armature windings," and they therefore proceed to give a vast amount of attention to the combinations and permutations of these windings. No one need now be at a loss to know exactly in what order to complete the circuit round the armature, when he has once decided on the general type of winding to be employed. But further study must be given than we have found possible before the information will be forthcoming—which is the best winding for any given multipolar ring or drum. This book gives ample information as to the order and disposition of the armature conductors, but it does not give with any sufficient clearness comparative information as to the results in practical working to be obtained from these several arrangements. Seeing how much greater the experience of large multipolar dynamos has been in the United States than in this country, English electricians cannot but feel grateful to the authors for placing before them at least a portion of the wisdom of the West. The authors were hampered at the outset "by the intervention of certain circumstances contingent to their position in an industrial concern," and from the absence of information of the greatest importance to designers it is probable that the restrictions were only partially removed. We must confess we do not share the authors' opinion that there is no other question than that of armature windings requiring special study, or rather we consider that in the question of armature windings is involved a number of allied questions on which by no means the last word has been said.

Some doubt is cast upon the efficacy of the Sayers device, of which a short description is given with a diagram. So far as we are aware, this device has never been applied to multipolar machines having other than the ordinary parallel winding with cross connections or multiple brushes. A question well worth consideration is whether that device is not specially applicable to multipolar machines having series winding, seeing that in these latter the question of collection is one of increased difficulty.

It must be 12 or 14 years since Prof. Perry invented the series armature winding for multipolar dynamos, and it is now nearly five years since Mr. Kapp in a Cantor Lecture first gave publicity to that form of the multiplication table known as an armature winding table. But series windings have never become popular, indeed they have probably not been very carefully studied in this country. In the United States large multipolar machines have been made in considerable numbers both for traction and for lighting. According to English ideas the multipoling has been carried to excess in many cases, but at least a great deal of experience must have been yielded as to the effects of different arrangements of armature windings. Some of the results of this experience are indicated in the large volume under consideration, and we are sure that designers of dynamos will turn its pages over with the object, in the first place, of finding at once what the authors have to say on this matter. They will find that before they can get much information they must familiarise themselves with some novelties in the shape of expressions and symbols, and then, armed with these weapons, proceed to a careful attack on the book, gradually finding out that there is a great deal more in it than they at first supposed. They will probably at the commencement of their studies be disposed to consider the diagrams and tables need not go quite from "twice one" to "twelve times twelve," but will probably come later on to appreciate the comfort of having all this in print in one book. They may also, sometimes, feel that no great harm would have been done in description of windings by the omission of passages such as the following: "It could be connected so as to give one-third as great a terminal electromotive force, by joining the three elementary

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groups, of which each winding is formed, in parallel, instead of in series," but will find numerous instances in which the meaning is so much less obvious that they will be glad to have had the temporary relief.

The diagrams of armature windings number 129, all except two or three being full page, and as the book is quarto it will be evident that clearness has been given a first place—the descriptions face the diagrams, still further facilitating the task of tracing the connections and the reasons for their very numerous variations.

The last 70 pages or so consist of winding tables, giving the pitch for various numbers of conductors on armatures having various numbers of poles.

In conclusion, we wish to recommend this book as a collection of diagrams of armature windings, but must point out that it is not—and probably was not intended to be—a complete treatise on armatures. The general and particular knowledge necessary to properly use these diagrams in practice must be sought elsewhere.

The welcome accorded this book will be all the heartier from the fact that the first-named of the authors is now, and has for some time been resident in England, and engaged in applying here the knowledge and experience gained in the United States.

W. M. M.

Die Lehre von der Electrizität und deren Praktische Verwendung. By T. SCHWARTZE. (Leipzig: J. J. Weber. 1895.)

Electricity, with its innumerable branches, is a wide and far-reaching subject, but not too wide for this book; it embraces everything. Everything, theoretical and technical, from the foundations of dynamics to dynamo machines, is treated of more or less fully, and the only work left to the bewildered reviewer is to point out which subject is more and which less full.

The book is divided into three parts: General Physical Principles; Electrical and Magnetic Phenomena; Electrotechnics. The first part starts with a dissertation on fundamental units. Here mass is treated with the utmost contempt, and has to give place to force, "for we have nothing further to think of if we lay force aside." Mass is finally dismissed with the following words: "Mass is objective only in so far as it refers to space; all other properties are intuitive. Mass is therefore an intuitive form of space, *i.e.*, energy." These ideas, applied to the law of Coulomb, produce the following varieties: Line force, surface force and volume force, with respective dimensions $M L$; $M L^2$ and $M L^3$. These and the resulting dimensional formulæ are delightfully simple—when one gets to them, but the way to them leads through a valley of darkness; here, for instance, is one of the stumbling blocks we found there: "Space is defined as a field of force of mass, relatively incompressible, highly endowed with self-induction, capable of motion in transverse oscillations, and similar to a rigid body."

These elementary principles having been set on a satisfactory basis, we come to chapters on physical fields of force, oscillations, the composition of forces and rotation. Each is a treatise in itself, dealing with the whole range of its subject very concisely, but yet fully enough to show how exceedingly complex these matters are, when only considered from the right point of view.

The author begins the second part with a long discussion on electrical units and their dimensions; he gives Maxwell's dimensional formulæ with their later modifications, and also applies the dynamical ideas we have already mentioned to the formation of an improved system. The next chapter is devoted to electrostatics, especially to static potential, which is defined by the dimensional formula $M^2 L$. Then follows a well-arranged chapter on the various propositions of Gauss, Coulomb, Poisson and Green, deducing in conclusion a general formula for potential energy. Chapter XI. forms a splendid example of compression; the whole subject of specific inductive capacity, with its relation to the refractive index of light and various molecular properties, is run through in four pages of German—say one page of English. A student at this rate would become a first-class "theoretician" in a week! And a practician too, for suddenly, after pages of formulæ, we light on Sprague's instructions for setting up a tinfoil condenser, followed by three methods of measuring and comparing condensers. Constant current is the next subject. Ohm's law, after much discussion, is shown to be a consequence of Joule's; the next paragraph contains a deduction of Joule's law from Ohm's. Finally electrolysis, like everything else, is considered as a "force-working;" we read of an "overgoing force-ray-bundle" between the electrodes.

In the chapter on magnetism the author is fairly in his element; it is a thoroughly theoretical and dimensional chapter. It starts by showing the earth's magnetism to be a consequence of oscillations of the mass-centre, and finishes with remarks on metripolar, megapolar and brachypolar magnets. The author accounts for the attraction and repulsion of unlike and like poles by the action on one another of ether currents, due to each pole disturbing the equilibrium of the system. Chapter XVI. is an excellent exposition of electromagnetism, containing values and curves of magnetisation and hysteresis for the different kinds of iron, and a good deal on the windings and fields of electro-magnets. In the next chapter self and mutual induction, with their influence on alternate currents, are dealt with very thoroughly. The second part concludes with a survey of Hertz's and Elihu Thomson's experiments.

The third part, of 100 pages, calls for no special remark. It treats in the usual form of measuring instruments and measurement in general. The fullest information is given as to how the instruments ought to work, and how the various methods ought to give the required results; practical details, of course, a well-regulated German student leaves to the laboratory assistants, and would be out of place here.

It is a striking book. Its object—we learn it, luckily, from the preface—is to harmonise the fundamental principles of physics with the teaching of Faraday and his successors. But what is especially striking is the length of the words; setting quality aside, "Massengeschwindigkeitsaeusserungen" will be found hard to beat in point of quantity.

THE MAGNETIC FIELD OF A RECTANGULAR COIL.

BY PROF. G. M. MINCHIN, M.A., F.R.S.

The calculation of the value of the magnetic potential or force produced at any point in space by a rectangular coil of given length, breadth and depth is a matter of considerable difficulty. Of course, strictly accurate mathematical calculation is not practically necessary, since no coils in use are of an exact rectangular form.

In the following Paper we shall show how to calculate practically the component of magnetic force parallel to the axis of a coil of any dimensions at any point in space, and also the value of the potential due to any flat rectangular coil. A few numerical examples will be added by way of illustration.

In *The Electrician* for September 6th we have an accurate expression for the potential at any point in space due to a current of strength i flowing in any plane rectangular circuit, viz.:—

$$\frac{V}{i} = \sin^{-1}(c_1 c_2) + \sin^{-1}(c_2 c_3) + \sin^{-1}(c_3 c_4) + \sin^{-1}(c_4 c_1), \quad (1)$$

the notation of which is explained in the Paper referred to. We shall now put this expression into another form. In Fig. 1, *The Electrician*, September 6th, let the sides A B, B C of the rectangle be $2a$, $2b$; let α, β be the co-ordinates of Q with reference to the principal axes of the rectangle at its centre; then, taking the term $c_4 c_1$ in (1) as typical of all we have

$$c_4 c_1 = \frac{(a+\alpha)(b+\beta)}{\sqrt{\{z^2+(a+\alpha)^2\}\{z^2+(b+\beta)^2\}}}. \quad (2)$$

As we are about to calculate the value of V for any flat coil, such as that represented in Fig. 4 of *The Electrician* for September 27th, we shall suppose that we are now dealing with the individual rectangle $a\,b\,c\,d$ in that figure. The sides of A B C D in that figure being $2a$, $2b$, the sides of $a\,b\,c\,d$ are $2(a+x)$, $2(b+x)$; hence we write $a+x$ for a and $b+x$ for b in (2), and thus we have, putting $a+\alpha=p$, $b+\beta=q$,

$$c_4 c_1 = \frac{(x+p)(x+q)}{\sqrt{\{z^2+(x+p)^2\}\{z^2+(x+q)^2\}}}. \quad (3)$$

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If we put

$$x+\tfrac{1}{2}(p+q)=X\,;\quad z^2+\tfrac{1}{4}(p-q)^2=h^2\,;\quad \tfrac{1}{2}(p-q)=k, \qquad (4)$$

this becomes

$$c_4 c_1=\frac{X^2-k^2}{\sqrt{(X^2+h^2-2k^2)^2+4k^2(h^2-k^2)}}$$

$$=\frac{X^2-k^2}{\sqrt{(X^2-k^2+z^2)^2+4k^2z^2}}. \qquad (5)$$

This term is typical of the others. Thus, to get $c_1 c_2$, we simply change α to $-\alpha$ in (5); to get $c_2 c_3$, change α to $-\alpha$ and β to $-\beta$; and so on.

Now, in (5), let $X^2-k^2+z^2=2kz\tan\phi$. Then, if $\sin^{-1}(c_4 c_1)=\psi_{41}$, we have

$$\sin\psi_{41}=\sin\phi-\frac{z}{2k}\cos\phi, \qquad (6)$$

in which, for convenience, we may omit the suffix from ψ, understanding that there will be four angles—ψ_{12}, ψ_{23}, ψ_{34}, ψ_{41}—corresponding to the several terms in (1).

Let R^2 be written for X^2-k^2; then we have the equations

$$R^2+z^2=2kz\tan\phi, \qquad (7)$$

$$\sin\psi=\sin\phi-\frac{z}{2k}\cos\phi. \qquad (8)$$

Now the value of V at the point P, due to the flat coil represented in Fig. 4 of *The Electrician*, September 27th, is obviously given by the equation

$$V=\frac{i}{h}\int(\psi_{12}+\psi_{23}+\psi_{34}+\psi_{41})\,dx, \qquad (9)$$

where h is the diameter of the wire, the limits of x being 0 and $m\,m'$, the breadth of the coil. Obviously $dx=dX$, so that

$$V=\frac{i}{h}\int\psi\,dX, \qquad (10)$$

where the integral is to be taken for each of the four gnomons $A'q'qApp'$, $qq'B'm'mB$, $mm'C'n'nC$, and $nn'D'p'pD$. Taking the first of these gnomons, to which ψ and X, taken as above, apply,

$$\int\psi\,dX=\psi.X-\int X\,d\psi, \qquad (11)$$

the right-hand side being taken from the point p to the point p' in the figure referred to. We now proceed to show how $\int X\,d\psi$ can be approximately evaluated. For this purpose we shall form a curve whose radius vector is X and polar angle ψ. To do this, eliminate ϕ from (7) and (8), and we obtain

$$\sin\psi=\frac{R^2}{\sqrt{(R^2+z^2)^2+4k^2z^2}}, \qquad (12)$$

which gives

$$R^2\cos^2\psi=z\sin\psi\{z\sin\psi+\sqrt{z^2+4k^2\cos^2\psi}\}. \qquad (13)$$

From this equation we proceed to construct R, and thence X. Take any two rectangular axes, Ox, Oy, Fig. 1; take $OZ=z$, $Ok=k$, $OK=2k$, and $OL=ZK$; on OZ and OL describe two semicircles. Now draw a line OQ making any angle, ψ, with Ox, and meeting these circles in N and S; take $Os=OS$ and on the line OQ take Q so that $ZQ=Zs$; at Q and N draw perpendiculars to the line OQ meeting Ox in q and n; on Oy lay off OT equal to the mean proportional between On and Oq; and finally on OQ take

$$OP=Tk.$$

Then $OP=X$, and the locus of all the points P obtained by drawing a series of positions of OQ is the curve kAPB represented. This, then, is the curve in which the radius vector OP is X and the polar angle is ψ; it is thus easily constructed, and were it not for the single operation of finding OT as the mean proportional between On and Oq the construction of the curve would be very rapid.

Now the expression $\int X\,d\psi$ between any two points, A, B, on the curve is the sum of the successive small steps perpendicular to the radius vector described by a point travelling along the curve from A to B; and this can be read by a planimeter, or, with sufficient accuracy, by actual measurement and summation of a few of the steps.

There is another simple mode of constructing this curve AB, which is as follows: at K draw a perpendicular to ZK, meeting yO in C; on yO produced through O take $OA=\frac{1}{2}ZC$; on AO take $AF=\frac{1}{2}OZ$; describe a parabola whose focus is F and vertex A; let any line, OQ, meet this parabola in H; on Oy take T such that OT is the mean proportional between ON and OH; then, as before, $OP=Tk$.

The calculation of the potential of any flat rectangular coil at any point in space requires, therefore, the tracing of four curves of the above kind, in all of which the circle on OZ is the same, and the circle on OL alone varies, because k varies, the four values of k being $\frac{1}{2}(m+n+\alpha+\beta)$, $\frac{1}{2}(m+n-\alpha+\beta)$, $\frac{1}{2}(m+n-\alpha-\beta)$, $\frac{1}{2}(m+n+\alpha-\beta)$.

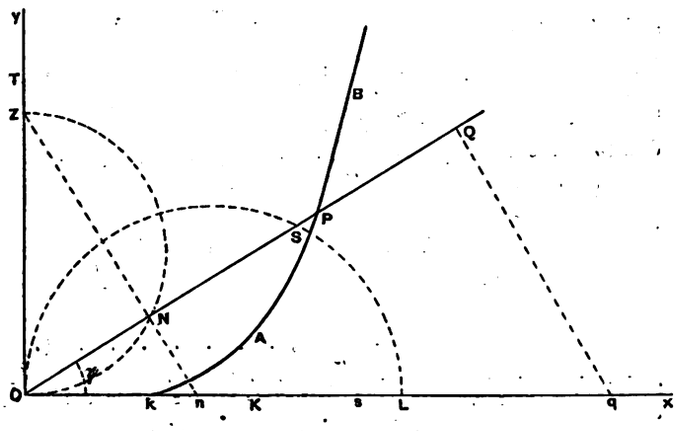

FIG. 1.

Having, by means of the determination of a few points, described the curve AB, the integral $\int X\,d\psi$ is to be measured by dividing up the curve by a series of sufficiently close points, A, P_1, P_2, . . . B; then with O as centre draw a small circular arc, Ap_1, meeting OP_1 in p_1, and a small arc, $P_1 q_1$, meeting OA in q_1; similarly take Op_2 on OP_2 equal to OP_1, and also Oq_2 on OP_1 equal to OP_2; and so on. Then half the sum of the internal steps, Ap_1, $P_1 p_2$, . . . and of the external steps $P_1 q_1$, $P_2 q_2$, . . . is a very close approximation to the required integral. The limiting points, A, B, of the curve are determined by the values ψ_1, ψ_2 of ψ given by (12), by substituting X_1 and X_2 for X.

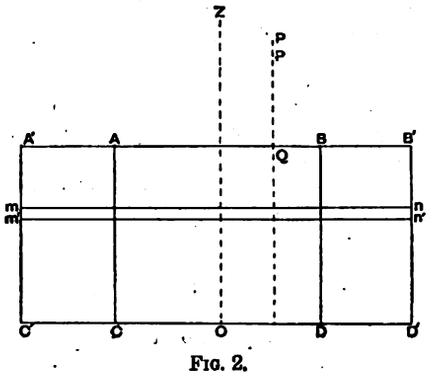

FIG. 2.

We shall now call attention to the following theorem, which is applicable to solenoids built up of coils of any shape whatever (whether circular, elliptic, rectangular, &c.), provided only that the axes of such solenoids are straight lines. The direction of the axis of the solenoid we shall call the *longitudinal direction*, while the planes of the windings are in the *transverse direction*.

Theorem: *The longitudinal component of the magnetic force at any point in space due to a solenoid of any shape whose transverse sections are all equal, similar, and similarly placed about the axis, is very simply expressible in terms of the potentials produced at the point by the two terminal faces of the solenoid.*

To see this, let Fig. 2 represent a projection of any solenoid on the plane of the paper; OZ is its axis; the hollow portion

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of the solenoid is the space A C D B; the breadth of the solenoid is A A′ or B B′; and the windings (which are curves of any shape) occupy the spaces A A′ C′ C and B B′ D′ D. Let P be any point in space; let P P′ be drawn parallel to O Z, and let P P′ = h = a very small length. Take any layer, or flat coil, of the series represented by $m n$, and let $m' n'$ be the adjacent layer, the distance $m m'$ between the central cores of these layers being h. (In other words, P′ is taken distant from P by the distance between the centres of two successive layers of the solenoid.)

Now the total longitudinal force at P is the sum of the forces due to all the separate layers. Let v be the potential at P due to the layer $m n$, and v' the potential of $m n$ at P′; then the longitudinal force at P due to $m n$ is $\frac{v - v'}{h}$. Similarly, let u and u' be the potentials at P and P′ due to $m' n'$; then the force due to this layer is $\frac{u - u'}{h}$; but, obviously, from the exact similarity of positions, $u = v'$, therefore the sum of the forces due to these two layers $= \frac{v - u'}{h}$. Taking all the layers, then, from A′ B′ to C′ D′, the successive potentials all cancel in pairs in the sum, with the exception of those due to the terminal layers A′ B′ and C′ D′. If the potential of the first of these layers at P is V_1, and that of the second at P′ is V_2', we have the total longitudinal force at P equal to

$$\frac{V_1 - V_2'}{h}, \quad \ldots\ldots\ldots \quad (7)$$

and unless C′ D′ is very close to A′ B′, for V_2' we may put V_2, the potential of C′ D′ at P itself.

Hence, if the solenoid is very long, *i.e.*, if C′ D′ is very distant from P as compared with A B, the total longitudinal force of the solenoid at P is simply $\frac{V_1}{h}$.

If P is inside the hollow A C D B, the same elementary method shows that the longitudinal force is

$$\frac{4 n i \pi - (V_1 + V_2)}{h}, \quad \ldots\ldots \quad (8)$$

where n is the number of windings in each layer, since the potential of any winding at a point in its plane, and inside its area, is $2\pi i$; and, moreover, for any point inside the hollow but not very near either terminal face, there will be almost no *transverse* component of force, since the transverse components for layers above and below the point will obviously be in opposite senses; so that, except near the faces, the lines of force inside the hollow will be nearly straight lines parallel to the axis O Z.

Indeed, our theorem, above given, holds also in the general theory of attraction for any prismatic body of uniform density, whether the body is hollow or completely solid; but the theorem is not, I think, given in any treatise on attractions.

There is just this difference between the solenoid and the attracting prismatic body, that at every point the longitudinal magnetic forces due to the successive solenoidal layers are in the same sense, whether the point is between the planes of the terminal faces or beyond them; whereas, for the attracting prism, if the point lies between the planes of its terminal faces, the attractions of the parts of the body above and below the point are opposed.

For the latter body, whatever be the position of the point P, the longitudinal force is

$$\frac{V_1 - V_2}{h},$$

where V_1 is the potential produced at P by one terminal plate of very small thickness, h, and V_2 is the potential of an equally thick plate at the other end.

Inasmuch, then, as we have the means of measuring the potentials of the two end layers of any coil at any point in space, we have the value of the longitudinal force at the point.

Numerical Examples.

As an exercise for any reader who is interested in the subject, I append a few numerical examples of the application of our formulæ for rectangular circuits and coils.

1. Let there be a single flat coil whose windings are contained between the rectangles A B C D and A′ B′ C′ D′ in Fig. 3; let A′ B′ = 20cm., A′ D′ = 10cm., A B = 16cm., A D = 6cm., so that the breadth of the coil = 2cm., and the diameter of the wire = 1mm. Find the magnetic force intensity produced by a current i—

(a) at the centre, o;
(b) at q;
(c) at r,

where $p r$ and $s q$ are the principal axes of the rectangle.

Apply the formula (15), *The Electrician* for September 27th, we have $n = 20$, $b = 2$; hence

force at centre $= 22{\cdot}3 \times i$,
force at q $= 85{\cdot}6 \times i$,
force at r $= 82{\cdot}5 \times i$.

2. Let Fig. 3 represent a rectangular coil such that A′ B′ = 26cm., A′ D′ = 16, A′ F = 10, A B = 14, B C = 4, so that the windings occupy a breadth of 6cm., and let the diameter of the wire be 1mm.; find the value of the force at a point coincident with the corner C.

Here we have the potential, V_1, due to the upper layer $= 120\pi i$; and to find V_2, the potential at C due to the layer F G H K, we have $z = 10$, while the values of k corresponding to the angles ψ_{41}, ψ_{12}, ψ_{23}, ψ_{34} are 5, 2, 0, 7 respectively. Hence for the first of the corresponding four curves we have $X_1 = 9$, $X_2 = 15$, $\psi_1 = 17° 35' 27'' = 0{\cdot}307$ in circular measure; $\psi_2 = 39° 14' = 0{\cdot}6847$; so that $\psi_2 X_2 - \psi_1 X_1 = 7{\cdot}51$, and we find

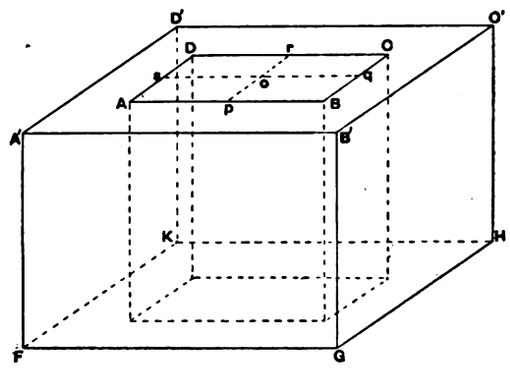

Fig. 3.

by measurement of the steps of the corresponding curve $\int X \, d\psi = 4{\cdot}575$; hence the contribution of this curve to the expression (9) is $2{\cdot}935 \times \frac{i}{h}$, or $29\,35 \times i$. In the same way the contributions of the other curves are $11{\cdot}95 \times i$, $6{\cdot}33 \times i$, and $14{\cdot}77 \times i$, so that $V_2 = 62{\cdot}4 \times i$ $\therefore V_1 - V_2 = 314{\cdot}6 \times i$, and the force at C due to the coil is $3146 \times i$ dynes per unit pole if i is taken in absolute electromagnetic units, or $314{\cdot}6 \times i$ if the current is in amperes.

Note.—In my letter to *The Electrician*, November 1st, on the magnetic force at any point in a plane circuit, for "and ω is the perpendicular from O on the first pedal of the circuit," read, "and ω is the perpendicular from O on the tangent to the first pedal at the point which corresponds to P."

THE MAGNETIC FORCE AT ANY POINT IN A PLANE DUE TO ELECTRIC CURRENTS.

BY ALEXANDER RUSSELL, M.A.

The correspondence which has appeared in your columns, due to Prof. Minchin's Papers on the above subject, has shown what an interesting problem it is when treated mathematically, but it is apt to make us lose sight of the fact that it is a very easy problem to solve practically. In a former Paper (*The Electrician*, Vol. XXXI., p. 284) I gave a method of finding the force inside a plane circuit by means of an ammeter and a small magnetic needle.

The method, briefly described, is as follows: Place the circuit with its plane vertical and at right angles to the

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magnetic meridian. Send a current round it in such a direction that the magnetic force due to it opposes the earth's horizontal field inside the circuit. Increase the current until the horizontal magnetic field is neutral at the point under consideration. Suppose that when this is the case the current is A′ amperes. Then when the current is A amperes the strength of the field at the point due to the current is $H\frac{A}{A'}$ C.G.S. units, where H is the horizontal intensity of the earth's magnetic field. By this method a first-year student can easily map out the zones of equal magnetic force inside any closed electric circuit.

The problem of finding the magnetic force due to a portion of a wire is a more difficult one, but admits of several easy graphical and mechanical solutions. Ampère's method, suggested by Prof. Minchin in your last issue, namely, finding twice the area of the little triangle whose base is ds and vertex O, and dividing by r^3, is one which would give very unsatisfactory results, owing to the difficulty of finding the *small areas* with any accuracy.

The following graphical method is interesting, and is easily applied in practice with perfectly satisfactory results. Suppose that we have to find the force at O due to the current i in the portion A B of the wire C D.

With O for pole, construct a new curve $a\,p\,b$, such that

$$O\,p^2 = \frac{K^3}{O\,P}.$$

Then the force at O

$$= 2i \times \frac{\text{area } O\,a\,b}{K^3}, \quad . \quad . \quad . \quad . \quad . \quad (1)$$

i being the strength of the current in absolute measure.

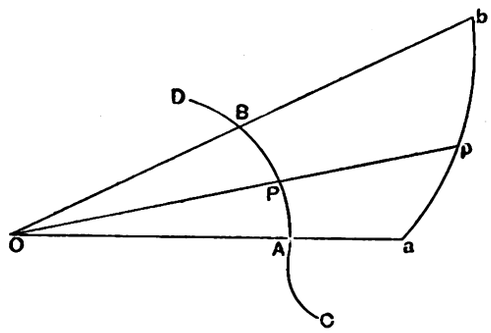

FIG. 1.

At first sight the calculations for drawing the new curve might be thought troublesome; but, by making K^3 some multiple of 10, and by having a table of reciprocals and square roots, the values of Op can be written down at once. We have only to find some six or seven positions of the point p, and draw a smooth curve through them freehand.

The proof of the formula (1) is not difficult. We know that

$$F = i\int\frac{d\theta}{r}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where F, θ and r have their usual meanings. Now if (r', θ) be the polar co-ordinates of the inverse square curve ($r\,r'^2 = K^3$), then

$$F = \frac{i}{K^3}\int r'^2\,d\theta. \quad . \quad . \quad . \quad . \quad (3)$$

But $\int r'^2\,d\theta$ is twice the area $O\,a\,b$, hence (1) follows.

We shall apply this theorem to solve the following example, and will check the results obtained by those got by mathematical calculation, in order to obtain some idea of its accuracy.

To find the forces at P (Fig. 2) due to the portions A B and B C of the semicircular wire A B C in which a current of A amperes is flowing.

A C has been taken = 10cm., A P = 8cm., and P B is perpendicular to A C. To construct the inverse square curve for which $K^3 = 1{,}000$, we put r equal to 8, 7, . . . 2 successively and write down r' from the tables; we then, by means of compasses, find the points. It would have been easier if polar paper, similar to that recommended by *The Electrician*, had been available. As only one point has been found in $b\,c$, another was found by taking $r = 2{\cdot}4$. The curve $a\,b\,c$ was then drawn freehand, there being only two points marked between b and c, and the required areas were found by the planimeter.

The area $a\,P\,b = 128{\cdot}9$ sq. cms.

The area $b\,P\,c = 318{\cdot}1$ sq. cms.

Therefore the force at P due to the current in the portion A B is

$$F_1 = \frac{A}{10} \times 0\ 2578,$$

and the force due to the current in the portion B C is

$$F_2 = \frac{A}{10} \times 0\ 6362.$$

Now, by an approximate formula given in the Paper referred to above,

$$F_2 + F_1 = \frac{A}{10} \times 0{\cdot}8865,$$

and it can be proved by elementary mathematics that

$$F_2 - F_1 = \frac{A}{10} \times \frac{2\,O\,P}{P\,B^2}$$

$$= \frac{A}{10} \times 0{\cdot}3750.$$

Therefore $$F_1 = \frac{A}{10} \times 0{\cdot}2557,$$

and $$F_2 = \frac{A}{10} \times 0{\cdot}6307.$$

The forces F_1 and F_2 have therefore been found fairly accurately by the graphical method. The above example

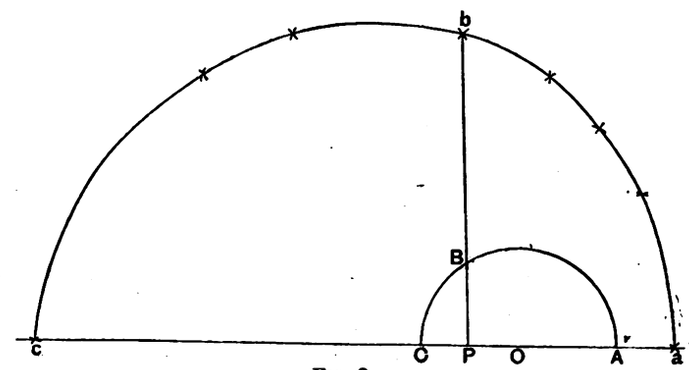

FIG. 2.

having been done very hurriedly is sufficient to prove that the method is capable of great accuracy.

An entirely mechanical method can also be used to solve the above problem. If we describe the inverse of the portion of the curve we are considering ($r\,r' = K^2$) by any simple mechanical arrangement, then

$$F = \frac{1}{K^2}\int r'\,d\theta. \quad . \quad . \quad . \quad . \quad . \quad (4)$$

From this, if we have an instrument that reads $\int r\,d\theta$, we can at once get F.

Mr. K. H. P. Powles has designed and made such an instrument. Its principle is that a little wheel always runs at right angles to r, and the distance of the wheel from the fixed origin is in a constant ratio to r. The instrument was invented to solve some integrals which occurred in certain problems we were considering; in fact, we could not solve them any other way. Applied to the particular case of a circle it calculates the value of elliptic integrals between any limits at once.* However, the former method is the one which will be found most generally useful, as no special instruments are required, it being easy to find the areas from the sectional paper used.

* The above problem is very easily solved by this integrator, for if we take $K^2 = 16$ the circle is its own inverse. Hence we have only to move the pointer over the portions B C and A B of the circle in Fig. 2, and divide the reading of the instrument by 16. The following values for F_1 and F_2 were obtained in this way:—

$$F_1 = \frac{A}{10} \times 0{\cdot}2556,$$

$$F_2 = \frac{A}{10} \times 0{\cdot}6313.$$

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WATER-TUBE RESISTANCES.

Resistances, whether intended to be used "rheostatically," to reduce the current in a given circuit, or on the C^2R principle, to absorb power, have, in common with most other heavy electrical apparatus, undergone of late a very rapid

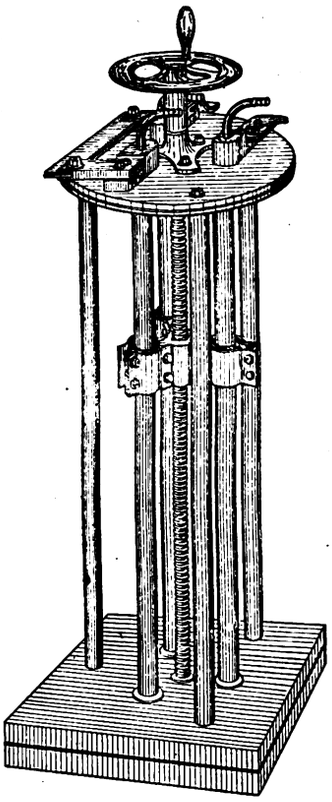

FIG. 1.—Perspective view of 5,000 ampere Water-Tube Resistance at the Board of Trade Standardising Laboratory.

process of evolution. In Fig. 1 we give a perspective view of a lineal descendant of that old and well-tried telegraph organism, the rheostat. The illustration shows a regulating resistance made by Mr. Crompton to Major Cardew's and Mr. Rennie's design, for use

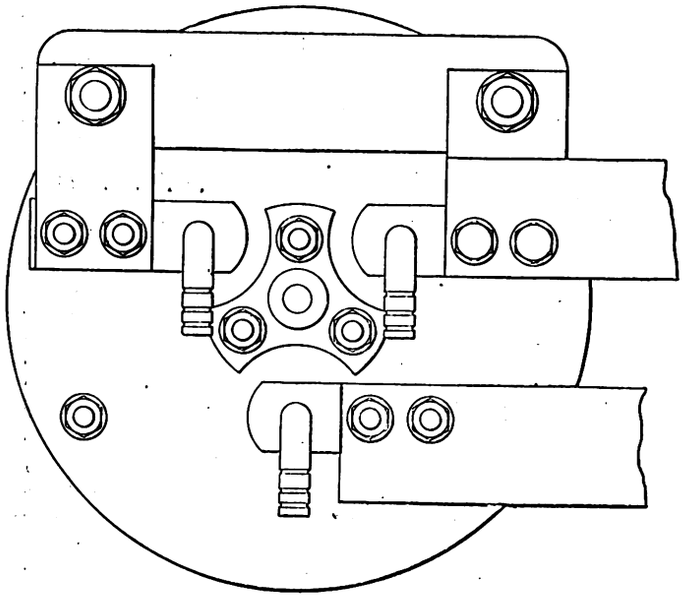

FIG. 2.—Plan of Top Connections of Board of Trade-Water Tube Resistance

in connection with the grand army of Kelvin balances quartered at the Board of Trade Standardising Laboratory. The overall dimensions of the apparatus are 3ft. 6in. high by 15in. × 15in., and its range is from 60 up to 5,000 amperes. It consists of three resistance tubes, 1 metre long, 35mm. in diameter, and 0·5mm. thick, two being of manganin (0·004 ohm) and one of copper. Through each current-carrying tube water is passed from bottom to top, carrying away the heat generated by the current, the density of which sometimes attains 30,000 amperes per square inch. These three tubes, as will be seen by the sketch, are arranged triangularly around the centre of the base. The three outer tubes are supports, and do not carry current. The current-carrying tubes are connected across by a travelling brush, adjustable by means of a screw and wheel. In Fig. 2 we give a plan of the top connections of the apparatus, as arranged at the Board of Trade Laboratory for regulating the current through the Kelvin balance circuit, the water-tube resistance being placed in series with the circuit containing the balances. The manganin tubes are placed in parallel with each other and in series with the copper tube. The whole

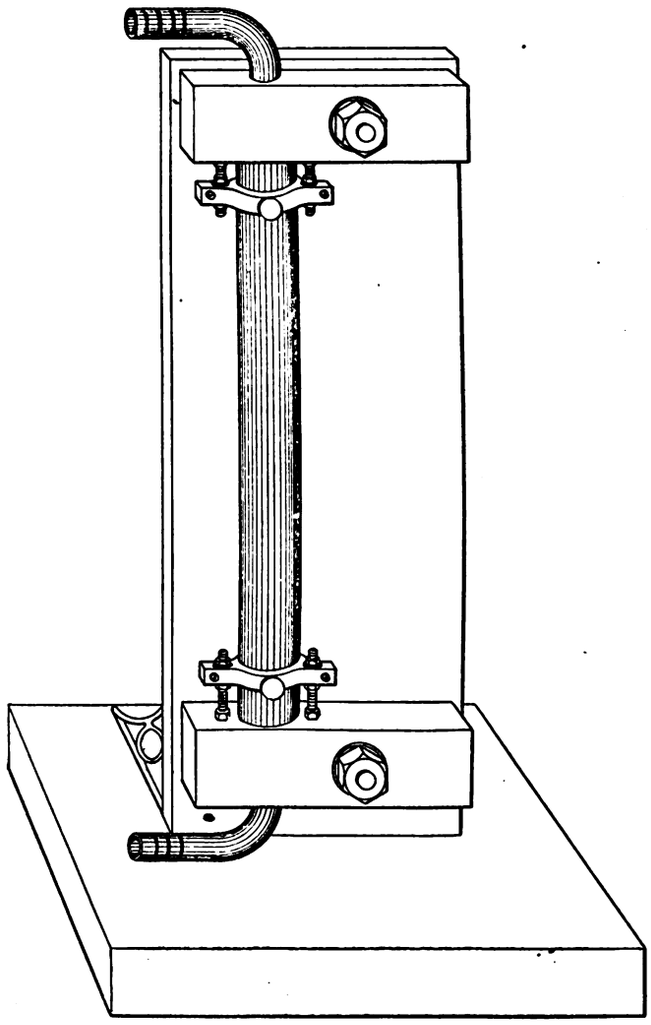

FIG. 3.—Perspective View of Standard Water Tube Resistance.

apparatus has been well thought out, and presents a very workmanlike appearance.

Mr. Crompton is also making for, anyone requiring them, a number of *standard* water tube manganin resistances. In Fig. 3 we give a perspective view of such a standard, shown us by Mr. Crompton's able assistant, Mr. W. C. Fisher; its resistance is a thousandth of an ohm, and it has therefore, with a current of 1,500 amperes, a potential difference of 1·5 volt between its terminals, the overall dimensions being base 11in. by 11in. and height 18in. In connection with potentiometer measurements of current a handy standard resistance of this type should prove invaluable. The water used in carrying off the heat generated by a current density of 15,000 to 20,000 amperes per square inch is obtained from the ordinary supply by means of a small rubber hose pipe.

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WESTINGHOUSE ELECTROMAGNETIC RAILWAY AUTOMATIC SWITCH.

In our issue last week we commented on the system of electromagnetically-controlled contacts, for electric railway and tramway traction, which has recently been developed by the Westinghouse Electric Company. We are now able to give to our readers two illustrations of the details of the mechanism by which any section of the track is placed in and taken out of connection with the feeders on the passage of a car over the section. Figs. 1 and 2 show the details of this electromagnetic device, and comprise all the mechanism that is placed in each of the switch boxes along the track. One such switch box must be placed in every length of track somewhat less than the length of a car, in order that each section may come into action a moment or so before the lapse of the preceding section.

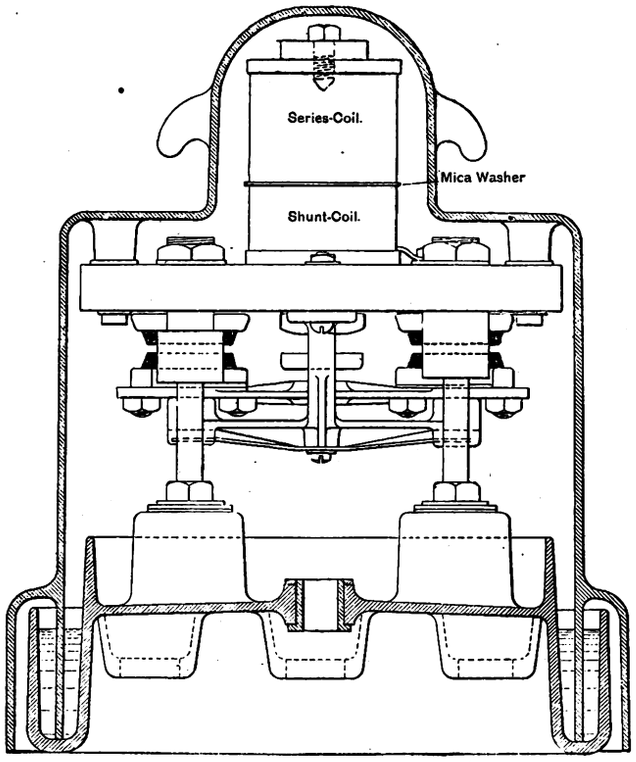

FIG. 1.

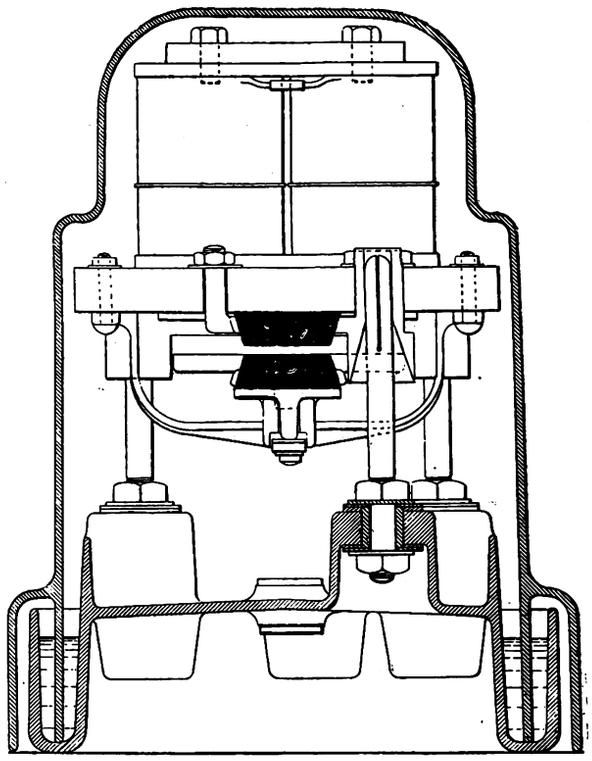

FIG. 2.

Where the cars are long, therefore, or where trailers or made-up trains will always be used, the sections may be of greater length, the number of switch boxes fewer, and the expense of these boxes less, than with small, short, single cars.

Each motor car is provided with a couple of small secondary cells; and when the car comes on to any given section of the track a current from these cells passes through a contact slider beneath the car, and through one of the two wrought-iron studs which project their well-rounded heads slightly above the ground between the two track rails; and goes to earth through a fine-wire coil wound on the electromagnet in the switch box which controls that section. Immediately, the electro-magnet is magnetised and lifts its armature, thereby bringing into contact the two pairs of carbon contact-pieces (which are shown black in the illustrations). One pair of these carbons is permanently connected to the feeder, and the other is continuously connected to the positive stud on the track, against which stud the positive collector bar of the car will by now have made contact. The negative collector bar under the car touches, at the same time, the other stud, which is connected to the return conductor. The lifting of the electro-magnet armature, and the consequent closing of the carbon contacts, therefore sends a current from the feeder through the car motors; and this current is also caused to pass through a short thick coil of few turns on the electro-magnet of the switch, thereby reinforcing the grip of the magnet upon its armature. Immediately the car passes off the particular section from which it has been deriving power, the opening of the contacts between the collector bars and the road studs will break both the power circuit and the auxiliary secondary cell circuit through the electro-magnet. At that instant, therefore, the magnet armature will fall, the carbon contacts will be separated, and the positive stud will no longer be in connection with the feeder. Thus all those road studs which are not in immediate use, and which are not by that fact lying directly beneath the cars, are not and in ordinary conditions cannot be at a dangerous electric potential, they being isolated from the live conductors of the system. The advantages of this, both from the standpoint of safety and of efficient insulation of the system, are sufficiently obvious.

The bare parts of the switch require to be maintained free from deposits of dust and moisture; and in order to ensure these conditions the whole of the mechanism is contained within a diving-bell shaped case, the lower edge of which dips into an annular oil seal. This construction is well shown in the illustrations, and it is one which very efficiently provides for the insulation of the mechanism.

THE BRIGHTON-ROTTINGDEAN ELECTRIC RAILWAY.

There is something almost morbid in the mania for novel sensations exhibited by seaside resorts, or rather by those who resort to the seaside. To be suspended from a steel hawser in a sort of basket and raced through the air just out of reach of the waves, a form of amusement much affected in America, is a tolerably novel experience. At Brighton, however, Mr. Magnus Volk, if he is allowed his way, proposes something scarcely less unconventional. Mr. Volk's idea is to run the steel structure shown in the illustration overleaf *through* the water from the far end of his well-known little electric tramway to Rottingdean, a total distance of exactly 3 miles; 4 furlongs 8 chains of which are within the jurisdiction of the Brighton Town Council. Hence the tears, to which reference is made in another column. The main object of the line is doubtless

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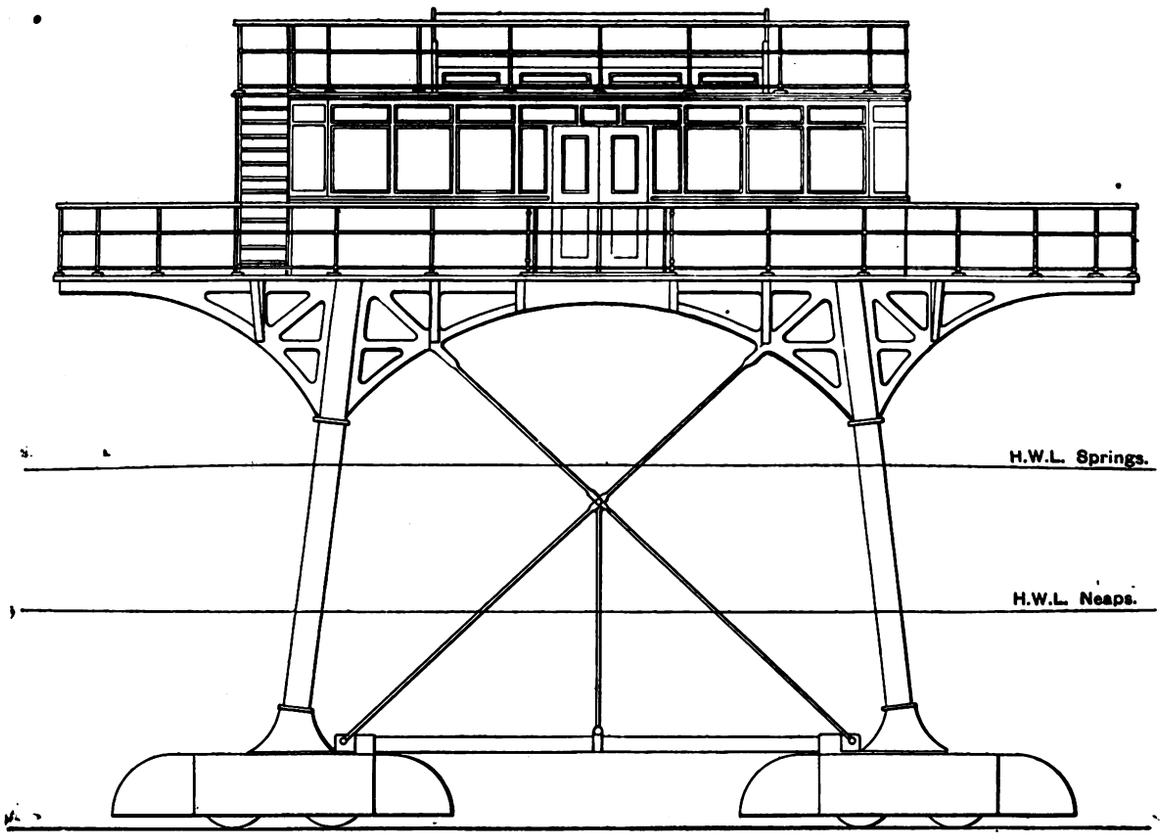
to attract traffic by the novelty of running through the waves in a sort of hybrid tramcar-lifeboat conveyance. There is, however, no little justification for the tramway purely as a means of "rapid transit," as our American friends would term it, between Brighton and Rottingdean. The road is tortuous and uninteresting, and the "'bus" is slow; the proposed line is straight, and in the matter of speed and of interest should leave little to be desired. If the weather during the next six months is not altogether unpropitious, and the opposition of the Town Council is overcome without delay, it is expected that the line will be at work by June next; already all but a few hundred yards of the track has been laid.

The rails run along the foreshore at a distance of about 150 to 250 yards from the base of the cliff, slightly above low-water mark; at high tide they are covered by 14ft. of water. Instead of two rails connected by tie-rods, there are two *pairs* of 54lb. rails, a distance of 18ft. intervening between the two outers. Each pair of rails (2ft. 8½in. gauge) is laid separately, on concrete blocks mortised to the chalk below. In 1893, when the Act was obtained, the chalk was covered in some places by a layer of sand 3ft. thick. During the storms of last winter the sand was all swept away, to be subsequently slowly silted up again. The steepest gradient is 0·3 per cent.; the sharpest curve has a radius of half-a-mile.

The car, which was designed by Mr. St. George Moore, joint engineer to the Company with Mr. Volk, is being built by the Gloucester Waggon Company. It is supported by four splayed-out legs, each leg consisting of a 12in. steel tube, running on a four-wheel bogey. The wheel base is 28ft. Each of the two leading bogeys will be driven off vertical shafting inside the tube by a 30 H.P. vertical motor, to which current will be conveyed on the overhead trolley system at a pressure of 500 volts. The deck of the car will be 24ft. above the rails, and will measure 50ft. by 22ft.; it will carry a saloon 25ft. by 12ft. The structure by itself will weigh 40 tons, and, with motors, gearing, and 150 passengers, the total weight will be 60 tons. The speed expected to be realised is six miles an hour.



Elevation of Latest Pattern Car.

The Brighton-Rottingdean electric line presents several exceedingly interesting electrical and mechanical problems, and engineers will wish Mr. Volk every success in his new venture.

THE BRIGHTON TOWN COUNCIL AND THE ROTTINGDEAN ELECTRIC SEASHORE RAILWAY.

As the dispute between the Brighton Corporation and Mr. Magnus Volk is a matter of more than local and personal interest, involving as it does the important question of the relative merits of electric and gas motors for traction purposes, we give in full the reports on the subject presented at last week's meeting of the Town Council by the Borough Surveyor and the Borough Electrical Engineer, together with the comments of the Brighton and Rottingdean Seashore Electric Tramroad Company and the Report of their Engineer; we also append a brief abstract of the proceedings at the meeting of the Town Council on Thursday, October 31st:—

BOROUGH SURVEYOR'S REPORT.

In obedience to your command to place before you all the facts relating to the construction of this tramroad, I beg to say that when the promoters first submitted for your consideration the Bill by which they proposed to seek for Parliamentary powers to construct their tramroad, and the plans which are always deposited with such Bills, your Committee were distinctly informed:—

1. That there would only be two lines of rails, about 26ft. apart.
2. That these rails would only project 4in. above the surface of the chalk, or sand, forming the foreshore or beach.
3. That the line would not interfere in the least degree with the construction of any new groynes, as it could easily be carried over any such groyne, or round the south end of it at any point.
4. That the car would be of light construction.
5. That the car would be easily driven by electricity from accumulators carried on the car.

If these arrangements had been adhered to there would have been—

(*a*) Practically no risk to bathers or boats.

(*b*) The groyne at Black Rock would have been constructed as originally designed and approved by the Town Council solely as the best method of protecting the eastern foreshore.

(*c*) There would have been no obstruction to the free use of the sea, nor anything visible above the water.

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The original proposals have been departed from in the following particulars:—

1. There are four lines of rails about 18ft. wide between the outside rails.

2. Without having first obtained the sanction of the Town Council, the minimum projection of the rails above the chalk has been raised from 4in. to 18in., and rises from this to 2ft. 3in. at Paston-place groyne; but the consent of the Council has been obtained, on the recommendation of your Committee, to raise the line to 3ft. above the chalk at Black Rock groyne.

3. By the special request of the Company, and on the recommendation of your Committee, the Town Council has agreed that the concrete groyne at Black Rock shall be reduced from 7ft. 6in. to 3ft. solely for the accommodation of the Company, to enable them to carry their line over the groyne, instead of constructing it in low water beyond the south end of the groyne.

4. The car and the gantry on which it is carried, as it is now being constructed, is designed to carry 150 persons, and is estimated to weigh when finished upwards of 40 tons, exclusive of the weight of the motors and driving gear, and of the weight of the passengers. The total weight of the car and passengers will therefore probably be little short of 60 tons.

5. It is the intention of the Company to abandon the use of accumulators, and to drive the car by overhead wires carried on poles, a method know as the "trolley system," if the Council will give their assent to the proposal.

The effects of these deviations from the original proposals are—

(*a*) The lateral obstruction caused by the rails is doubled.

(*b*) The additional height of the rails is likely to be a source of danger to bathers and to boats, when hidden from view by shallow water only.

(*c*) The reduction of the height of the groyne at Black Rock as originally designed, although perhaps unimportant at the present time, may in future years seriously detract from its usefulness.

(*d*) The increased weight of the car and its gantry will make it of such unwieldy and ponderous proportions that it will have a very different appearance to that of the little elegant toy car at first proposed to be used by the Company, and of which a model was submitted to you. You will gather some idea of the proposed car if you will realise that it will be equal to the weight of five or six steam road rollers or of an ordinary railway steam locomotive.

(*e*) The proposed poles and overhead cables are likely to be an obstruction to the sailing craft at high water, in rough weather and at night, owing to the poles and wires being invisible.

With regard to the application of the Company for your permission to erect within the borough thirteen cast-iron poles 21ft. above the high water line, with arms 4ft. long, to carry two lines of cable, or overhead wires, for the purpose of driving the car by what is known as the "trolley system," you instructed me to confer with the Corporation Electrical Engineer, and to call in other expert assistance if we required it, to consider whether the overhead wire system is the only one that can be adopted by the Company. I beg to say that we have conferred together as directed, and your Electrical Engineer will send in his special report upon the subject of electric traction, and its method of application; also as to the practicability of adopting a motive power other than electricity, in order to avoid the use of overhead wires; therefore I need not refer to that part of the subject.

It is, however, within my province to report to you that, in considering the subject from a broad or general engineering point of view, it was necessary that we should be supplied with further information respecting the scheme than that which had already been furnished. I therefore put the following questions in writing to the Engineer of the Company, but I have not yet received any written replies thereto:—

1. What is the weight of the proposed car?

2. At what speed will it be driven?

3. What is the maximum horse-power required to drive it at any part of the line at the time of high tide?

4. On what data is this power estimated?

5. Send a detailed drawing of the car, with the motors and trolley attached.

The Company's Engineer and their Electrical Engineer, however, afterwards called together to see your Electrical Engineer and myself. They courteously offered to give us all the information they could, and we elicited from them at the interview that it was impossible for them to give us definite information in reply to the questions I had put to them, because, as the project is entirely a new departure in engineering, there is no known data or formula on which they could base their calculations. They assured us they had done their best to arrive at correct conclusions from their own experience, and such other information they possessed as could be applied; but, at the same time, frankly confessed that their conclusions are, to a great extent, problematical, and that it is by experience only, after actual experiments made on the line, that more reliable information can be obtained or given.

I quite believe this to be the true state of the case, and in view of the facts that the Company have found it necessary to depart entirely from the first arrangements—that they have no reliable knowledge that the present proposals are workable—that they need knowledge which can be gained only by actual experiments—that your Electrical Engineer is of opinion that a motive power other than electricity may, in practice, be found better and cheaper than electricity—and having been informed by the Company's Engineers that neither the engines, dynamos, poles or wires have yet been ordered, I recommend your Committee to endeavour to make an arrangement with the Company for them to complete so much of their line as is outside the borough, and to make their experiments thereon. This line is 2 miles 2 furlongs 2 chains in length, and, therefore, affords sufficient scope for the purpose. The line within the borough is only 4 furlongs 8 chains in length, and could be easily finished when the Company had ascertained all the necessary particulars for working it successfully. These experiments and their results would afford your Committee and the public an opportunity of forming a correct opinion as to whether the project is likely to be beneficial or prejudicial to the interests of Brighton.

COMPANY'S NOTES *RE* SURVEYOR'S REPORT.

2. This was an impossible condition imposed in the Corporation Protection Clauses, owing to the undulating surface of the chalk and the shifting sand, and was not in our original Bill at all.

(*a*) The line as constructed does not cause any additional risk either to bathers or boats.

(*b*) The following letters will show the site of the line was moved to allow the new groyne as originally designed to be constructed, and the line as now laid is 100ft. from the timber groyne, and that it was an amended proposal, of which we had no notification for twelve months afterwards, that caused all the difficulty.

(*c*) The poles would be a distinct advantage as indicating the position of the line.

1. The total width of the line is now only about 16ft., instead of 24ft. as originally intended.

2. The words "or sand" which are in our Act have been omitted after the word "chalk." The line was laid to conform to these conditions as far as possible; but the sand was withdrawn by gales when the Surveyor measured the work. Since then, on two occasions, the rails have been covered with sand. A photo, showing the sand level with the rails, will, if possible, be in the Council Chamber.

(*a*) The rails being at one level, the lateral obstruction is the same whether two, four, six, or any other number be laid.

(*e*) With regard to this matter, the wires would be erected high enough to clear all small sailing craft. The submerged ends of the groynes, which project considerably further to sea than the line of rails, would cause all vessels to keep a course far outside them; whilst in stormy weather, when the whole shore is covered with breakers, a vessel getting within their influence would be wrecked any way, and the poles and wire would offer no obstruction to her coming ashore, and as at such times no current would be in the wire, no inconvenience could arise from this cause.

BOROUGH ELECTRICAL ENGINEER'S REPORT.

As requested by your Committee, the Borough Surveyor and myself have carefully considered the new proposal of the Rottingdean Tramway Company for driving their car, and we agreed that it would be well for us to put our views in the form of two separate reports.

I therefore beg to state that, judging as best I can from the unfortunately very scanty information obtainable from the Engineers of the Company as to the horse-power required by a car running under such novel and difficult conditions, I am of opinion that, as steam power is considered by the Corporation to be inadvisable, the only two remaining systems known to me, by which there is any probability that such a line could be worked so as to be a mechanical and, possibly, a commercial success, are:—

First, the ordinary trolley overhead wire electric traction system, as used in America, Bristol, and other places.

This method, although it involves the use of overhead wires, has the advantage of great flexibility, in that an almost unlimited amount of power can be conveyed to the motors on the car. I consider this, under the circumstances, a great advantage, as it appears that only the most hazy ideas are obtainable as to the horse-power required to drive the tramcar through the water at anything like a reasonable speed. Other advantages are that the trolley system has been well tried and worked out, and is very cheap to instal.

Second, the compressed gas-motor system, as about to be used at Blackpool and in use on the Continent, in which the necessary gas is carried in tubes under the car in a compressed state.

This method has the great advantage over the first of being practically self-contained. Theoretically, it certainly ought to be cheaper in initial cost and maintenance than the other system, and, considering the particular line of route, I am not aware of any feature which would render it unsuitable for the tramway in question.

In my opinion it is quite possible to drive the car by the ordinary electric accumulators, but I consider this system to be unsuitable by reason of its much greater expense, both initial and maintenance, than either of the other two systems, and I do not consider that any combination of the electric accumulator and trolley systems could be satisfactorily worked in practice, as there are serious technical difficulties involved in the suggestion of working the car by accumulators while in the Brighton Borough, and the trolley system when beyond it.

Owing to the impossibility of ascertaining the horse-power required to drive the car with its full complement of passengers, as neither the weight to be moved nor the amount of resistance due to wind and water or other friction appear to have been ascertained, and as no drawings have been submitted to me showing the proposed method of driving the wheels from the motors, I am quite unable to express a more definite opinion as to the practicability of the project beyond stating that I think it would be quite as possible to drive the car by compressed gas as by the overhead wire trolley system, especially as I understand it is only intended to run one or, at the most, two cars.

The Committee report that they have also received communications from Sir Albert Sassoon and Colonel Wilson, stating that they have no objection to the carrying out of the proposal, and from Mr. Mellor, on behalf of the Kemp Town Enclosure Committee, objecting to the erection of the poles.

The Committee submit the application of the Company for the decision of the Council,

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REPORT OF THE ENGINEER TO THE BRIGHTON AND ROTTINGDEAN SEASHORE ELECTRIC TRAMROAD COMPANY.

GENTLEMEN: In accordance with your instructions, I herewith beg to report on the subject matter of the report of the Works Committee to the Town Council as follows:—

With reference to the gauge of the rails being altered from 24ft. to 18ft., and the number of lines of rails being increased from two to four, I beg to point out that these alterations were sanctioned by the Corporation prior to the commencement of the work.

The alteration in the level of the rails was rendered necessary by the height of the sand while the works were being carried out. The Borough Engineer stated to the Works Committee on their visit to our works that, judged from an engineer's point of view, he did not consider the rails had been laid one inch higher than was necessary to enable the line to be worked.

I beg to enclose with this report two drawings to the same scale, A being the "model car" referred to by the Borough Engineer, and B the car as now being constructed.

I beg further to report that on the 15th inst. I received a letter from Mr. May, asking for certain information as regards the car, and in order to save time I went to Brighton on the 15th inst., saw Mr. May and Mr. Wright early on the 16th inst., and gave them the following replies to their questions:—

Q.—What is the weight of the proposed car? *A.*—The weight of the structure would be about 40 tons, and the weight of the electric machinery and people would bring it up to from 55 to 60 tons.

Q.—At what speed would it be driven? *A.*—We expected that the power we proposed putting on board would enable us to travel at an average speed of six miles per hour.

Q.—What is the maximum horse-power required to drive it at any part of the line at the time of high tide? *A.*—That we proposed putting two 30 H.P. motors on the car, which in our opinion would suffice.

Q.—On what data is this power estimated? *A.*—On the resistance (1) due to traction on the level, (2) due to the greatest incline, (3) due to the curve, (4) due to the wind, (5) due to the water, (6) due to the skin friction.

Copies of the drawings sanctioned by the Board of Trade were handed to them the same day. Pending the settlement of the question now before the Corporation, detail drawings of the electrical arrangement have not as yet been made, so I was unable to supply them with these, but at the same time explained that the trolley pole would be as sanctioned by the Board of Trade for the Bristol Tramways.

I did not understand from Mr. May that he wished me to repeat this information in writing.

I cannot understand what experiments Mr. May desires should be made outside the Borough boundary, and what object would be gained by the stoppage of the works within the same.

In reference to this I must point out to you that owing to the short time the work within the borough boundary is uncovered by the tide, we have only been able to complete 50 yards of the line between September 5th and October 21st, so that any further stoppage of this portion of the works would render it impossible to complete the same within the time allowed by the Act of Parliament which expires in July next

The only point which now remains to be determined is what speed will the car travel at with a certain amount of power.

The great flexibility of the overhead wire system (as stated by Mr. Wright, the Electrical Engineer to the Corporation) in that an almost unlimited amount of power can be conveyed to the cars, coupled with the following facts—

(*a*) The system has been well tried and worked,

(*b*) The large range of power that can be obtained from electric motors,

(*c*) That the motors can easily be changed,

are the reasons which had led the advisers to the Company to adopt this system, thereby ensuring that there will be sufficient power available to drive the car at a satisfactory speed.

With reference to Mr. Wright's (the Electrical Engineer to the Corporation) suggestion as to the adoption of gas engines, this method of driving was carefully considered prior to applying to the Corporation on May 14th for permission to temporarily use steam, and was abandoned for the following amongst other reasons:—

1st. No gas engines for traction purposes have been made approaching the power required.

2nd. The vibration in the compressed-gas motor cars to which Mr. Wright refers, although the motors are close to the ground, is considerable; therefore it is evident that if motors ten times the power of these were placed on our high car, the vibration would be so excessive that passengers would not travel on it.

3rd. The objectionable smell and noise.

4th. Serious mechanical difficulties in reversing and starting in the case of large powers, and where the inertia of our large car would have to be overcome.

5th. The manufacturers, although willing to make an engine of sufficient power, would not, on account of the above-mentioned difficulties, undertake any liability as to the effective working of the arrangement.—Yours obediently, (Signed) R. ST. GEO. MOORE,

Engineer to the Company.

MEETING OF THE BRIGHTON TOWN COUNCIL, OCTOBER 31ST.

Alderman BRIGDEN moved that the Report of the Works Committee on the application of the Brighton and Rottingdean Seashore Electric Tramway for leave to erect steel poles on the foreshore from Paston-place eastward be entered on the minutes. The Committee, he pointed out, made no recommendation, but left the matter entirely in the hands of the Council. He wished the Council, however, to understand that the Committee to a man had no hostility to the electric railway. It was a unique and novel venture, and they were all desirous of seeing it carried out satisfactorily.

The motion was put and carried.

Councillor BOOTH moved the following resolution: "That the application of the Brighton and Rottingdean Seashore Electric Tramroad Company, dated September 23rd, for permission to erect 13 tubular steel poles 80 yards apart on the foreshore between Paston-place jetty and the borough boundary at Black Rock, for the purpose of carrying the electric trolley line, be, and is hereby granted, provided that the Company pay a rental of £1 per annum, and enter into a covenant to remove the poles on receiving three months' notices." He contended that the railway would be of the utmost benefit to the town, and would bring people to Brighton from the ends of the earth. Only a sixth of the whole line was within the jurisdiction of the Council, and he maintained that as the Board of Trade had more knowledge and greater responsibility in the matter than the Council, they would have been the first to raise objections if there had been any of a substantial character. As to the changes that had been made in the plans, he contended that they were essential in any invention.

Alderman ABBEY urged that the present scheme was a complete departure on the part of the Railway Company from the old scheme that was partially assented to by the Town Council. It embraced all the objectionable parts of the old scheme, and now was added these poles and the overhead wires, the result of which would be that the inhabitants of Brighton would be deprived of a quarter of their foreshore. The foreshore of Brighton was nearly 4,000 yards in length, and it was proposed to destroy the use of it for about 1,000 yards. In granting this the Council should have some guarantee, some security in the way of a deposit, that in the event of a railway not being carried out the *débris* would not be left, probably for years, as a monument of their foolhardiness. His amendment was that the application be granted conditionally on £1,000 being deposited as a security for the whole of the *débris* being cleared away if the railway did not answer, and that the whole matter be referred to the Works Committee to carry out. After some little delay Alderman ABBEY put his amendment in this form: "That the motion be amended by adding the following words: Provided that the sum of £1,000 is deposited by the Company with the Corporation by way of security for the removal of the tramway in the event of its being abandoned at any time hereafter, and that the details as to the application of such security be embodied in an agreement to be approved by the Works Committee."

Councillor DANIEL said Councillor Booth entirely ignored the fact that the Surveyor had, at the request of the Committee, reported on this application, and had practically told them point blank that they would be doing a very foolish thing if they granted this application.

Councillor GEORGE pointed out that the Council had already granted the Company the power to raise their line 3ft. above the proposed groyne. That might be a very great obstacle to the boating interest, but it had been done.

Councillor SUTTON said he supported the application almost entirely on the two reports furnished by the Council's own officials. The reduction in the height of the groyne was a matter already settled by the Council; and, moreover, he thought it unfair to press for the Company being bound down to full details when the Surveyor admitted in his report that it was at present impossible to give them. But in the report of their own Electrical Engineer the Council would find all the justification necessary for granting the application. Mr. Wright said the trolley system was the best means to work the line to ensure financial success.

Councillor BLAKER said if the 13 poles had been in the original proposal, it would never have been listened to, and he considered the present scheme a violation of the rights of the people.

Councillor DUTTON BRIANT said he found in an inspired article on the railway that the sand had shifted very much since the commencement of the undertaking, from which one might fear alteration in the future that would seriously affect the railway. Then the lines, he understood, were placed on concrete blocks "mortised into the rock." But the only rock was chalk, and with the vibration of a 60-ton car going over them, was there any likelihood of the concrete blocks being able to hold on? He was anxious to see the railway a success, but these objections, in his mind, would have to be removed before he could support the proposal at all.

Alderman MOON said that Mr. Wright, instead of recommending the trolley system, really recommended the gas motor system. He reminded the Council that in the first instance the promoters said the car would be run by means of accumulators. This, it turned out, was not impossible, but would probably prevent the railway being a commercial success. This was not the fault of the Council, nor of the Works Committee. They naturally supposed that when gentlemen commenced an undertaking they counted the cost, and did not begin until they knew they could finish. It seemed to have dawned on the promoters in some way that the car, instead of a light thing, would have to be 40 tons in weight, or with passengers and motors 60 tons. That was not the fault of the Council or the Works Committee. Then the Company raised their rails from 4in. to 18in. without any notice to the Corporation, and now they asked for leave to erect thirteen steel pillars of a considerable height with brackets to carry a cable about ½in. diameter, probably with suspending cables. It was not only a question of the danger to boating and bathing, but of how far this was going to interfere with the beautiful view.

Alderman REEVES suggested for the consideration of the Council whether, at a private meeting of the Council in about a fortnight's time, with the Electrical Engineer, the Surveyor, and the Engineer to the Company present, they would not be able to arrive at a better understanding on the matter, and a more just conclusion than at present. After some hesitation, Councillor BOOTH accepted this proposition, and

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amendment and resolution were withdrawn by leave of the Council. On the motion of Alderman REEVES, it was then formally decided that the debate be adjourned to a convenient time, about a fortnight after the election of the new Council, that the Company be invited to send their Engineer, and that the Borough Surveyor and Electrical Engineer attend.

THE ELECTRIC LIGHTING OF EDINBURGH.*

BY HENRY R. J. BURSTALL.

(Concluded from page 18.)

The arrangement of the switchboard and conductors is as follows: The feeders enter the building at a cellar under the pavement on the west side, and are brought along the wall under the platform in the form of heavy copper rods, which are carried on insulators, and pass up through the floor to their respective terminals at the back of the switchboard, and are attached to the terminals at the top of the board by cones and nuts. They are connected, through a duplex fuse and an ampere-meter, to heavy vertical copper bars on the front of the slates, each bar having three holes in it, through which plugs can be inserted. The leads from the dynamos are carried in the form of insulated cable to their respective terminals at the back of the board, near the bottom; and through fuses, automatic switches and ampere-meters are connected to vertical copper bars fixed to the front of the slates, similar and parallel to the feeder bars. The automatic switches are so constructed that the switch, after being closed by hand, is held in place as long as the current flowing through it exceeds from 15 to 20 amperes; should it fall below this, a trigger is released and the switch is automatically opened, thus breaking the circuit and preventing damage if a machine should fail from any cause. Three heavy copper "omnibus" bars are fixed horizontally at the back of the three outer slates on each side, and are capable of being connected to any of the feeder and dynamo bars of that side by means of heavy copper plugs, which are inserted through holes in the vertical bars and slates, and screw into the omnibus bars at the back, the contact being made on the front bars by a faced collar. The feeders under ordinary circumstances are all connected to the top omnibus bar, and are all in parallel. In order to connect any dynamo to the feeders, plugs are screwed into the top holes of the vertical bars corresponding with that dynamo, the brushes of the machine are put down upon the commutator, and the stop valve of the engine is fully opened so that the engine is running on its governor; the switchboard attendant regulates the electromotive force of the machine until it is equal to that shown on the voltmeter between the top bars, and then closes the automatic switch, putting load on the dynamo by taking resistance out of its field circuit. During the whole time the machine is on circuit it is regulated by the switchboard attendant, the engine running on its governor with the stop valve full open; the engine driver has to attend only to the running of the engines and dynamos. For the sake of economy, however, the engines are run somewhat slower at low loads than at full load; after about three-quarters of the full load has been reached, the setting of the governor is altered, and the engine run at full speed. In order to take the machine off circuit, resistance is put into the field circuit until the current falls so low that the automatic switch opens; the driver then lifts the brushes out of contact, and shuts down the engine.

Balancing Machines.—The foregoing description applies only to the high-volt machines; the connections for the balancing machines are somewhat different (Fig. 3). The leads for each of these dynamos are connected—through fuses, ampere-meters, and automatic switches, as for the high-volt machines—to two contacts of a double-pole switch on the centre panel; and can be connected alternatively with two of three contacts, one of which is connected to the middle wire and the other two to dynamo bars on the positive and negative sides of the switchboard respectively. Thus each balancing machine can be put between the middle wire and either the positive or the negative side of the switchboard. These machines are run in exactly the same manner as the high-volt machines, and the whole of their regulation is done from the switch platform.

In the circuit of each dynamo is a registering ampere-hour meter, from which are taken readings whenever the machine is started and stopped; and the station records of the units generated are made up from these readings. Voltmeters are provided, which can be connected to the terminals of each dynamo by means of multipolar switches; other voltmeters are also connected, so as to show the electromotive force between any of the omnibus bars on the positive and negative sides, and also between the omnibus bars and the middle wire. A pair of voltmeters are fixed on the upper part of the centre slate, and are connected through multipolar switches, so as to show the pressure between the middle wire and the positive and negative wires respectively at any feeding point on the system; and for this purpose light wires are brought back from the feeding points. The switchboard attendant is thus able to know directly the electromotive force on the distributing mains; and regulates the electromotive force at the switchboard so as to keep this constant.

The two lower horizontal omnibus bars can be connected by plugs to any feeder or any dynamo; by this means it is possible to run any feeder or feeders at a higher or lower electromotive force than the others, should occasion arise. The same two bars are also used for testing, and for the introduction of standard instruments into the circuit of any feeder, dynamo, or battery, for the purpose of checking or calibrating the switchboard instruments without breaking any permanent connections or running the circuit on temporary connections. The instrument or standard resistance, &c., is connected between two of the omnibus bars, and the dynamo or feeder, &c., is plugged on one of the lower omnibus bars; the current passes through the resistance, &c., to the top bar, which is on the outside circuit. In the actual running of the station considerable use is made of these spare omnibus bars.

Battery.—In ordinary circumstances the two outer ends of the batteries are plugged on to the top omnibus bar on the positive and negative sides of the switchboard; but can be disconnected either by removing the plugs or by the emergency switches. One of the cells near the inner end of each battery is connected with the middle wire through the regulating switch. Save under exceptional circumstances, however, the electromotive force of the whole battery in series would be much too high for the circuit; and therefore by means of a regulating switch any number up to twenty-six of the inner cells of each battery can be put in parallel with the inner cells of the other battery, thus keeping the electromotive force of the battery the same as that required at the omnibus bars to which the feeders are connected. When the dynamos are running, the battery-regulating switch can be set so that no current is passing into or out of the battery: putting more cells in parallel will lower the electromotive force of the battery, which will then be charged by the dynamos; while putting fewer in parallel will raise the electromotive force of the battery, and cause it to discharge and thus to help the dynamos. Under normal circumstances the battery is charged while the load is light, more or less current being put into the battery as the load on the external circuit varies so as to keep the engines running at that time as fully loaded as possible. During heavy load the battery is kept as far as possible with no current going either into or out of it; only after the dynamos are stopped is it discharged at all heavily, or when the load suddenly rises, and then only for short intervals. This method of regulating the battery by putting the centre cells in parallel, which is due to Mr. B. M. Jenkin, necessitates connecting up to the regulating switches more cells than the usual arrangement of regulating by cutting out cells on the outer ends of the batteries; but it renders the manipulation of the battery much more simple, and does away to a great extent with the somewhat troublesome charging of the back cells, that is to say, the cells at the outer end of the batteries, which also in the usual arrangement may be used for only a few hours or even only a few minutes in the day, while they have always to be charged and kept ready for work.

Battery Connections.—The connections to the battery may appear somewhat complicated, but in actual work the regulation of the battery is effected by moving only one wheel like a steering wheel, fixed on the middle slate of the switchboard. The switches themselves are placed in the battery room above, and are worked by wire ropes from the wheel below. A special circuit and switch is provided, by which the cells that are in parallel can be charged independently of the rest of the battery; but in actual work this is not regularly used. In this arrangement of battery regulation the whole of the cells in the battery are always used, but the centre cells are not charged or discharged to such an extent as those which constantly remain in series. By properly choosing the time of charging, the regulating cells can receive rather more charge than they discharge; and in order to enable the charging to go on at light load, when there is only a small drop on the feeders, the "hospital" or "milking" cells are connected up, as shown in the diagram, four on each side of the system, through two small switchboards on the switch platform. By suitably arranging the switches these cells can either be put in series with the main battery, or be put between the dynamo charging the battery and the feeders; in the latter case part of the current goes to the battery and part on to the circuit. The electromotive force of the dynamo charging the battery can thus be made higher than that required at the station end of the feeders; and the battery can be charged with more of the regulating cells in series than would be possible if it was in parallel with the circuit. This arrangement has the additional advantage that full use can be made of the hospital cells, which are usually standing idle unless any cell in the battery requires assisting. When used for this last purpose, the hospital cells are cut entirely off the circuit, and are put, two in series, in parallel with any cell which shows signs of weakness

* Paper read before the Institution of Mechanical Engineers.

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during the discharge of the main battery; connections are made from the hospital-cell switchboards in the engine room to terminals in the battery room, and adjustable resistances and ampere-meters are put into each of these circuits, so that the current passing from the hospital cells to the weak cell can be regulated, and is always under control of the switchboard attendant.

Battery Room.—The battery room is directly over the west end of the low-tension engine room (Fig. 2), and is reached by a spiral staircase directly from the switch platform. It has a fire-proof floor covered with acid-resisting asphalt, and is well lighted and ventilated, having windows on both sides of the room, as well as a ventilator in the ceiling. The battery consists of 132 cells of the new Crompton-Howell 31-plate type. It is divided up into two half-batteries, positive and negative; and is arranged in two tiers on four rows of stands, which are of cast-iron, with wooden longitudinal bearers carrying the cells; the eight hospital cells are arranged on separate stands. All the cells are similar, and have each a nominal capacity of 1,000 ampere-hours, the normal rate of discharge being 200 amperes. They are contained in lead boxes, and stand on glass oil insulators upon the longitudinal wooden bearers. The 26 cells in each half nearest the middle wire are connected up by solid copper rods with the regulating switchboard, which stands directly over the main switchboard below. Provision is made for a second battery of similar size, should it be necessary in the future. In the battery circuit there is a registering ampere-hour meter between the outer end of the battery and the switchboard, so connected that its pointer goes backwards on the dial during the charging of the battery, and forwards during the discharge. The mechanism is such that the pointer is 10 per cent. slow on the charge; thus, if the pointer is always brought back to zero by charging the battery, 10 per cent. more current will be put into the battery than is taken out. This percentage can be altered from time to time, as may be judged necessary. The regulating switchboard is connected up to the battery bars on the main switchboard, which are similar to the dynamo bars, and is also connected up to the middle wire. These connections, as well as the special connections for charging the parallel cells and for the hospital cells, are carried in the form of bare copper rods by insulators on the engine-room wall to their respective terminals. The battery has ample capacity to meet the whole of the load of the station from daylight till the evening; thus during the summer time it can do the lighting during more than half the whole 24 hours.

High-tension Engine Room.—The high-tension portion of the station consists at present of only two engines and alternators with their switchboard (Figs. 2 and 3), and the rectifiers for arc lighting with their regulating arrangements and switchboard; but in the immediate future this plant will be considerably extended. Each of the alternators is driven direct by a Willans three-crank engine of 150 I.H.P. on the same bedplate. The alternators are of the "Portsmouth" type, with some modifications necessary owing to their increased speed of 450 revolutions per minute. Their armatures are stationary, and are of great strength; the core, consisting of sheet-iron segments, is solidly bolted into the framing of the machine, with the coils threaded through holes in the sheet iron, well insulated, and completely enclosed in brass boxes. The field-magnets revolve, and consist of two heavy cast-steel discs, having on their circumference claws projecting sideways alternately over the field winding, which is between the discs, and is well protected from injury. The exciting current is taken from the low-tension switchboard at 230 volts, and is only a few amperes. The alternators work at an electromotive force of between 2,000 and 2,200 volts, with a frequency of 52½ complete alternations per second. The main leads from the alternators, which are concentric, as well as the leads for the exciting current, are taken to the switchboard in chases similar to those in the low-tension engine room. The arrangement of steam, exhaust, and drain pipes is similar to that already described for the low-tension engine room.

Switchboard.—The switchboard stands on the switch gallery (Figs. 2 and 3), and is built up of slabs of slate, forming shelves projecting from the west wall of the engine room, and divided up into compartments for each alternator and circuit by slate partitions. The outer pole of each circuit and each alternator is connected to an earth plate at the station, the whole of the rest of the system being insulated from earth; owing to this arrangement all the switching can be done on the inner pole, which renders the switchboard and its manipulation very simple. The inner pole of each alternator and each circuit is connected to two similar switches through ampere-meters and fuses, and can by these switches be connected to either or both of two omnibus bars at the top of the switchboard. In this way any alternator and any circuit can be connected, and the system can be worked at two different electromotive forces if necessary. The primary object of this arrangement, however, is to enable a machine to be thrown into circuit rapidly, by running the machine up to full volts on one omnibus bar, and changing circuits over from the other omnibus bar, on which the other machine is running, without having to synchronise the second machine; the two omnibus bars can then be synchronised, the alternator and circuits changed over at leisure, and all the circuits and alternators run in parallel. In the outer circuit of each alternator is connected a registering watt-hour meter for measuring its output. Voltmeters are connected between both of the inner omnibus bars and the outer omnibus bar; and duplicate synchronising transformers with lamps and switches are provided between the two inner omnibus bars. In the exciting circuits are ampere-meters and regulating resistances, the switches of which are placed opposite the switches and ampere-meters of their respective machines. At present the switchboard is arranged for only two alternators and two circuits; but it can be readily extended when required, the gear for new circuits extending in one direction, and that for new alternators in the other. The two circuits are at present connected only to the rectifiers for arc lighting.

Rectifiers.—Opposite to the alternators, and standing on the same foundation block, are placed the Ferranti rectifiers for the series arc lighting (Fig. 3). These are three in number, one for each of the two circuits, and one to spare. They each consist of a self-regulating transformer, of which the primary winding is connected to the omnibus bars of the high-tension switchboard, and the secondary winding is connected through a commutator and distributing switchboard to the arc lamps. One winding is hung on knife edges in a frame, and is capable of movement nearer to and further from the other; this automatically keeps the current in the secondary winding constant at 12 amperes, varying the electromotive force to suit the number of lamps in circuit. The current from the secondary winding of the transformer is then changed, by a commutator driven by a synchronous motor, from an alternating current to a uni-directional pulsating current, which is distributed to the lamps. A small distributing switchboard is placed close to the rectifiers, by means of which any rectifier can be put on to either of the high-tension omnibus bars, and either circuit of arc lamps can be put on to any rectifier; and provision is made on this switchboard for extending the number of arc lamp circuits.

Schedule of Machinery and Plant in the Station.—In the boiler house (Figs. 1 and 3), six boilers of 10ft. 3in. mean diameter and 12ft. length, each estimated to evaporate actually 10,000lb. of water per hour; all fitted with superheaters and mechanical stokers; contractor, Mr. G. Sinclair, Leith. One duplex steam feed pump. Two electrically-driven feed pumps.

In the engine room (Figs. 2 and 3), the low-tension plant comprises eight Siemens dynamos; two have each an output of 450 amperes at 135 volts; two of 220 at 275: two of 600 at 260; and two of 865 amperes at 260 volts. The contractors for the engines, dynamos, steam and exhaust piping, feed-pumps, heaters, &c., were Messrs. Siemens Brothers and Co., who also supplied the switchboard and all connections.

The high-tension plant in the engine room consists of two alternators (Figs. 2 and 3), each having an output of 40 amperes at 2,100 volts; a high-tension switchboard; and three rectifiers for arc-lighting, with switchboard. The contractors for the whole were Messrs. S. Z. de Ferranti.

In the battery room (Figs. 2 and 3), 140 Crompton-Howell 31-plate cells, for which the contractors were the Crompton-Howell Electrical Power Storage Company.

Mains.—In the three-wire system of distribution for the northern and central districts, the electromotive force between the two outer conductors, positive and negative, is 230 volts, while that between the middle wire and the positive or negative is 115 volts. The latter is the electromotive force of the lamps on the consumers' premises, no trouble being now experienced in obtained glow lamps to work at this electromotive force, or even higher. Distributing mains are laid throughout the streets; all three wires are laid in those streets where the demand for current is large. In the other streets the positive and middle wires are laid on one side of the street, the negative and middle on the other; and a spare way is left on each side for a third conductor, should the demand require it. The distributing mains are all in parallel, and are connected up throughout the system; rings are completed wherever possible, so as to ensure equality of pressure, and to admit of disconnections being made without interrupting the supply.

Feeders.—The feeders from the station are connected to the distributing mains at 16 points. They consist of two conductors only, the positive and negative; the middle wire is interconnected throughout as much as possible, and is brought back from three districts on the system. The cables are put in parallel at the station, and one connection only is made to the switchboard. The positive and negative sides respectively of all the feeders are put in parallel at the switchboard, but any feeder or feeders can be put on a separate machine if required.

Balancing.—As far as possible consumers in each street and district are balanced against one another by connecting them alternately between positive and middle wires and between negative and middle wires; large consumers have all three wires taken into their premises, and their lights balanced against one another in a similar manner. But however carefully this balancing is done,

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it is impossible to get a really accurate balance; the "out of balance" current varies from hour to hour, and even from minute to minute, and is different on different days of the week. The amount out of balance is compensated for at the station by means of the balancing machines, one of which can be put on either side of the system; the balancing during the light load is done from the battery alone. Light wires, forming potential leads or pilot wires, are brought back from all three conductors at each feeding point, and are connected to the feeder voltmeters on the switchboard; so that the pressure at the feeding points at any part of the system is directly known at the station, and the necessary regulation made for keeping the electromotive force constant. The distributing mains are brought back to the station, but are used only for the supply of light and power there; no regulation is done on the mains anywhere, except to the feeding points.

High Tension.—No high-tension feeders or distributing mains have yet been laid. They will be laid as concentric cables in ring circuits, and banked transformers in small sub-stations will be used wherever advisable, while houses in districts where the lighting is scattered will be served by isolated transformers. The concentric cables will be pulled into Doulton stoneware casings under the footways, and into cast-iron pipes under the roadways. The casings have already been laid in those streets which have been opened up for the low-tension mains, and the work of laying the high-tension mains in the southern and eastern districts is now being proceeded with.

ROADWORK.

Distributing Mains.—Practically the whole of the distributing mains are laid as cable insulated with india-rubber, heavily

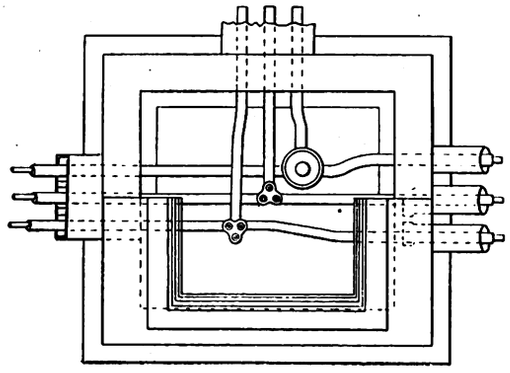

FIG. 4.

braided, drawn into Doulton stoneware casing under the footways, and into either Crompton-Davis cast-iron casing or cast-iron pipes under the roadways (Figs. 4 and 5). At all crossings, and at intermediate places on the footways, brick junction boxes are built for the purpose of drawing in, connecting and testing, and smaller brick boxes are provided at suitable intervals, where connections

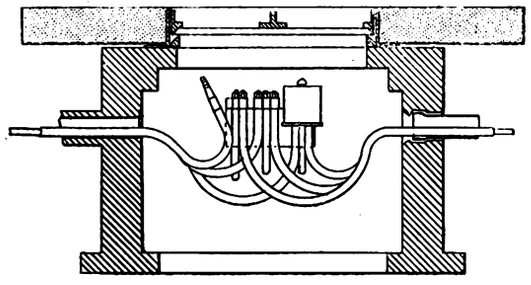

FIG. 5.

are made to consumers; but for this purpose, when space is limited, a special length of Doulton casing is provided, which is so made that it can be easily split longitudinally and removed; the house connection is then made with vulcanised joints, and the casing replaced and jointed up with a special collar and bitumen cement. The collar is provided with a socket, into which the pipe carrying the house connection can be jointed. A mark is made on the kerb to indicate the position of the service box; and the pavement is then replaced. These service boxes are found to be of great use, owing to the number of cellars under the pavement. The brick junction boxes are covered with a cast-iron frame, which is fitted with a cast-iron cover filled in with concrete, a water-tight joint being made with the frame. In most places the bottom of the box is filled in with dry rubble, so as to form a drain for any water which may find its way in; but where water has been found in the soil, the bottom of the box is concreted, and the whole made water-tight. Where it has been necessary in some places to put junction boxes in the road, they have been made as water-tight as possible, and covered with a double cover, the upper being a heavy cast-iron cover with wood blocks let into it. Boxes in the road have been avoided as much as possible, as it is found so difficult to make a satisfactory job of them. In a few places the distributing mains have been laid as bare copper strip, carried on stoneware insulators in concrete culverts.

Feeders.—Wherever sufficient space has been found under the footways, the feeders have been laid as bare copper strip, carried on stoneware insulators in concrete culverts. Across all roads, and where there has not been sufficient space for culvert, the feeders are laid in Siemens armoured cable, laid direct in the ground with a tarred board over them to act as a protection to them and as a warning to any workmen opening the ground. The cable has everywhere been laid of greater section than the copper strip in the rest of the feeder, so that the capacity of the feeder can be largely increased, and yet the resistance be kept right, by pulling in additional copper strip into the culverts, without bringing the current density up to any excessive amount in the portions laid in cable. Thus the feeders can be made to carry considerably more current than that for which they are now designed, with the same drop of electromotive force, and without either disturbing the streets or over-running any of the cables. All the feeders have been designed to have a total drop of 44 volts at full load. In the culvert the copper strip is laid in lengths of about 20 yards with a brick inspection box at each joint, so that the culvert can be easily seen by means of a lamp pushed into it, and the strip can be readily drawn out and in, as required. The joints are made by tinning the ends of all the strips, and clamping them together by a gunmetal grip box with two $\frac{3}{8}$in. bolts; at the feeding points the feeders are connected to the mains by short pieces of cable. Everywhere the culvert is kept quite straight in plan, but with a fall towards every junction box or inspection box. The strip is in no place lower than 2ft. below the level of the pavement, for it has been found elsewhere that it is impossible properly to inspect or do any work to culverts which are constructed at any great depth. There is nowhere any culvert under a roadway.

Potential Leads.—These lines, by which each feeding point is connected back to the station, consist each of three sets of wires, insulated with specially prepared paper, laid up together, and covered with the same material, a lead tube being drawn over the whole. These leads are drawn into special ways, either in Doulton stoneware casing or cast-iron pipe, laid alongside the culverts; and are joined up into one length back to the station. The joints are made in a brass tube, soldered on to the lead sheathing, and containing insulating oil; the wires are kept separate from one another by fibre discs.

Connections.—The whole of the cable connections are made by cone connectors, sweated on to the cables, and fitting into gunmetal connecting blocks (Fig. 5). The cones are all the same size for all sizes of cable, and are interchangeable; when the section of cable exceeds 0·7 sq. in., two cones are used; the taper employed is one in eleven, which makes a good fit and is yet readily disconnected. The cone connecting blocks are made in four sizes, having two, three, four, or five holes bored in them. The holes are bored conical to fit the cones on the cable connectors; and the blocks are interchangeable with one another. The armoured cables, which are all of large section, have special connectors sweated on to them, and these have either one or two of the standard conical holes bored in them; the connections to the distributing mains are then made by one or more short lengths of cable having cone connectors at each end. Enough slack is left in the boxes to allow the ends of the cables to be turned upwards; they are then connected together by slipping the connecting block on them, and the cones are drawn tight into the holes by means of a nut fitting upon a $\frac{3}{8}$in. screw on their ends. In order to obviate any trouble from end-leakage through water dripping on the bare terminals, and also to minimise the risk of short circuits through accidental contact between the blocks, stoneware caps are dropped over the connectors, and entirely cover all bare metal.

**Public Lighting.*—The streets in which there are low-tension mains are lit by electricity, by means of altogether 176 public arc lamps. The arc lamps are run four in series off the distributing mains; and each series of four is provided with a fuse, switch, and line resistance. Each lamp in the series is also provided with an automatic device, which, in the event of the lamp failing, cuts it out and introduces into the circuit a resistance equal to the lamp, so that the other lamps in that circuit are not affected. The lamps in Princes-street are constructed for a normal current of 15 amperes, and all the other low-tension lamps for 10 amperes.

In the streets, in which no low-tension mains are laid, the lamps are run on special high-tension series-circuits from the

*[Owing to some references to a coloured map, which it has been impossible to reproduce here, this paragraph has been slightly altered without, however, altering the sense conveyed by it.—ED. *E.*]

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rectifiers at the station. There are at present two series-circuits, both of which are laid in all the streets lit by high-tension lamps, and the lamps are connected alternately to each circuit. The circuits are laid as concentric cable drawn into cast-iron pipes, the outer conductor of the cable being insulated. There are 24 lamps on each circuit, each provided with an automatic cut-out in case of its failing to act; and also with a switch in the pillar, by which it can be entirely disconnected from the circuit if necessary, while the switch is so made as to complete the circuit for the other lamps.

In arranging the circuits for the arc lamps, care has been taken to put alternate lamps on separate circuits in all streets, whether run from the distributing mains or from the series circuits. This minimises the risk of any street being left in darkness by the failure of any circuit, and also allows half the lamps to be switched off at or about midnight, still leaving the streets well lighted. The arc lamps are of Crompton-Pochin type, and are fitted with 18in. spherical globes. They hang from the bracket of a cast-iron pillar, the centre of the globes being 23ft. above the level of the pavement. In Princes-street the lamps are about 45 yards apart, and are on one side only of the street. In the other parts of the city the lamps are about 60 yards apart, and are placed alternately on the two sides of the street.

No contractor was employed for the roadwork or laying of the mains; the whole of this work, including the erection of the arc lamp posts, was carried out by the resident engineer, Mr. E. W. Monkhouse, with his own staff of workmen. The armoured cables were supplied by Messrs. Siemens Brothers and Co.; the unarmoured cables by the Henley's Telegraph Works Company and the India-Rubber, Gutta-Percha and Telegraph Works Company, Silvertown. The potential leads were supplied by the British Insulated Wire Company. The stoneware casing was manufactured by Messrs. Doulton and Co., and the cast-iron work by Messrs. Maclaren and Messrs. Shaw and Co. of Glasgow. The copper strip was supplied by Messrs. Bolton and Co., of Oakamoor Works. The posts for the arc lamps were designed by the Edinburgh School of Art, and the castings were made by Messrs. Mackenzie Brothers of Edinburgh. The whole of the arc lamps were supplied and fixed by Messrs. Crompton and Co., of Chelmsford, who also supplied the cable-cones and connectors.

In this account of the electric lighting of Edinburgh the author has endeavoured to describe the arrangement of the plant and mains, and any details in their design and construction which may be of interest without discussing general principles or the advantages or disadvantages of any individual system. Having himself had the good fortune to be connected with this particular work from its earliest stage to its opening, he desires to express his deep indebtedness to Prof. Kennedy for permission to prepare the present Paper and to use the drawings from which the diagrams have been enlarged, and also for his suggestions and assistance, without which it would have been impossible for this Paper to be laid before the Institution.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October 26, 1895.*

Electrically Annealing Armour Plates.—At the meeting of American Institute of Electrical Engineers on Wednesday, one of the two Papers read was by Mr. Herman Lemp, junr., on a method of local annealing by means of the electric current which has been applied in United States naval work. The method consists in passing an alternating current, by means of two copper contacts kept cool by water circulation, through the portion of a Harveyised plate which it is desired to anneal in order that a hole may be pierced. The current employed is usually of 10,000 amperes, or equivalent to 40,000 amperes per square inch of surface; it is gradually increased and decreased, the operation generally taking seven minutes all told. An extension of the method has been applied to annealing gun shields in order that gun openings may be cut in them; in this case the copper contacts are moved along the line of the opening to be cut. The generator employed for this work is a separately-excited alternator with a maximum capacity of 100 amperes and 300 volts and a frequency of 50 $\sim$. A special converter is used, and a reactive regulator, which is made automatic in its action by a very simple method.

The Rating and Behaviour of Fuse Wires.—The second Paper read was by Prof. W. M. Stine and two of his students, giving the result of an elaborate series of experiments on fuse wires. The Paper severely condemned most of the commercial forms of porcelain fuse blocks, principally on account of the short lengths of fuses which their use involves. It was found that the rating of fuse wire is of little or no value unless lengths are also specified. The Paper speaks very favourably of the use of copper wire for fuses, and recommends that copper fuses in cylinders of insulating material be used on electric lighting and power circuits. The tests showed that copper fuses are much more reliable and sensitive than those of alloy, for the reason that after the copper has arrived at a certain temperature only a slight increase in current is required to render it fluid. The use of multiple fuses is advised, as the experiments showed that a fuse circuit of several fuses was much more reliable and sensitive than a single-fuse wire having an equal capacity.

Montreal Street Railway Convention.—The meeting last week at Montreal of the American Street Railway Association was the most successful in its existence, if judged by attendance, which numbered little less than 1,000. The commercial exhibits were also very creditable, notwithstanding the deterrent influence of the Customs. But few Papers were read, however, and these of little value. One of the Papers was a commercial one on air brakes, which argued very strongly for their adoption on American street railways, and incidentally impressed upon street railway men the absolute necessity of intelligence and skill on the part of the motorman operating them. Another Paper presented arguments in favour of creosoting street railway cross ties and line poles. It was claimed that this would result in increasing the life of the material usually employed from six or eight years to 24 years or more. It was the intention to take action at this meeting with a view to enlarging the scope of the Association; but the unexpected discovery of a deficit of about $4,000 in the Treasury resulted in deferring the matter until next year. The most notable discussion of the proceedings was on the report of the Executive Committee, recommending an amendment to the constitution of the Association whereby manufacturers and dealers in electric railway supplies could become associate members. Notwithstanding the fact that the recommendation was signed by every member of the Executive Committee, it was defeated after a spirited discussion by a vote of 87 to 11.

CORRESPONDENCE.

ALTERNATE CURRENT WAVE FORM DELINEATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to the letter of Messrs. Barr, Burnie and Rodgers, published in *The Electrician* of October 18th, I think it right to say that in making my claim with regard to the method employed by these gentlemen I had not any intention of putting their good faith to question, nor of depreciating the merit due to them for the construction of their apparatus, which shows, I am glad to observe, a serious advance, from the point of view of insulation. I am very much obliged to these gentlemen for the good grace with which they have accepted my claim.

As to the remarks of Prof. Hicks in *The Electrician* of October 25th on this point, they would only be justified if Messrs. Barr, Burnie and Rodgers' apparatus enabled one to see the entire curve at a glance. But these gentlemen have taken pains to say that this is not the case, and that being so, it is as easy to follow the tracing with a pencil on a drum as on a screen. To see the entire curve it must be described in at least $\frac{1}{10}$th of a second, which could not give accurate results unless the galvanometer had a period of vibration equal at the utmost to $\frac{1}{200}$th of a second. Prof. Hicks, doubtlessly, did not think of this important condition, which led me to adopt a clockwork.

I may add, moreover, that if it is a question of projecting the periodic curve on a screen I can also claim priority, for I showed to the Académie des Sciences two years ago (March 6th and April 10th) the first instrument (the telephonic method

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of Fröhlich being, as I have shown, quite erroneous) which enabled one to obtain this result with accuracy and without the aid of a "contact brush." This apparatus, called an "oscillograph," has worked in a most satisfactory manner for several months in a large factory at Paris, and I published, at the Chicago Congress, curves obtained by this device, of which few electricians seem even now to admit the possibility. It will, doubtless, be reinvented by other gentlemen in a short time, and it will then, we may be sure, be found excellent.—Yours, &c.,

A. BLONDEL.

MAGNETIC FORCE AT ANY POINT IN A PLANE CIRCUIT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The mistake in my second formula was really made, as it has been said by Mr. A. Russell. I am sincerely obliged to him, and to your other correspondents, for having detected it. I must say I do not regret it when I see the number of interesting letters it has suggested.—Yours, &c.,

Brussels, November 2, 1895. OSC. COLARD.

SHAPE OF E.M.F. CURVE AND IRON LOSSES OF TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of October 25th a letter appeared from Mr. Alfred Hay, in which attention was drawn to an obvious error in Mr. C. P. Feldmann's article on the above subject, contributed to *The Electrician* of October 18th.

Perhaps I may be allowed to point out another mistake which proves equally disastrous to Mr. Feldmann's results. If reference is made to Figs. 4 and 5, it will be seen from a short study of the curves that Mr. Feldmann has *reversed the direction of the* B-H *cycle*. As a necessary consequence of this error it is evident that if "the curve of total E.M.F. E_1" (Fig. 1) represents the applied P.D. (as it assuredly does), then the current wave is about 180deg. out of phase.—Yours, &c.,

October 29, 1895. STANLEY BEETON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I plainly admit the blunder attributed to me by Mr. Alfred Hay in your last issue, but am at a loss to understand how it could pass my attention. Mr. Evershed's valuable series of articles was well known to me, and I referred to it at several places of my book upon the calculation, testing and working of alternating-current transformers. The salient points of my article—*i.e.*, the splitting-up of the hysteresis curve into its components and the evaluation of the component idle currents and E.M.F.'s—remain intact, and are not affected by the error into which my mathematics have fallen.—Yours, &c.,

Cologne, October 27, 1895. C. P. FELDMANN.

LEGAL INTELLIGENCE.

Burne-Jones v. New and Mayne.

In the Chancery Division on Friday last, before Mr. Justice Kekewich, Mr. Renshaw, Q.C., said that he had a motion in an action in which Sir E. Burne-Jones, who was the plaintiff, moved for an injunction to restrain the defendants, Messrs. New and Mayne, from working electrical machinery at Rottingdean in such a manner as to cause a nuisance to the plaintiff by noise, vibration and smoke. The defendants had submitted to a perpetual injunction and to pay the costs. Operation of the injunction was ordered to be suspended in order to enable the defendants to carry out certain alterations with a view to abating the nuisance complained of.

Electric Traction in Switzerland.—A Syndicate, having its seat at Zurich, has applied to the local and federal authorities for the concessions of several electric metre-gauge road railways to be constructed in the cantons of Zurich, Argovie, and Zug, the plans and designs having been prepared by Dr. Du Riche Preller, M.I.E.E.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1895 (thirteenth) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is READY. In addition to the old well-known features of the book, which are brought up to date, a quantity of new and useful matter has been added, rendering the book more than ever indispensable to the Electrical, Engineering, and Allied Trades. Price 7s. 6d., post free 8s. 3d., abroad 9s.

The Edition for 1896 is in active preparation, and orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. The usual circulars, &c., will be sent out in a few days.

TENDERS INVITED.—The Corporation of Derby invite tenders for the wiring, fittings, &c., for the completed portion of the Derby Municipal Technical College, at Green Hill. Tenders to Mr. H. F. Gadsby, Town Clerk, by noon on Tuesday next.

——— The Metropolitan Asylums Board invite tenders for the execution of wiring and other work in connection with the electric light installation at the Brook Hospital and Ambulance Station, Shooter's Hill, S.E., from specification, drawings, &c., prepared by Prof. A. B. W. Kennedy, which can be obtained at the offices of the Board, Norfolk House, Norfolk-street, Strand, W.C. Tenders must be in by 11 a.m. of Monday, the 18th inst. Further particulars are given in our advertisement columns.

——— The Town Commissioners of Fermoy (co. Cork) invite tenders and schemes for the public and private lighting of the district by electricity. Some further particulars are given in our advertisement columns, to which particular attention is called. Tenders and schemes have to be sent in to Mr. P. J. Lane, Town clerk.

——— The Cheshire Lines Committee invite tenders for the supply of telegraph materials, instruments, wire, &c., galvanised and zinc sheets, pulleys, bolts, screws and various other stores for the year 1896. Tenders by the 30th inst. to the Secretary (Mr. Glegge Thomas), Central Station, Liverpool.

——— The Blackburn Corporation invite tenders for steam alternators and motor alternator, switchboard and engine room connections, street transformer chambers, transformers, &c. Tenders, addressed to the Town Clerk (Mr. Robert C. Fox), Town Hall, Blackburn, by the 30th inst.

——— Tenders are invited for the manufacture and laying of a submarine telegraph cable from Puerto Montt to Punta Arenas, Chili. Conditions and specifications may be consulted at the Chilian Legation, 36, Victoria-street, S.W., and tenders must be sent in by December 5th next.

ELECTRIC LIGHTING SCHEMES INVITED.—The Battersea Vestry offer premiums of £50, £30 and £15 for the best three schemes, reports, designs and estimates for a system of electric lighting for the parish. Schemes must be delivered to the Vestry Clerk (Mr. W. Marcus Wilkins) by December 12th next.

TENDERS ACCEPTED.—The Glasgow City Improvement Trustees received eight tenders for wiring and fitting up the New Family Home, in St. Andrew-street, for the electric light. The tenders varied from £540 to £312, and the lowest, that of Mr. R. Miller, of Glasgow, has been accepted.

——— The Board of Guardians of St. Saviour's, Southwark, London, S.E., have accepted the tender of Messrs. Morris and Son for wiring the Board room and offices for the electric light for the sum of £59. 10s.

——— The Asylums Committee of the London County Council have accepted the tender of Mr. Wm. Harbrow for the erection of temporary buildings at Banstead for the sum of £13,790. It will be remembered that this tender includes the installation of a complete system of fire alarms throughout the buildings. No tender has yet been accepted by the Committee for the buildings at Colney Hatch.

——— The Dewsbury Corporation received 13 tenders for wiring the Public Baths and Library for the electric light. The figures ranged from £284 to £895, and the lowest tender, that of Mr. G. A. Steinthal, of Bradford, has been accepted.

SALES BY AUCTION.—Messrs. Wheatley, Kirk, Price and Goulty issue a preliminary notice *re* the sale by auction, at an early date, of the entire contents of the works premises at 45, Broadway, Walham Green, S.W., now in the occupation of Messrs. Russell and Co., who, as announced in a previous issue, have decided to give up business. Further particulars are given in our advertisement columns.

——— Messrs. Wheatley Kirk, Price and Goulty make preliminary announcement of the piecemeal sale of the plant, machinery,

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tools, &c., at Smithfield Works, New-road, Blackwall, E., recently in the occupation of D. W. Forbes, Limited (in liquidation). Some further particulars are given in our advertisement columns.

BUSINESS FOR SALE.—Electrical engineers can obtain particulars from Messrs. Wheatley Kirk, Price and Goulty of a small electrical business for disposal in London, which would well suit a person with a small connection to add to the present business.

APPOINTMENT.—Mr. J. McF. Smythe has been appointed assistant engineer at the Blackburn Corporation Electricity Works. Mr. Smythe was formerly with the Metropolitan Electric Supply Company.

BANKRUPTCY.—A receiving order has been made against Walter Raynes Smith, described as an electrical engineer, of St. Audries, Hitherfield-road, Streatham, London, S.W.

LIQUIDATIONS.—A meeting of the shareholders in the Swan United Electric Light Company (Limited) will be held at Ediswan-buildings, 36 and 37, Queen-street, London, E.C., on December 17th next, at 1 o'clock, to receive the liquidators' account of the voluntary winding up of the Company.

——— A meeting of the members of the Cadogan Electric Light Company (Limited) will be held at 3, Lothbury, London, E.C., on December 16th next, at 12 o'clock noon, for the purpose of receiving an account of the voluntary winding up of the Company.

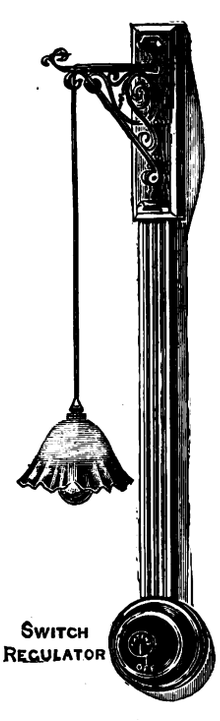
——— The public examination of J. Millington, J. Duce, J. H. Martin, R. J. Surman, and W. J. Hill, in connection with the liquidation of the New British Electric Installation Contractors (Limited) takes place at the Worcester County Court on the 20th inst., at 11 a.m.

——— It was resolved on October 14th that Hemming and Co. (Limited), electrical engineers, of Birmingham, be wound up voluntarily. Messrs. G. Thompson (Mayo and Co.) and G. W. Thompson (Flint and Thompson), of Birmingham, were appointed liquidators.

——— On the petition of the Hon. C. A. Parsons a compulsory order has been made for the winding-up of the British Steam Generator and Refuse Utilisation Company.

J. C. HOWELL (LIMITED).—It is stated that this Company is about to go into voluntary liquidation, but this step is to be taken only in order to effect a dissolution of partnership between the two Managing Directors of the Company, Mr. J. C. Howell and Mr. W. M. Meredith, in consequence of which Mr. Meredith retires from any share in the management of the business. The assets of the old Company will be taken over by a new Company of the same name, and the usual business will be continued without interruption on precisely the same lines as hitherto. The liabilities of the old Company will be discharged by the liquidator, Mr. S. F. Isitt, of 6, Old Jewry, E.C., in due course.

REGULATING SWITCH. — The accompanying illustration shows a suspended glow lamp fitted with a regulating switch on the choking coil principle. The apparatus can be mounted in place of an ordinary switch, and the current through the lamp diminished gradually by turning round the knob in the direction shown by the arrow on the switch, till the lamp filament is only a dull red. The effect of turning round the knob is to cut out windings round a ring core one by one without causing any breaks or jumps in the current, and without finally leaving the resistance of the wire itself in the circuit as when a movable core is used. These devices are very handy for persons who are in the habit of keeping a dim light burning all night in their bedrooms, but the economy of the arrangement is not, of course, very high. The makers are Messrs. Miller and Woods.



SWITCH REGULATOR

DR. LESSING'S DRY CELLS. — The St. Edmunds Electrical Engineering Works and Universal Agency, 100, Bedwin-street, Salisbury, have been appointed sole agents for the West of England for Dr. Lessing's dry cells.

ADVANCE IN PRICES.—The Telegraph Manufacturing Company (Limited) notify that in consequence of the heavy advance in the price of raw materials, discounts on electric light cables and wires have been reduced by 10 per cent. from the 4th inst. The Company also notify a revision of their arrangements as to carriage, packages, &c. A copy of the circular can be obtained from the Company's chief offices at Helsby, near Warrington, or at the branch offices in London, Liverpool, Manchester and Glasgow.

NEW WORKS.—The Coventry journals express their satisfaction at the town being selected by the Consolidated Telephone Construction and Manufacturing Company (Limited) as the centre of manufacture for their specialities. The freehold works in Bond-street, which have been purchased by the Company, are now being prepared for the special machinery and apparatus necessary for the Consolidated Company's manufactures.

LAMP CATALOGUE.—Messrs. G. Straus and Co. (Limited), of Queen Victoria-street, E.C., have sent us List "C" of incandescent lamps and accessories. The list is fully illustrated, and contains particulars of incandescents ranging from ¼ c.p. to 1,800 c.p., with voltages from 1 to 280, and from 1½ watts to 3½ watts per candle-power. A special classification is given of 3½, 2½ and 1½ watt lamps, for which long life and high efficiency are claimed. Particulars of low candle-power or battery lamps for small accumulators, for decoration, dental, surgical or microscopic purposes, of high candle-power lamps, high-voltage lamps from 8 c.p. upwards, of fancy, tubular, crinkled, and other ornamental lamps for all purposes, are also included. 34 different lamp sockets are illustrated. The accessories section includes current-measuring instruments, shades, lamp-holders, switches, carbons, &c.

CASSIER'S MAGAZINE.—We have received the copy of the November issue of this well printed and beautifully illustrated magazine. Throughout the 80 pages a large number of illustrations are given, produced in a style for which the magazine is famous. The principal articles deal with the "Burning of Anthracite Culm and other Low-Grade Fuels for Steam Raising," "Mill Equipment," "Cheap Gas Power," "Electric *v.* Steam Heat," "Gaseous Fuels," "Electric Power from the Coal Regions," and "Modern Coal Handling Machinery."

HORSELESS CARRIAGES.—Mr. H. J. Knight, well-known as the inventor of the Knight Oil Engine, doubtless to bring the matter prominently before the public, permitted himself to be summoned for allowing a locomotive to be worked without a licence, in contravention of the Surrey County Council's bye-laws. Mr. Knight was riding a tricycle propelled by an oil motor, and it was contended that this came under the definition of a locomotive according to the Act. The case was, however, not contested, Mr. Knight's legal adviser recommending him to plead liability.

BANGOR.—A special meeting of the City Council was held on Friday last for the purpose of considering certain correspondence which had passed between Mr. F. H. Medhurst (consulting electrical engineer to the Council for their contemplated electric lighting scheme) and the Parliamentary agents with reference to the question of applying for a Provisional Order. Dr. Grey Edwards said that at the last meeting of the Council a resolution was passed to apply for a licence from the Board of Trade, and also for a Provisional Order. Some of them thought that they might be within the limit of time to apply for a Provisional Order within a year or two, and he thought it was also suggested that they should defer applying for an Order until the question of an electric tramway could be discussed. It seemed, however, that they must apply for both licence and Provisional Order at the same time. Although by a resolution passed on August 30th the Electric Lighting Committee were empowered to proceed with the work at once, yet some members did not agree to go further for the licence. The reason they passed the resolution to go on with the work next year was because it was necessary to provide additional light for the town. A long discussion followed, and ultimately Dr. Edward's motion that Mr. Medhurst be instructed to prepare the necessary plans and specifications forthwith, in order that tenders might be invited, was adopted.

BEXHILL (SURREY).—The Clerk to the District Council has prepared a report on the scheme recently submitted for the electric lighting of this district, and at the last sitting of the Council the report was referred to the Lighting Committee for consideration.

BIRMINGHAM.—In our issue of October 25th we stated that the Public Works Committee of the Corporation had decided to recommend the City Council to allow the Birmingham Central Tramways Company to introduce the overhead system of electric traction on their Nechells route. Numerous letters have appeared in the local Press concerning this matter, and a meeting was held in the Duddeston Ward Hall on Monday last to protest against the proposal, and Mr. Ryder, in the course of a somewhat incoherent speech, said "three widows and 26 orphan children in the Walsall and Darlaston district owed their present unfortunate position to the electric tram system. The deaths had been caused through defective wires by the electric current." In reply to this statement a letter from Mr. Alfred Dickinson (manager of the Tramways Company) appeared in Wednesday's issue of the *Birmingham Daily Post*, from which we cull the extract below :—

"There has not been a serious accident of any kind, much less a fatal accident, through the electric cars or overhead wires in the Walsall district. That there is exceptional immunity from accident is proved by the fact that the insurance company have reduced their premium to 60 per cent.

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less than was charged in the first instance, and also that amount less than is still charged for steam cars. I have received letters from the coroners for the South Staffordshire district and for the borough of Walsall. These two gentlemen cover the whole of the district traversed by the South Staffordshire electric tramways. One coroner says: 'I have never been called upon to hold an inquest on any person whose death was caused by an accident on the line of the electric trams. From my experience, I have no hesitation in saying that I consider the electric trams to be far safer than steam.' The other coroner says: 'I have never held an inquest in case of deaths through accidents caused by defective wires on the overhead electric system, nor has any fatal accident caused by such wires been reported to me.'"

BRIERLEY HILL (STAFFS.).—At the meeting of the District Council on Monday last the Lighting Committee reported that they had received several communications from electric lighting contractors relative to the lighting of the district, and the Clerk was instructed to write and obtain estimates of the cost of putting down an electric lighting plant.

BRIGHTON.—The Borough Accountant's office is to be wired and fitted up for the electric light. At a recent meeting of the Electric Lighting Committee, letters were read suggesting that Bond-street, Gardner-street, Kensington-gardens, Sidney-street, Upper-street, James's-street and Bristol-road be lighted electrically, but it was resolved to reply that, until the present street lighting works were completed, the Committee were unable to consider the question of extending the electric light mains. At the meeting of the Town Council last week the Electric Lighting Committee's report was adopted.——Col. Tester, Chairman of the Finance Committee of the Town Council, was able to make the satisfactory announcement that, owing to a contribution of £2,000 profit from the Corporation's electric light undertaking, upon which he cordially congratulated the Lighting Committee, and with other small increases in their income, for the coming year they would be able to continue the 1895 rate of 1s. 7d. in the £, which was 2d. less than in 1894. Mr. Stafford, Chairman of the Lighting Committee, said he particularly wanted to point out to the Council that they were not making large profits this year out of the electric light, but if they had not made the reductions recently announced they would in all probability have made from £4,000 to £5,000 more profit. Had it not been for the profit on the electric light the borough rate would have been a 1s. 8d. instead of a 1s. 7d.

BRISTOL.—In order to encourage the use of electricity as a motive power the Electric Light Committee have decided to make an all-round charge for the supply of electric current to motors of 4d. per unit, instead of 6d., as heretofore, provided that a separate motor is fixed and no lamps are connected to it. The Committee have recently received several important applications for the supply of current, including one from Messrs. Mardon, Son and Hall for an additional 1,000 lamps, and no fewer than 2,000 additional incandescents were connected during the month of October. The electrical department is described as "extremely busy."——The extension of the electric tramway beyond the Kingswood Church in the direction of the Warmley railway station will be completed this week. From accounts in the local papers it would appear that the residents of St. George, Kingswood, and the neighbourhood are highly pleased with the electric cars, more especially as to their frequency, regularity and speed. Already there is some talk of extensions to the present line.

CAIRO.—On Saturday evening, October 26th, the official test of the electric light at the Khedival Opera House, Cairo, took place. Messrs. Nahman and Co., electrical engineers, some time back entered into a contract with the Government to light the theatre for a period of 10 years. The installation has been carried out during the past summer under the personal supervision of Mr. A. E. Levin, A.I.E.E., superintending engineer to the contractors. The Opera Committee expressed themselves as very pleased with the effect of the lighting, which is an immense improvement on the old gas system. The installation consists of over 800 incandescent lamps and 4 arcs. The latter are arranged on the exterior of the building. The stage is lighted by 226 white, 44 red, and 44 blue lamps, and complete switching arrangements are provided for lowering the lamps by means of liquid resistances as may be required for the various scenic effects. The generating plant consists of two 22-kilowatt dynamos, by Brown, Boveri and Co., belt-driven from two Robey high-speed compound engines. A small battery of Tudor accumulators is also provided to furnish current during the day for rehearsals, &c. Either half of the generating plant is so arranged as to be capable of lighting two-thirds of the lamps if required.

CANCER HOSPITAL, BROMPTON (LONDON, W.).—The Committee of this Hospital have decided to introduce the electric light throughout the hospital premises, and have instructed Mr. Morgan Williams, C.E., to prepare specifications for the work.

CAPE COLONY.—It is intended to erect an electricity generating station at Table Bay breakwater.

CARDIFF EXHIBITION.—Arrangements have been made with Messrs. Strode and Co. for an electric light installation at Cathays Park during the period of this exhibition.

CHEDDLETON (STAFFS.).—The foundation stone of a County Asylum was laid last week by Lord Wrottesley. The amount of the building contract for this asylum is £175,000, and the question of lighting the building throughout by electricity is under consideration, and this method of illumination is most likely to be decided upon.

CLERKENWELL (LONDON, E.C.).—At the last meeting of the Clerkenwell Vestry the Works Committee reported that they had refused permission to the County of London and Brush Provincial Company to drain their transformer chambers into the gullies, and had informed the Company that the drains must be carried into the sewers in the usual way, it being the surveyor's expressed opinion that risk of explosion would by this means be minimised.

CLUB LIGHTING.—The new Conservative Club at Stroud (Gloucester) is to be lighted electrically, and the contract for wiring and fitting has been given to Mr. A. Sanders, of Cheltenham.

EAST GRINSTEAD (SUSSEX).—At the meeting of the District Council on Wednesday last a letter from Messrs. Owen Lucas and and Pyke explaining their proposals for the introduction of the electric light into East Grinstead was referred to the Lighting Committee for consideration and report.

ELECTRIC LIGHTING IN THE DUTCH EAST INDIES.—Concessions have recently been granted for the electric lighting of Solkaboemie, Padang, Soerakarta, Bandong, Poerworedje, Magelang and Djokjakarta, Java.

ELECTRIC TRACTION IN JAPAN.—It is stated that three petitions for permission to lay down electric tramways in the city of Tokyo have been received by the Japanese authorities.

EXHIBITION.—A National Industrial Trades' Exhibition was opened in the east end of Glasgow on Monday. The principal portions of the Exhibition are brilliantly lighted by electricity, the installation having been put down by the Scottish Electrical Engineering Company, under the direction of Mr. Gardiner. Twenty 2,000 c.p. arcs and about 400 16 c.p. incandescents are used. The engines are by the Acme Machine Company, Glasgow, and the dynamos by Messrs. Crompton and Co.

FAREHAM.—Major Cardew's report on the state of the local wires and poles of the Electric Lighting Company was discussed at the last meeting of the District Council. The report states that the wires and poles are in a satisfactory condition, and have suffered little from decay, although they have been erected a considerable time.

FLEETWOOD.—At a special meeting of the District Council last week Messrs. B. Sykes and Murray, representatives of the promoters of an electric tramway between Blackpool and Fleetwood, had an interview with the Council. Mr. Sykes explained the route of the tramway, and said that if the promoters could come to an agreement with the Blackpool Council they would construct the line to the borough boundary at Norbreck, which could be done without a Provisional Order or Act of Parliament. If the assistance of the Fleetwood Council and the large landowners *en route* could be obtained, they would introduce a Bill in the next session of Parliament to construct the tramway from Blackpool to Fleetwood. If not, the tramway would stop at Norbreck, and they would introduce a Bill in the following session to enable them to go through to Fleetwood. The matter was discussed at considerable length, but the Council finally adopted a resolution approving of the construction of the tramways, subject to the condition that the plans, &c., were approved by them when ready.

FULHAM (LONDON, S.W.).—The Vestry recently resolved to make some experiments with incandescent gas burners, with a view to employing same for the lighting of the main streets of the parish, but at the last sitting of the Vestry, on Mr. Sayer's motion, it was decided to rescind this resolution. Mr. Sayer stated it was unwise to incur any expense in connection with improvements in gas lighting until they had come to a decision as to the adoption of an electric lighting scheme.

HAMPSTEAD (LONDON, N.W.).—At the last meeting of the Vestry the question of lighting High-street, Rosslyn-hill and Haverstock-hill, by means of arc lamps, was referred to the Lighting Committee for consideration and report. The Finance Committee reported that they had considered the question of raising a further loan for electric lighting purposes, and recommended that application be made to the London County Council for sanction to borrow a further sum of £30,000 at the lowest possible rate of interest. The engineer reported that fresh applications for current were coming in in a most satisfactory manner.

HUYTON-WITH-ROBY.—At the last meeting of the District Council it was decided to oppose the application of an electric lighting company for a Provisional Order.

ISLINGTON (LONDON, N.).—The Electric Lighting Committee recently invited the Prince of Wales to formally open their electricity generating station, but at the last sitting of the Vestry it was stated that His Royal Highness would be unable to perform the ceremony.

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LIGHT RAILWAYS.—Mr. C. T. Ritchie, President of the Board of Trade, Earl Dudley, and Sir Courtenay Boyle are making a tour of inspection of the various light railways in Belgium, with a view to obtaining information to be laid before Parliament at an early date on the subject of the construction of light railways in this country.——The Denbigh Town Council and the Merionethshire and Carnarvon County Councils are considering the question of constructing a light railway on the Holyhead-road from Corwen to Bettwycoed.

LLANDUDNO.—At a meeting of shareholders in the Great Orme's Head Marine Drive Company on Tuesday it was resolved to sell the Company's rights in the Marine Drive to the Manchester Edison-Swan Company, at a price to be agreed upon, for laying an electric tramway round the Great Orme. It is stated that the Company intend applying to the District Council for sanction to make a connecting line along Gloddaeth-street and North-parade past the Happy Valley, so as to make a circular tour of about seven miles in length.

LONDON COUNTY COUNCIL.—At the weekly meeting on Tuesday several notices under the Electric Lighting Acts and Orders were agreed to. A notice from the St. James's and Pall Mall Company for sanction to lay mains across Carnaby-street, in Ganton-street, King-street West and Argyll-place, W.—the Highways Committee stated that, according to plan, the Company proposed to cross Regent-street, which is outside the Company's area of supply. It was, therefore, agreed to give the required sanction on condition that it shall apply only to those works which are within the Company's area of supply.

LONDONDERRY.—The Corporation have approved the report of the Lighting Committee, recommending that the erection of electric lamps for the Harbour Commissioners for cattle inspection purposes be proceeded with.

MILL LIGHTING IN INDIA.—The *Indian Textile Journal* states that during the year ended September 30th electric lighting has made considerable progress in Indian mills, but not in the manner at first anticipated. Overtime and night and day working have made very little progress among cotton mills, but as certain parts of many mills are imperfectly lighted in the morning and evening, a small electrical installation has proved of value in ensuring adequate light during the whole of the working day. Among jute mills the high price of the gas and the conditions of insurance renders the electric the only suitable method of lighting.

NEWPORT (MON.).—The local gas company are in high dudgeon at a notification received from the Corporation intimating that it is the latter's wish to dispense with 50 or 60 gas lamps in the area now supplied with electric light. The gas company call upon the Corporation to light up certain waste spaces in order to bring up the consumption of gas to a standard quantity. The Corporation are seriously considering the desirability of dispensing with gas altogether for public lighting.——At the last meeting of the Governors of the Intermediate and Technical Schools the recommendation of the Building Committee that the whole of the schools should be lighted electrically was agreed to.

NOTTINGHAM.—At the County Court on Tuesday last Mr. Joseph Blackburn, electrical engineer, of Gresham Works, Nottingham, was successful in an action claiming from a late employé named Slack the sum of £5. 16s. 2d. for "overpaid wages."

PETERBOROUGH.—The Lighting Committee of the Town Council recently presented a report on the lighting of the town by electricity. The report recommended the adoption of a scheme which would involve an initial expenditure of £20,000. At the last meeting of the Council the report was, after discussion, referred back to the Committee for further consideration and report.

PRESENTATION.—The employés at Messrs. Crompton and Co.'s Lillie-road works, on October 31st, presented Mr. D. Heap with a handsome set of carvers on his vacating the position of works manager to take up another appointment. The presentation was made in feeling terms by a member of the staff, and Mr. Heap expressed his sincere appreciation of the gift.

REIGATE.—Mr. F. H. Medhurst has been appointed consulting electrical engineer to the Town Council.

SALE.—At the meeting of the District Council on Tuesday it was decided to apply for a Provisional Order.

STAFFORD.—The new County Council buildings are lighted throughout by the electric light, current being obtained from the mains of the Corporation. The wiring and fitting up has been carried out by Mr. W. O. Rooper, of Stafford.

ST. PANCRAS (LONDON, N.W.).—At the meeting of the Vestry last week the Electrical Engineer, Mr. S. W. Baynes, presented a report in defence of his high-voltage theory. "At this present date," he says, "the old 50-volt lamp is obsolete, and a number of first-class lampmakers are producing lamps of 8 c.p., 16 c.p., and 32 c.p. and upwards at various voltages up to 250. When commencing my duties in St. Pancras, I found that a number of premises had been wired ready for connection to the mains from the King's-road station; and I learned that no instructions had been issued to the wiring contractors as to the subdivision of the circuits so as to enable a supply to be given on a five-wire system. Experience elsewhere has shown that no service line should carry more than from 10 to 15 amperes; and it has become the rule to run the five services into the majority of the houses. In this way a potential difference of 440 volts frequently exists in the buildings; but, so far, no trouble has been experienced by the consumer from this cause. Our customers, having their premises already wired, could not readily comply with the requirements of the five-wire system, neither could we call upon them to re-arrange their wiring; but we could supply them with increased voltage, which would only need two service lines, and suit the arrangements already made." Mr. Baynes claims that his recent circular has saved the Vestry something like £5,000, inasmuch as the Westinghouse Company claim a royalty on Hopkinson's patent, and the money paid on the Stanhope-street mains did not cover the use of a five-wire system over the area supplied by the existing mains. Mr. Baynes gives the text of the Provisional Order, to prove that a pressure of 300 volts is authorised by the Board of Trade, and adds that, as required by Section 27 (*d*), the standard pressure on the mains is unaltered, and will remain so.

SWANSEA.—In December last the County Council appointed a Sub-committee to consider the question of the purchase of the local tramways. This Committee have just presented their report, which is to be discussed at the meeting of the Council to-morrow (Saturday). The report states that it is desirable that the control of the tramway system should be in the hands of the Council, who need not, however, work the tramways, but could lease the system to a company. The Committee state that one of the principal factors which has occupied their attention, and which has influenced them in their decision, is the question of introducing a system of electric traction on the lines. This is rendered desirable on account of the heavy gradients in many parts of the road. The Committee think it is the most suitable substitute for horses, and are of opinion that if this can be arranged, the success of the scheme for the electric lighting of the borough, which has recently been adopted by the Town Council, will be fully assured. The provision of a day load by keeping the machinery employed at a time when there is no demand for lighting would effect a very material reduction in the cost of electricity all round, and the working of the cars by electric traction would at once provide such a day load. The report states that sufficient electric current could be provided for working the cars at a cost which would reduce to almost one-half the amount proposed to be expended on their electric lighting scheme, and if these results are attained, electric current might be provided within the borough at a cost below that now charged for gas. There would also, it is urged, be a great saving of cost in the wear and tear of the roads. The following is an abstract of the provisional arrangements which the Committee have made with the Tramways Company:—

(1) The Corporation to purchase the tram lines, depots, &c., of the Company (exclusive of rolling stock) for £32,000, £10,400 of this sum to be used in discharging the Company's existing mortgage debt, and the balance to be expended by the Company in the purchase of motor cars for working the tramway system. (2) The Corporation to double the lines as far as possible, and to put in the necessary posts, wires, and bends, so as to make the lines suitable for electric traction. (3) The tramways to be leased to the Company for a term of 21 years on the following terms: Payment of the interest annually paid by the Corporation on the total money borrowed, with an additional ½ per cent.; provision for a sinking fund on tramway expenditure, for reconstruction and additions at 3 per cent., and 21 years; and a sinking fund on the balance, being purchase money for tramways, roadways, costs, &c., at 3 per cent., and 30 years. (4) The Corporation to supply electric current at a price to be agreed upon; and (5) the lines to be kept in repair by the Corporation at cost price, but no charge to be made for renewals.

The Committee also recommends that the Town Clerk be authorised to take the necessary steps for the promotion of a Bill in the next Session of Parliament to enable the Corporation to carry out the foregoing recommendations.

THE PACIFIC CABLE SCHEME.—It is stated that the South Australian, the West Australian, and the Tasmanian Governments have all declined to cooperate in pushing forward the Pacific cable scheme. With regard to the deputation which is to be received by Mr. Chamberlain on the subject no date has yet been fixed.

THE BERNE VOCABULARY.—*The Times* of the 5th inst. contains a long epistle from "Codex," in which is given, with the utmost possible brevity that so difficult a question will permit, the case on behalf of the official vocabulary from a purely mercantile point of view. On the subject of code telegraphy, an interesting article by Mr. F. Jones appears in the *London and China Telegraph* of September 30th last. Mr. Jones calls attention to the small use made of letter variations in coding, and recommends that its adoption would promote economy and give wider direct ranges and greater facility than figure variations. Mr. Jones recommends

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the teaching of mercantile telegraphy, and the cultivation of a systematic knowledge of the subject in commercial schools and colleges, as if the sympathies of influential commercial firms could be secured "it would not be difficult to devise text books so graduated and illustrated that its principles could be easily grasped and adapted to any one of the manifold purposes to which it is applied, thus improving a mechanism to which recourse is daily becoming most necessary."

WAKEFIELD.—The Board of Guardians have decided to erect a new Workhouse Infirmary at a cost of £25,000. The building is to be lighted electrically.

WHITECHAPEL (LONDON, E.).—The Board of Works have appointed a committee to attend the forthcoming conference on the proposed regulations by the Board of Trade as to the supply of electric current.

WIMBLEDON.—Major-Gen. Carey held a Local Government Board inquiry at Wimbledon on Friday last into the application of the District Council to borrow £32,000 for the purpose of lighting the district electrically. There was some opposition to the application from the Ratepayers' Association, who were represented at the inquiry by Mr. E. J. Castle, Q.C., and Mr. Fordham Spence. Evidence in support of the proposed scheme was given by the Chairman of the Council (Mr. A. Holland), Messrs. A. H. Preece (the consulting engineer to the Council), W. H. Preece, C.B., and some ratepayers. In reply to Mr. J. Fletcher Moulton, who appeared for the District Council, the Chairman of the Ratepayers' Association (a Mr. Cooke) admitted that the local gas company had contributed towards defraying their expenses in connection with the opposition to the scheme. Mr. Preece said that for street lighting electricity was cheaper than either gas or oil. Several ratepayers present demanded a poll of the parish on the matter, to which the Council decline to concede.

WOLVERHAMPTON.—At the last meeting of the School Board, the Cookery Committee recommended the purchase of an electric cooking stove for the Walsall-street Girls' School at a cost not exceeding ten guineas, but after some discussion the Committee's recommendation was rejected.

COMPANIES' MEETINGS AND REPORTS.

Victoria (British Columbia) Electric Railway and Lighting Company (Limited).

An extraordinary general meeting of the shareholders in this Company was held on Wednesday at 8, Austin Friars, London, E.C., Mr. R. M. Horne-Payne presiding.

The CHAIRMAN said: The Trustees having, in accord with the trust deed, appointed me to act as Chairman of this meeting, I have, in the first place, to inform you that the annual drawing of bonds took place this morning, when £1,000 worth of bonds were drawn for redemption at 105 per cent. Shortly after the result of last year's working became known, and after the last coupon was paid, we immediately paid out such moneys as we were authorised to pay under the prospectus—namely, £43,000 for liabilities. Not long after doing so it came to our knowledge that a further debt of $9,000 was claimed by Mr. Dunsmuir in respect of coal delivered to the Company. This debt was not scheduled in the list of liabilities, and therefore we declined to pay it. We further declined to expend any money in betterments or part with any of the bondholders' money in any way until this had been explained. The Trustees sent a representative to British Columbia to make inquiries, and as a consequence they learnt that there existed between £8,000 and £10,000 additional liabilities which had not been disclosed in the Directors' schedule. We have refused to part with any money beyond the original amount, and the action we have taken has brought the Company to what may be described as a deadlock. Mr. Dunsmuir applied to the Court to appoint a Receiver in respect of his $9,000, and this the Court granted, but with the distinct understanding that every penny taken by the Receiver should be held in trust for the benefit of our bonds, and that all bonds and mortgages and encumbrances should be amply protected. The Court at the same time admitted that we had the right, if we so desired, to enter into possession of the property. It thereupon became the Trustees' duty to consider how best to protect your property and work the road in your interest. Preliminary negotiations have been entered into with the Consolidated Railway of British Columbia to guarantee your bonds in consideration of their receiving the surplus profits of the Company. We have asked you to assemble here to-day to give us your permission to carry such an arrangement into effect. The Consolidated Company owns bonds and debentures which were issued in England about two years ago, bearing interest at the rate of 4½ per cent., and they consequently will only guarantee our debentures to the same rate of interest. In order, however, to make up the interest to what you have been receiving, 5 per cent., it is proposed to give a quarter of a $100 Ordinary share for every £100 you have in the Company. For the purpose of effecting these arrangements, the Trustees ask your consent to the resolutions, copies of which you have received. The solicitors to the Trustees and myself are going out to British Columbia, to endeavour to carry through the arrangements set out in the resolutions as speedily as possible. I think you will agree with me that by what is proposed you are giving up nothing, but that you will be put in a better position than you are in at present. Although the first accounts are not yet to hand for the year, I may say that the receipts of the Company, notwithstanding the receivership, shows an increase of between 10 and 12 per cent. over those in the previous year.

Mr. J. HORNE-PAYNE, Q.C., pointed out that if the proposed amalgamation of the Victoria Company with the Consolidated Railway and Light Company were carried out the bondholders in the former undertaking would have not only an improved security, but a debenture which would be more marketable than now held by them.

In reply to Mr. Tremlett and Col. Mitchell, the CHAIRMAN said that if they agreed to have their bonds guaranteed by the Consolidated Company, he presumed that that Company's debentures would rank first and their own bonds next, before the share capital of the Consolidated Company. If, however, the two concerns were consolidated, the bonds or debentures of both Companies would be on the same footing in all respects. The share capital of the Victoria Company might be regarded as lost.

The resolutions were carried unanimously, and the proceedings terminated.

West India and Panama Telegraph Company (Limited).

The following report is issued by the Directors of this Company for the half-year ended June 30th last, and will be submitted to the thirty-seventh ordinary general meeting, to be held at Winchester House, London, E.C., on Wednesday next, at 12 noon:—

The amount to credit of revenue is £39,849. 18s. 6d., against £40,598. 1s. 2d. for the corresponding half-year of 1894, and the expenses have been £21,848. 19s. 8d. against £24,488. 17s. 5d., leaving a balance of £18,000. 18s. 10d., which, with £710. 1s. 7d. brought from last account, makes a total of £18,711. 0s. 5d., with which it is proposed to deal as follows:—

First Preference Shares—			
Dividend, six months to June 30th, 6s. per share..	£10,368	18	0
Second Preference Shares—			
Dividend, six months to June 30th, 6s. per share	1,400	14	0
Ordinary Shares—			
1s. 3d. per share (free of income tax).....	5,520	1	3
Balance to current half-year's account.....	1,421	7	2
	£18,711	0	5

The traffic receipts for the six months show a decrease of £241. 18s. 4d., as compared with the corresponding period.

The expenses of repairing cables during the half-year amounted to £8,849. 5s. 11d., being £2,524. 14s. less than those for the corresponding period. This decrease is due to the smaller quantity of cable used, and to the Company's s.s. "Grappler" not having been occupied so many days in effecting repairs. The "Grappler" came home in August last for the purpose of shipping a cargo of 203 knots of new cable, and has since returned to the West Indies. The "Duchess of Marlborough" still continues to lie up in London, out of commission.

The Right Hon. G. W. Balfour, M.P., resigns his seat on the Board on accepting the office of Chief Secretary to the Lord Lieutenant of Ireland, and it is not proposed to fill up the vacancy at present.

Western and Brazilian Telegraph Company (Limited).

The following is the report of the Directors of this Company for the half-year ended June 30th last, to be presented at the thirtieth ordinary general meeting of the Company to be held at Winchester House, E.C., on Thursday next, at 12 o'clock:—

The total earnings for the half-year amount to £84,936. 16s. 11d., against £77,603. 3s. 6d., or an increase of £7,333. 13s. 5d. compared with the corresponding half-year of 1894. The working expenses amount to £37,891. 9s. 6d., as against £37,953. 0s. 2d., a decrease of £61. 10s. 8d. Including the amount brought forward from 1894 (£2,846. 1s. 9d.), the balance to the credit of the revenue account is £49,891. 9s. 2d., from which has to be deducted £11,223. 10s. for debenture interest, £7,876. 10s. for the debenture redemption fund, £1,729. 18s. for income tax, and £5,000 placed to reserve fund. The Directors now recommend the payment of a dividend, free of income tax, for the half-year, at the rate of £2. 10s. per cent. per annum, as against £2 per cent. per annum for the corresponding period, carrying forward £5,803. 7s. 5d. This dividend will be payable as follows, viz., 3s. 9d. per share to the Ordinary shares, and 3s. 9d. per share to the Preferred Ordinary shares.

The position of affairs between the Government of Brazil and the Company as to the acquisition of the cables remains the same as at the date of the last general meeting. The Government, however, are taking authority to continue the authorisation for the purchase of the Company's system.

The shareholders are aware that the Amazon Telegraph Company (Limited) has recently been formed for the purpose of laying a system of cables up the River Amazon and connecting many important places on that river with Para, the northern terminus of this Company's system. The Directors anticipate that when this line is opened, in or before March, 1896, it will prove a valuable feeder to this Company.

The Directors notify that the conversion of Ordinary shares into Preferred Ordinary and Deferred Ordinary shares will be suspended on and after January 1, 1896, until further notice. The dividend warrants will be posted on the 15th inst.

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Western Union Telegraph Company.

The following is the annual report of the President of the Company for the year ended June 30th, and which has been approved by the Executive Committee and ordered to be issued to the stockholders :—

The capital stock outstanding is $95,370,000.00, of which $28,850.35 belongs to and is in the treasury of the Company. During the year the capital stock outstanding was increased $550,000.00 for the purchase of telegraph lines and property of the American Rapid Telegraph Company. The bonded debt at the close of the year was as follows :—

6 per cent. bonds due March 1, 1900	$800,928 00
7 per cent. bonds due May 1, 1900	4,920,000 00
7 per cent. bonds due May 1, 1902	1,163,000 00
5 per cent. bonds due January 1, 1938	8,397,000 00
	$15,280,928 00
Less balance of sinking funds appropriations not yet used for redemption of bonds	428,720 74
	$14,852,207 26

During the year £2,100 sterling bonds, due March 1, 1900, and $14,000 building bonds, due May 1, 1902, were redeemed by the sinking fund trustees and $44,000 of 5 per cent. collateral trust bonds, due January 1, 1938, were issued in exchange for a corresponding amount of capital stock of the New York Mutual (formerly Mutual Union), International Ocean, and Gold and Stock Telegraph Companies, upon which, under leases of those companies' lines, interest was being paid at the rate of 6 per cent. per annum.

The business of the past year is set out as under :—

Surplus July 1, 1894		$7,007,633 54
The net revenues, expenses and profits of the year ended June 30, 1895, were as follows :—		
Revenues	$22,218,019 18	
Expenses	16,076,629 97	
Showing total net profits		$6,141,389 21
		$13,149,022 75
From which there was applied—		
For dividends	$4,767,733 75	
„ interest on bonds	893,821 65	
„ sinking funds appropriations	39,991 00	
		$5,701,546 40
Deducting which left surplus, June 30, 1895, of...		$7,447,476 35
The expenses of the year were—		
For operating and general expenses.....		$11,667,413 70
„ rentals of leased lines		1,578,584 64
„ maintenance and reconstruction of lines		2,202,378 66
„ taxes		429,361 53
„ equipment of offices and wires		198,891 44
Total expenses.....		$16,076,629 97

The following table exhibits the mileage of lines operated, number of offices, number of messages sent, receipts, expenses, profits and average tolls and cost per message since 1866 in periods of five years :—

—	Offices	Messages.	Receipts.	Expenses.	Profits.	Av. toll per message.	Av. cost to Co. of message.
1866	2,250	...	...	...	...	...	...
1867	2,565	5,879,282	$6,568,925	$3,944,006	$2,624,920	...	...
1872	5,237	12,444,499	8,457,096	5,666,863	2,790,233	66·2	43·8
1877	7,500	21,148,941	9,812,352	6,672,225	3,140,128	43·6	29·8
1882	12,058	38,842,247	17,114,165	9,996,096	7,118,070	38 2	25·8
1887	15,658	47,394,530	17,191,910	13,154,628	4,037,281	30·4	23·0
1892	20,700	62,387,298	23,706,404	16,307,857	7,398,547	31·6	22·3
1895	21,360	58,307,315	22,218,019	16,076,630	6,141,389	30·7	23·3

The Company acquired during the year the property of the American Rapid Telegraph Company, and by this purchase the lease of that Company at a rental of $60,000 per year is cancelled. During the year 817 miles of new pole line have been constructed, and 15,748 miles of new wire, of which over 10,000 miles are of copper, in accordance with the policy of replacing the defective iron wires on the trunk routes with copper wires. By this means two-thirds of the weight of the iron wires of the larger gauges necessary for the longer circuits is saved, with the consequent relief of so much of the strain on the poles, thus increasing their carrying capacity and making their maintenance the more economical. Besides, the smaller copper wires are so superior electrically to the larger iron wires that they can be used continuously, especially along the seaboard, through atmospheric conditions that frequently disable the best-constructed lines of iron wires. The cost of construction of new property for the year was $574,639.58, and $16,000 was paid for patents. These items were provided for from the surplus.

There is a decrease of 324,922 messages transmitted, as compared with the previous year; but an analysis of the returns shows that the Company transmitted about 600,000 more full-rate messages, and that the falling off in the total number was principally in Press messages, the newspapers throughout the country having curtailed their special despatches as much as possible during the recent depression in business.

The total expenses are practically the same as for the previous year. The increase of $178,284.46 in maintenance and reconstruction of lines includes unusual payments for Atlantic cable repairs, and for work upon important lines.

The year's business, taken as a whole, added $439,842.81 to the surplus, and is, the President thinks, gratifying, especially when it is remembered that the Company has maintained the dividend of 5 per cent., and at the same time has continued to make great improvements in the working plant. With the steady revival of business which seems to have begun, and which is indicated by an improvement in the weekly test office receipts, President Eckert has every reason to believe that the current year will bring the Company a larger measure of prosperity.

A complete list of the securities held by the Company is given in an appendix.

NEW COMPANIES, STATUTORY RETURNS, &c.

AUTOMOTIVE SYNDICATE (LIMITED).—This Company was registered on October 29th, with a capital of £5,000, in £1 shares, to acquire, work, sell or otherwise deal with certain undescribed patent rights, and to carry on the business of makers of electric, steam, gas, oil or other motors, iron-founders, metal workers, metallurgists, &c. The first Directors are: Edward H. Preen, chartered accountant, Basing House, Basinghall-street, London, E.C.; M. Holroyd Smith, engineer, 161, Trinity-road, Upper Tooting, S.W., and George L. Lyons, 39, Great Tower-street, London, E.C.

ENGLISH AUTOMOBILE HORSELESS CARRIAGE SYNDICATE (LIMITED).—This Company was registered on October 29th, with a capital of £5,000, in £1 shares, to manufacture, adapt, design, purchase, sell, let on hire, or otherwise deal in locomotives, carriages and vehicles of every description, and in particular those wholly or partly propelled by oil, steam, electricity, compressed air, or other mechanical motive power, and carry on the business of mechanical engineers, carriage makers, wire drawers, metallurgists, &c.

HORSELESS CARRIAGE AND MOTOR CYCLE COMPANY (LIMITED).—This Company has been registered, with a capital of £100, in £1 shares, to carry on the business of cycle makers, engineers' machinists, &c.

IMPROVED ELECTRIC GLOW-LAMP SYNDICATE (LIMITED).—This Company was registered on October 30th, with a capital of £5,000, in £1 shares, to acquire the benefit of letters patent for "an improved form of globe for electric glow-lamps," and registered designs for same, upon the terms of an agreement dated October 25th, between Thomas H. Jones and Ferdinand Fanta (for the Company), and to carry on the business of manufacturers of, dealers in and agents for lamps, fittings, plant, outfits, tools and apparatus used in connection with the supply of electricity. The subscribers, with one share each, are: W. Ash, engineer; Leo Steinberg; William F. Smith, electrical engineer; George W. Puttnam, engineer; Ferdinand Leleux, Harold Bilberg, and George H. Taylor.

GENERAL ELECTROLYTIC PARENT COMPANY (LIMITED).—This Company has just raised its capital from £24,000 to £30,000, in £1 shares, by the creation of 6,000 new shares of £1 each.

GENERAL TRACTION COMPANY (LIMITED.)—The statutory return of this Company, made up to September 2nd, has just been filed. The nominal capital is £50,000, divided into 5,000 Ordinary and 5,000 Preference shares of £5 each. All the Ordinary and 804 Preference have been taken up, and all considered as fully paid.

MANCHESTER SUBURBAN ELECTRIC SUPPLY (LIMITED).—The statutory return to September 13th has been filed. Seven shares have been taken up out of a nominal capital of £25,000, in £1 shares, but no calls have as yet been made.

MILVER PORTABLE ELECTRIC BATTERY SYNDICATE (LIMITED).—The statutory return to September 16th has been filed. Out of a nominal capital of £20,000, in £5 shares, 3,980 have been taken up, and of these 3,020 have been issued as fully paid, while £4 per share has been called on the remaining 960 shares.

IMMISCH ELECTRIC LAUNCH COMPANY (LIMITED).—The annual return to October 12th has been filed. The nominal capital is £12,000, in 10,000 Ordinary and 2,000 Preference shares of £1 each; 8,965 of the former and 1,647 of the latter have been taken up, and all the Ordinary have been issued as fully paid. A call of 10s. per share has been made on the Preference shares.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30 7/16d. per oz. (Nov. 7th). Consols (2¾ per cent.) 106 3/16 – 105 15/16 for money, 106 1/16—107 1/16 for account; 2½ per cent. 104—104 1/16 (Nov. 7th). Stock Exchange Settling Days: Consols, Dec. 6th; Stocks and Shares Continuation Day, Nov. 12th; Ticket Day, Nov. 13th; Pay Day, Nov. 14th; Mining Share Carry-Over Day, Nov. 11th.

DOUGLAS SOUTHERN ELECTRIC TRAMWAYS (LIMITED).—Letters of allotment in the recent issue of capital in this Company have, we learn, been posted.

AERATED BREAD COMPANY (LIMITED).—At the general meeting of this Company last week, the Chairman (Major Bolton), in moving the adoption of the report and accounts, referred to the fact that the Company had

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already installed the electric light in several of their depots, and said that, although the initial expense in comparison with gas was somewhat heavy, the electric light would undoubtedly prove cheaper in the end.

ALLGEMEINE ELEKTRICITATS-GESELLSCHAFT.—At a recent Directors' meeting of this Company the report for the business year ended July 1st last was accepted, and it was resolved to recommend at the general meeting of shareholders in December next a dividend at the rate of 11 per cent., against 9 per cent. for the preceding year. The Company report the trade outlook is very satisfactory.

ALUMINIUM COMPANY (LIMITED).—The report of the Directors of this Company for the twelve months ended June 30th, to be submitted at the ordinary general meeting to be held at the Cannon-street Hotel, E.C., on Monday next, at 3 p.m., states that their forecast as to the value of the new patents owned by the Company has been realised, and that the general business of the Company at Oldbury continues satisfactory. The accounts show a net profit of £5,376. The Directors recommend the payment of a dividend of 5 per cent. on the "A" shares, absorbing £3,000, leaving a balance of £2,376 to be carried forward. An agreement was entered into in January last with the Mathieson Alkali Company of America for the sale of the Electrolytic Alkali patents for the United States, and the Directors state that the plant has been completed and is being put into operation. The Company are to receive upon the satisfactory running of the plant the sum of £65,000 (£30,000 in cash and £35,000 in shares), besides substantial royalties calculated on the output, with a minimum sum guaranteed during the life of the patents. In October last the Company entered into an agreement with MM. Solvay et Cie., owners of the Kellner Alkali patents, for a combination of both the Castner and Kellner patents, for the mutual advantage of the Aluminium Company and MM. Solvay et Cie. Under this contract the Aluminium Company obtained the sole right to work the combined patents in England and the Colonies, while MM. Solvay et Cie. possess the sole right to work the same patents on the Continent, and the Aluminium Company receive £5,000 as an extra consideration for such agreement. The Directors have sold the Castner patents, together with the benefits of the agreement with MM. Solvay et Cie to the Castner-Kellner Alkali Company (Limited) for the sum of £125,000, payable as to £25,000 in cash and as to £100,000 in shares. It is decided to pay off the £12,000 10 per Cent. "B" Debentures, which fall due on January 1, 1896. The Directors are also making arrangements for reducing the present £6 per Cent. Debenture debt by paying off the present issue, and, if necessary, raising a smaller loan at a lower rate of interest. The Directors consider that the Company, in addition to its business at Oldbury will shortly be in possession of a large income from (1) dividends on the shares of the Castner-Kellner Alkali Company; (2) royalties to be paid by the Mathieson Alkali Company; (3) dividends on the share capital of the American Company now being formed to be allotted to this Company; and (4) from the sale of the British and Continental patents, in respect of which negotiations are now proceeding. The Directors also announce that in consequence of the important office in the Government which Mr. Gerald Balfour now occupies, he resigns his position of Chairman and Director of the Company. The retiring Directors, Lieut.-Gen. Sir Andrew Clarke, R.E., and Mr. Hamilton Y. Castner, offer themselves for re-election, as do the auditors, Messrs. Broads, Paterson and Co.

BRITISH ELECTRICAL MANUFACTURING COMPANY (LIMITED).—A prospectus is issued inviting subscriptions to a share capital of £20,000, in shares of £5 each, of which half are to be allotted as fully paid to the vendor. Payment is to be made: 10s. on application, £2. 10s. on allotment, and the balance one month after allotment, and as the necessary working capital has been guaranteed, the Directors proceed to allotment forthwith. We referred to this Company in our last issue, and it is only necessary to say that Mr. C. L. Baker, late of Cornbrook Telegraph Works, Manchester, has been appointed consulting engineer to the Company. The list of applications opens and closes this day (Friday).

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended November 3rd were £971, against £939 in the corresponding week of 1894, an increase of £32. The total receipts for the half-year amount to £15,649, against £15,750 for the corresponding period of 1894, a decrease of £101.

COMPAGNIE DE L'INDUSTRIE ELECTRIQUE GENEVE.—The report of this Company for the year 1894-1895 shows a loss of £7,680.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The estimated amount of the traffic receipts of this Company for the month of October is £2,520, against £2,101 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of October, amounted to £73,606, against £67,754 in the corresponding period of 1894, an increase of £5,854.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of October, amounted to £60,288, and to £42,584 in the corresponding period of 1894, being an increase of £17,704.

ELMORE'S PATENT COPPER DEPOSITING COMPANY (LIMITED).—The annual meeting of this Company was held at Leeds on Friday last. The Chairman (Mr. John North), in moving the adoption of the report, said that notwithstanding a drop in the average price of their finished manufactures of over £12 per ton, they had been able to wipe out the old sources of loss which were so serious during the two past years, and to make a net profit of £480. 6s. 4d. They had also to contend with determined competition, and the year had had to bear the burden of one or two low-priced contracts which had not been executed when the present Directors took office. He said that there had been a much larger turnover in the factory without any corresponding addition to the expenses, and they had also effected considerable economies. If their works had been engaged all through the year to their full capacity they would have presented a very different account. They had really made during the period under review a net profit of £1,236 on the proper basis of the Company's manufacturing operations, and they had now reached a point when it was practically impossible to do better than they had during the last six months, unless the Company had adequate capital at its command. They had no difficulty in securing very remunerative orders, and they expected to be appointed on the list of Admiralty contractors, which would greatly increase the amount of their business offered to them. They had already supplied tubes and cylinders to foreign navies, though they had not yet been directly appointed contractors to the British Navy. Referring to the method of raising further capital, the Chairman said it was proposed to extend the Company's borrowing powers. Substantial offers of assistance in the debenture issue had already been received, but the offer would in the first instance be made to the shareholders, and the Directors hoped they would respond now that the Company had passed through its difficulties, and had been established on a paying basis. The Chairman said if they could raise £30,000 they would be in a position to do a much larger business. The Chairman then referred to the proposal as to the reduction in the Ordinary share capital of the Company, and said the principal advantage to be derived would be the wiping out of the old loss, and they would then be in a position to divide at once any profits that might be made. Several shareholders criticised the report, and one of the speakers moved an amendment in favour of the appointment of a committee of inspection. The amendment, however, was lost, and the original resolution was adopted, with the suggestion (accepted by the Chairman) that the Directors be authorised to write of £11,012 standing to the credit of the reserve account by reducing assets to that extent. Special meetings were afterwards held, when resolutions in favour of raising additional capital were adopted.

GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).—The traffic returns of this Company in October, 1895, were £30,400, and the total receipts from January 1st to October 31st £261,600, against £226,800 and £234,600 respectively in the corresponding months of 1893 and 1894.

LIVERPOOL OVERHEAD RAILWAY COMPANY (LIMITED).—The traffic receipts of this railway for the week ended 3rd inst. amounted to £1,046. The amount for the corresponding week last year was £884; increase £162.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—The Directors of this Company announce the payment of an interim dividend at the rate of 3s per share for the half-year ended June 30th last.

MONTE VIDEO TELEPHONE COMPANY (LIMITED).—Warrants for the 4 per cent. dividend on the Preference shares of this Company have been posted.

SOUTH AUSTRALIAN ELECTRIC LIGHT AND MOTIVE POWER COMPANY (LIMITED).—At a meeting held at Adelaide on September 7th the shareholders authorised the Directors to present a Bill to Parliament authorising the Company "to generate, accummulate and supply electricity for lighting and motive purposes in Adelaide and other municipalities in the colony."

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to allow 6,000 Six per Cent. Preference shares (Nos. 14,001 to 20,000) and a further issue of 3,723 Ordinary shares of the Chelsea Electricity Supply Company (Limited) to be quoted in the Official List.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half-month ended October 31st are £2,163, as compared with £2,171 in the corresponding period of 1894.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The transfer books of this Company are closed from the 4th to the 14th inst. inclusive. The ordinary general meeting of the Company will be held at Winchester House, E.C., on Thursday next, the 14th inst., at 12 noon. The Company's traffic receipts for the week ended November 1st, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,965.

WOODHOUSE AND RAWSON UNITED (LIMITED).—A meeting of the debenture-holders in this concern was held on Tuesday at the Cannon-street Hotel under the presidency of Mr. C. J. Stewart (the Official Receiver), who stated that the meeting was called in consequence of an order of the Court, and in accordance with the decision of the meeting in June last. At that meeting it was decided that the debenture-holders were averse to the funds realised in the debenture action being appropriated for the purpose of taking proceedings against the Directors, auditors and officers of the Company under Section 10 of the Act of Parliament. This application against the Directors originally came before the Court as the result of the public examination. A case was prepared by the solicitors who were acting for the Official Receiver and liquidator, which was submitted to the solicitors representing the Receiver, and approved by them, and was then submitted to counsel, who gave his opinion that proceedings would be successful with respect to dividends paid by the Company during certain years. The matter subsequently came before Mr. Vaughan Williams, who directed that two meetings of the debenture-holders should be held for the purpose of obtaining their votes for or against proceedings being taken against the Directors and auditors. The debenture-holders who had sent in proxies against the proceedings, and who were willing to abandon their rights, numbered 16, and represented £8,826; those proxies sent in against the proceedings, and who were not willing to abandon their rights, numbered 21, and represented £9,054; and the proxies sent in in favour of continuing the proceedings numbered 54, and represented £33,254. After some discussion the debenture-holders were requested to sign and hand in the voting papers, and the Chairman stated that the result should be reported to the Court in due course.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Oct. 30.	Price Wednesday, Nov. 6.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending Nov. 2. Highest	Lowest
			TELEGRAPHS.						
£1,012,880	Stock	10/0	Anglo-American	44 45	43 45	5 0 0	Jan., Apr., July, Oct.	44½	..
£2,993,560	Stock	20/0	Do. Preferred	85 86	85½ 84½	5 6 6	" "	85½	85
£2,993,560	Stock	5/0	Do. Deferred	6¾ 7¼	6¼ 6¾	..	.. ..	7⅛	6¾
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	102 105	102 105	3 17 1	January and July ..	104	..
120,000	£10	3/0	Brazilian Submarine	14 14½	13⅞ 14¼	4 18 3	Mar., June, Oct., Dec.	14⅝	14 7/16
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111 115	111 115	4 8 4	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	164 168	164 168	4 8 7	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	13 14	13 14	5 14 4	February and August	13½	13
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 18 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	4 5	4 5	4 0 0	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	10½	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104⅞ 107⅞	104⅞ 107⅞	4 5 4	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8¾ 9¼	8 8¼	4 14 2	Jan., Apr., July, Oct.	8¾	8½
400,000	10	2/6	Eastern	17 17½	16¾ 17	3 16 6	" "	17½	17
70,000	10	6%	Do. 6 per Cent. Preference	18 18½	17⅞ 18½	3 5 9	" "	18	17⅞
£1,297,337	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock ..xd	127 130	126 129	3 2 0	May and November	128⅛	127½
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 11 11	February & August	..	..
250,000	10	2/6	Eastern Extension	17⅞ 18½	17⅞ 18⅛	4 2 2	Jan., Apr., July, Oct.	18⅛	17⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128 131	128 131	3 1 7	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 107	103 107	4 15 0	January and July ..	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103 107	103 107	4 15 0	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108 111	108 111	3 12 9	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.) ..xd	114% 117%	115% 115%	3 9 7	May and November	..	..
180,227	10	1/8	Globe Telegraph and Trust	10 10½	9⅞ 10½	4 3 11	Jan., Apr., July, Oct.	10½	10
180,042	10	6%	Do 6 per Cent. Preference	16⅞ 17⅛	16⅞ 17⅛	3 9 7	" "	17⅛	17
150,000	10	5/0	Great Northern	21⅝ 22⅛	21⅝ 22⅛	3 16 3	Jan., April, and July	22⅛	22
£130,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	104 107	104 107	4 14 4	March & September	105	104
17,000	25	12/6	Indo-European xd	48 51	47 50	5 0 0	May and November	..	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 110	106 110	5 10 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	109 112	109 112	3 12 3	" "	..	..
11,889	8	4/0	Reuter's	5½ 6½	5½ 6½	..	April and October ..	..	..
3,881	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	127 132	127 132	4 10 11	" "	..	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	..	January and July ..	6¾	..
£228,300	100	5%	* Do. 5 per Cent. Debentures (red.)	104 107	104 107	4 14 4	March & September	105½	..
30,000	10	2/0	West Coast of America	1½ 2	1½ 2	..	January and July ..	..	..
£150,600	100	8%	Do. 8 per Cent. Debentures, 1902	100 105	100 105	7 16 1	June and December	..	..
88,321	10	6d.	West India and Panama	¾ 1⅛	¾ 1⅛	..	..	1	..
84,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10⅝	10½ 10⅝	5 14 3	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8⅝ 9⅛	8⅝ 9⅛	..	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	111 114	111 114	4 9 1	June and December	..	..
64,242	15	6/0	Western and Brazilian	10½ 10⅝	10 10½	4 12 10	May and November	10 7/16	..
33,129	7½	4/6	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	..	—	6⅝	6 11/16
33,129	7½	1/6	Do. 5 per Cent. Deferred	3½ 4	3½ 4	..	—	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 13 9	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 13 9	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds ..xd	113 118	110 115	6 1 9	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100 103	100 103	5 17 8	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3½ 4	3½ 4	..	—	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16 1/8	1/16 1/8	..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	7/16 ½	7/16 ½	..	Yearly	..	..
484,597	5	2/6	National	6 6½	6 6½	4 0 0	June and December	6 3/16	6 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15½ 16½	15½ 16½	3 12 9	" "	16 3/16	15½
119,224	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6¼ 6¾	6½ 6¾	3 16 11	—	6⅞	..
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	106 108	105 107	3 6 2	January and July ..	107⅛	106½
58,000	5	3/0	United River Plate	2⅜ 3⅛	2⅜ 3⅛	..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	92 97	92 97	5 5 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	13 14	12½ 13½	1 17 0	—	12⅝	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15½ 16½	15½ 16½	3 12 9	—	16⅛	15⅝
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	188 187	182 186	3 14 6	June and December	135	183
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	—	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	6½ 6⅝	5½ 5⅝	..	—	6 7/16	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	—	..	..
3,822	£5	..	House-to-House Electric	— —	— —	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	— —	— —	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July ..	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 8⅛	7⅞ 8⅛	..	—	..	..
114,000	5	..	London Electric Supply	.. ..	.. ..	..	—	..	..
49,900	£10	6/0	Metropolitan Electric Supply (fully paid)	11 11½	10½ 11½	2 12 2	—	11⅝	..
150,000	Stock	4½%	* Do. 4½% Debs.	117 120	117 120	3 15 11	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9½	8½ 9½	..	—	..	..
..	..	..	Rand Electric	⅜ ½ prem	7/16 9/16 prem	..	—	..	..
19,980	£5	2/0	St. James and Pall Mall	8¼ 8¾	8¼ 8¾	..	—	8⅝	..
20,000	£5	7%	Do. 7 per Cent. Preference	9 10	9 10	3 10 0	—	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8½ 8¾	8½ 8¾	3 2 10	—	8½	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1½ 1¾	1⅝ 1⅞	9 5 2	—	2	1½
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2 2¼	2 2¼	5 6 8	—	2 1/16	2⅛
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 18 9	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1½ 2⅛	1½ 2⅛	..	January and July ..	..	..
89,261	5	1/6	Edison and Swan United	1¾ 2¼	1¾ 2¼	..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 5 4	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. —	.. —	..	..	..	..
110,000	2	..	Electric Construction	¾ 1	¾ 1	..	..	..	..
12,845	2	2/9⅛	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 12 0	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	9/16 ⅝	9/16 ⅝	..	..	..	1 1/16
20,000	5	..	Fowler-Waring Cables (fully paid)	¼ ⅜	¼ ⅜	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	19 20	19 20	3 15 0	February & August	19½	19½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	100 102	101 103	4 8 0	March & September	..	..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	⅜ ⅝	2s. 3s.	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	43 45	42 44	4 1 10	March and July	44½	43
£150,000	100	5%	* Do. 5 per Cent. Bonds	104 107	104 107	4 15 0	January and July .	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	..	—	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	—	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	14 14½	14 14½	4 2 9	—	14½	14½
£30,000	10	7/0	Do. 7 per Cent. Preference	15½ 16⅛	15½ 16⅛	4 4 10	—	16⅛	16⅛
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	107 110	107 110	4 2 5	—	110	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway	40 42	42 42	2 19 6	May and November	41	3
7,650	10	5%	Do. 5% Perpetual Preference	14⅜ 15½	14⅜ 15¼	3 5 8	..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture xd	133 134	132 134	2 19 9	May and November	..	..
37,500	£10	2½%	Liverpool Overhead Railway	11 11/16 12 1/16	11⅞ 12	1 17 6	—	..	..
10,000	10	5%	Do. 5% Preference	15 15½	15½ 15⅝	3 5 0	—	..	..
135,000	Stock	4%	Do. 4% Debenture	112 114	112 114	3 10 2	January and July ..	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

THE Institution of Electrical Engineers will, in all probability, shortly be tossed on the waves of a storm aroused by a singular lack of foresight on the part of the Council. Up to within the last few days, the *impasse* into which the Institution has been brought by the Council's policy of drift might have been avoided by the exercise of ordinary diplomacy. To force upon the Institution a President unacceptable to a large proportion, if not to a large majority of the members, cannot but seriously weaken the Institution. At the present moment there would seem to be nothing before us but an unedifying public washing of dirty linen; an open squabble painful to all concerned—and not least so, we feel sure, to the principal person around whom the storm will rage.

WHETHER the malcontents prove victorious or no, the Institution itself is sure to suffer, may be irreparably. Even if it be true that the *active* opponents of the Council's nominee are few in number, there is undoubtedly a widespread and exceedingly strong latent opposition to the proposed President which the Council must be sadly out of touch with their constituents not to be aware of. Of two evils choose the less, and if the great body of members decide that quiet submission to the Council's choice is the lesser evil, they will not be blameworthy. But members will have only themselves to thank for future incidents of the kind, if they do not straightway insist upon radical reform in the election of Council and increased stringency with regard to the admission of members and associates; at present both methods are farcical. The Institution would, we think, suffer a grave loss, if it were composed exclusively of *bonâ-fide* electrical engineers; nevertheless, no institution that wishes to be taken seriously ought to allow itself to be represented by mere amateurs. Let all such who take an interest in electrical science and electrical engineering take part in the discussions—preferably as honorary members—but let only those who actually belong to the profession represent it on the Council. The Council, we fully admit, have had a very hard nut to crack; but for that they are alone responsible; and it is perhaps too much to expect that one to whom they have rendered such a disservice will rescue them by gracefully retiring from the untenable position to which they have permitted him to aspire.

FOLLOWING up the admirable policy which led to the Round-Table Conference on the subject of the regulations proposed by the Board of Trade in connection with electric traction, a similar Conference on the revised electric light rules will be held at the Westminster Town Hall on Tuesday, under the chairmanship of Sir COURTENAY BOYLE. Those who are to take part in the Conference are, no doubt to a large degree, indebted for their invitation to the fact that they have presented objections to the proposed rules. But the fact that the meeting is a Conference gives to these—delegates shall we call them—a position of much greater importance than that of mere objectors. We do not exaggerate their status in any degree by calling them delegates—representatives of the electrical industry in all its departments—who have been requested to aid in the preparation of those rules and regulations which, for the sake of public safety and the good repute of the industry, should be loyally conformed to by all.

IT is evident that if the result of this Round Table Conference is a set of regulations to which all present have practically agreed, then such regulations will issue with an added weight. If, on the other hand, there should emerge a difference of opinion upon any important point between the members of the Conference and the Department, that particular regulation will require to be supported by practical and convincing reasons before the bar of public opinion. Each delegate will, in a sense, be witness as well as juryman. He has, therefore, laid upon him the difficult duty of appraising the value of his own evidence as against that of others, and in this connection it will be well for the delegate to remember that his opinion—his evidence—though largely based on experiment, it is true, really depends on an investigation often limited in character and duration, and his experimental basis may not, therefore, justify as emphatically as he is inclined to think it does, the conclusions he has reached. In other words, it does not follow that when he differs with the Board of Trade, the Board of Trade is wrong, although in forcing forward any particular regulation against the unanimous voice of practical men, that Department naturally takes a step involving grave responsibility. There is, however, every reason to anticipate that, as in the case of the Traction Conference, the meeting next week between regulation makers and regulation objectors will dissipate many erroneous notions entertained by the latter as to the wilful obstinacy of the former, and will result in a workable set of rules being imposed upon the industry.

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The manufacture of carborundum, an interesting account of which is given in another column, affords a typical instance of the best class of work to which the electric furnace can be put. In this material—the very existence of which was unknown a few years ago—we have a substance that appears to be capable of formation only at an extremely high temperature, and therefore not susceptible of industrial preparation without the aid of electrical energy. The temperature which can be obtained by purely chemical means—*e.g.*, by combustion—is always limited by the impending dissociation of the products of reaction; that which can be reached by electrical methods is limited solely by the degree of refractoriness of the materials of the furnace. It may be noted that the very localisation of the heat generated by an electric furnace, which has proved an obstacle to some industrial applications, is here the very essence of the process, in that it connotes the attainment of an extremely high temperature. A point of some scientific interest is that raised by the colour of the carborundum crystals, which are said to vary from yellow to blue. This may be due to the presence of small quantities of impurities such as are believed to control the hue of many coloured gems. Synthetic experiments with small known quantities of colour-producing oxides would go far to settle the question.

Though it may be an obvious platitude to say that the chief troubles with boiler feed water arise from hardness and the tendency to incrustation on the heating surfaces, it is by no means so obvious how to soften the water and prevent the objectionable "scruff." The difficulty arises largely from the composite character of the hardness of most waters, and from the necessity for dealing with the various kinds of hardness in a different manner. Temporary hardness arises from carbonates of the alkaline earths, permanent hardness mainly from their sulphates. But, though the one will be deposited before boiling, while the other will not, they both combine to harden on the boiler plates if the feed water is not properly treated before evaporation. We confess to a rooted dislike to anti-incrustation processes which are intended to take place in the boiler itself; the practice of dosing the boiler with nostrums designed to have this effect is a half-measure at the best, and in the majority of cases it is no remedy whatever. In our opinion the mineral matter should be extracted from the water before the water enters the boiler. There is not the same objection to the use of anti-incrustation compounds in the feed-heater or the economiser, provided always that the degree of hardness is not great, and that the compound is introduced continuously and not in great gulps.

In cases where there is a large percentage of mineral matter in the water, however, it is imperative, and in most cases it is advisable, to treat the feed water in bulk before it is taken by the feed pumps. The only objection to this process has been its relatively large prime cost, owing to the necessity for capacious settling tanks; but it is evident that the magnitude of this item will depend upon the rapidity with which large volumes of water can be treated. On Wednesday last Messrs. Mather and Platt exhibited, at Adlington, a plant capable of softening water for boiler use at the rate of 8,000 gallons per hour. The apparatus is the invention of Messrs. Archbutt and Deeley; and, in its action, deals with the feed water in three stages, all of which take place in the same tank. The first stage consists in the chemical precipitation of the mineral matter—the carbonates by means of quicklime, the sulphates by means of soda ash. The admixed chemicals and hot water are well stirred into the feed water in a capacious tank, the precipitation being accelerated by rapid commotion. The second stage consists in mechanically stirring up the mud in the bottom of the tank, so as to coagulate or flake the precipitate, and thus to hasten its settling. In about an hour the solid matter will have sunk to the bottom, and the clear soft "mother liquor" may be drawn off at the surface.

For ordinary boiler work these two stages should generally suffice, as, if they are properly carried out, there can be only a trace of mineral matter remaining in solution. But where it is especially desired to prevent the deposit in pipes or feed apparatus of any slight amount of carbonate of lime which may remain in solution, the third stage may be adopted. This stage takes place while the liquid is being drawn off from the tank; and it consists in the conversion of the slightly-soluble carbonate of lime into the much more soluble bicarbonate, by the passage of gaseous carbon dioxide through the liquid. The gas is generated in a simple and cheap manner by forcing air through a coke furnace. This supercarbonation will not, of course, prevent the residual hardness from producing a proportionate and small incrustation in the boiler; but, as we have said, it may serve to prevent trouble arising in the pipes and passages leading to the boiler.

Some amusing expert evidence was given recently, during a case which came before the New Jersey Supreme Court, at Trenton. A citizen's horse had become unmanageable through receiving an electric shock while crossing the electric tramway; and it was alleged that the rails were badly bonded. Prof. Moore, of Princetown College, went forth and measured the rail resistance, on behalf of the tramway company. It worked out to 0·62 ohm per mile; which, no doubt because Prof. Moore's problems often work out to a great many ohms, he considered a very low figure indeed. It was naught to him that this resistance represented a drop of 250 volts per mile of track; it was a decimal quantity measured to two places, and that meant that it was not very big. But a Mr. Woodbridge had also measured the rail resistance, apparently on behalf of the citizen who owned the horse; and *his* answer worked out to 0·08 ohm, which in his opinion was much too high for a mile of bonded tramrail. Nothing daunted, Prof. Moore, of Princetown College, produced a model to prove "that it was easier to get a shock on a dry day than on a wet day." He had a tin pan connected to one pole of a hand dynamo, and a piece of iron, resting on some sand in the pan, connected to the other pole. When the luckless jurymen touched the pan and the iron they received a shock; but on wetting the sand the shock ceased. Notwithstanding Prof. Moore's system of experimental logic and his mathematics, the judgment was in favour of the citizen who owned the horse.

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A little more than a century ago Dr. Galvani, of Bologna, convulsed the electrical world by his discovery of the convulsive twitching of a frog's leg when two dissimilar metals were placed in contact with a nerve and a muscle respectively, and then brought into contact with each other. An equally curious, and it may be an equally pregnant, observation has recently been placed to the credit of Dr. Waller. The tadpole, not the full-grown frog, has been the object of Dr. Waller's scientific attentions. "Taking a trough full of tadpoles, moving leisurely and jostling each other in all directions, and passing a moderate current, the commotion," says Dr. Waller, "is amazing; the tadpole community seems to have gone mad; a writhing mass is all that can be distinguished; but the disturbance does not take long to subside, and now all the tadpoles are fixed as if at attention, looking one way, heads to anode, so that they are traversed by a current from head to tail. . . ." A tadpolar effect is also observable with hay infusion. The "paramœcia," we are told, rudely turn their noses up at the cathode, but nevertheless swim towards it in converging lines; on reversing the current the fickle horde breaks up and goes over to the other pole. "Flagellata," on the other hand, affect the anode. "Start the current," says Dr. Waller, dramatically; "two armies assemble at the two banks—ciliata to the cathode, flagellata to the anode. . . .", cathode to right of them, anode to left of them. There is evidently more in the electrical behaviour of the lower organisms than has hitherto been dreamt of in our everyday philosophy.

Cable Interruption :—

	Date of Interruption.
Cadiz-Teneriffe	Sept. 25, 1895.

The Faure Patent in Germany.—The Faure accumulator patent in Germany expires in February next. It is expected that this will be the signal for keen competition in the accumulator trade in that country.

New Berlin-Vienna Telephone Trunk Line.—The Austrian Budget contains an item of £30,000 to be expended on a second telephone line between Berlin and Vienna, the erection of which is to commence next spring.

Electrical Treatment of Disease.—It is reported that a sum of £800 has been granted by the Paris Municipality to the Salpêtrière Hospital, for the erection of buildings in which to treat mental and nervous affections by electricity.

Institution of Electrical Engineers.—We are informed by the Secretary that the annual dinner, which was to have taken place on Friday, November 29th, has been postponed until Friday, December 13th, when H.R.H. the Duke of Cambridge will honour the Institution with his company. A circular to the above effect is being issued to the members.

City and Guilds of London Institute.—One of the most useful of the many useful functions of the City and Guilds of London Institute for the advancement of technical education is the annual examination in technology which it conducts throughout the United Kingdom. Recently we have received a copy of the report on the work of this department of the Institute during the 1894-5 session. No less than 10,293 candidates have been examined, an increase of 386 since last year; and of these, 5,824 succeeded in obtaining passes, an increase of 343 above the successes of the previous year.

Institution of Civil Engineers.—Sir Benjamin Baker, speaking recently at Leeds to a gathering of Yorkshire students connected with the Institution of Civil Engineers, advocated a modification of the charter in order that the sphere of its usefulness might be greatly extended. When the charter was first granted there were only 156 members, now they number nearly 7,000. He thought the Council should be so enlarged that the great manufacturing centres of Great Britain, the Indian Empire and the Colonies should be represented upon it.

Royal Institution.—The Christmas Course of Lectures, adapted to a juvenile auditory, will be delivered this year by Prof. John Gray McKendrick, F.R.S., Professor of Physiology in the University of Glasgow, and formerly Fullerian Professor of Physiology in the Royal Institution. The subject will be "Sound, Hearing and Speech," and the lectures will be experimentally illustrated. The first lecture will be delivered on Saturday, December 28th, at 3 o'clock, and the remaining lectures on December 31, 1895, and on January 2, 4, 7 and 9, 1896.

"The Engineer" One Thousand Guinea Road Carriage Competition.—The conditions of this competition are to be found in full in *The Engineer* of November 8th, p. 459. The judges will be Sir Frederick Bramwell, Mr. John Audley F. Aspinall, and Dr. John Hopkinson. The competing vehicles will be divided into four classes, receiving prizes of 350, 250, 250, and 150 guineas respectively. The trials are to consist of a 100-mile run out and home—200 miles in all. No speed of more than 10 miles an hour will be placed to the credit of any competitor. The limit of weight is two tons. The competition will probably take place about a year hence.

Royal Society.—The following is a list of those who have been recommended by the President and Council of the Royal Society for election into the Council for the year 1896 at the anniversary meeting on November 30th :—President, Sir Joseph Lister; Treasurer, Sir John Evans; Secretaries, Prof. Michael Foster, Lord Rayleigh; Foreign Secretary, Mr. Edward Frankland; Members of Council, Mr. William Crookes, Sir Joseph Fayrer, Mr. Lazarus Fletcher, Mr. Walter Holbrook Gaskell, Mr. William Huggins, Lord Kelvin, Prof. Alexander B. W. Kennedy, Prof. Horace Lamb, Prof. Edwin Ray Lankester, Prof. Charles Lapworth, Major Percy Alexander MacMahon, Prof. John Henry Poynting, Prof. Arthur William Rücker, Mr. Osbert Salvin, Prof. Harry Marshall Ward, Admiral William James Lloyd Wharton.

Electrical Tanning.—In the *Zeitschrift für Elektrochemie* Herr Folsing, writing on this subject, states that he has worked out an electrical method of tanning, which he considers is suitable for both thin skins and heavy hides, and only requires three to six days. The tanning pit contains 15,000 litres. Electrodes of nickelled copper are fixed to the walls of the pit, in which the hides are hung so that the current has to pass right through them. A current of 12 amperes with an E.M.F. of 12 volts is used. The colour of the leather is not quite satisfactory when commercial unpurified extract is used. The author lays stress on this, and he himself uses an oak extract (with a little hemlock extract added) which is cleared and decolorised by a special electrolytic process. When this is used he finds that the colour is exceedingly good and bright. Light cow-hides were found to require 72 hours, heavy cow-hides 5 days, and heavy ox-hides 6 days. The latter would require about a year by the old process.

Prize Offered for a Fuse Design.—The Verband Deutscher Elektrotechniker is offering a prize, consisting of a diploma and £15, for the best device by which mistakes, such as placing the wrong size fuse in fuse terminals and the interchanging of fuses except by authorised persons, shall be rendered impossible. The standard sizes of lead fuses adopted by the Verband at its last annual meeting are to be employed. These are :—

Amperes.	Distance between centres of fuse terminals in inches.	Diameter of terminal screw in inch.
50	2·8	$\frac{1}{4}$
100	3·2	$\frac{5}{16}$
400	3·8	$\frac{1}{2}$
1,000	4·4	$\frac{3}{4}$

The designs are to remain in every respect the property of the individual, and must be sent in not later than April 1, 1896, addressed to the Verband at 3, Monbijouplatz, Berlin, N., and marked with a motto. The result will be made public at the next annual meeting of the Verband.

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"Chicago Times-Herald" Motor Cycle Race.—This race took place on November 2nd, but of the 90 vehicles entered only two were ready to put in an appearance, and as a delay of three weeks would enable most of the competitors to produce their machines, the race has been adjourned to November 28th. Although only two vehicles crossed the line on November 2nd, 150,000 persons turned out to see the start. By the terms of the competition the vehicles had to cover a course of 92 miles in a maximum period of 13 hours. Half-way over the course one vehicle was disabled, and the Benz motor had the race all to itself, and covered the ground in a gross time of 9 hours 30min. Its real running time, after deducting all time lost in stoppages, &c., was 8 hours 44min., averaging about 10 miles an hour gross and 12 miles an hour net. The victorious motor cycle was made in Germany. It is driven by gasolin, and when it started it contained four gallons; four additional gallons were taken in *en route*, but $2\frac{7}{8}$ths were not consumed—therefore it took $5\frac{1}{8}$ gallons to convey the machine with its four riders ninety-two miles, the total cost of fuel being less than 4s. On concluding the course, the judges carefully examined the machine, and announced that it was in excellent condition, and quite capable of repeating the journey at once. Ice was packed on the wagon to keep down the temperature, but the cylinder was not unduly heated, nor was there any perceptible heating of any of the bearings.

The Work of Technical Societies.—In a very interesting leading article on this subject in *Engineering* of November 8th, the following judicious remarks occur :—

"The stimulus of controversy and criticism is worth more than the sacrifice of the small amount of exclusive experience which is made to obtain it. Just as time judiciously spent in physical exercise is not lost, but brings its reward in heightened mental and physical activity, so the intellectual effort of unfolding and defending one's ideas finds its compensation in increased power of mind and will. The result of measuring oneself with others may not always be agreeable, but the very fact that it is not is the best proof of the necessity of the operation. To shun the trial is not only to acknowledge defeat, which may be inevitable, but also to abandon the struggle for improvement. Personal intercourse in connection with technical societies fosters the scrupulous etiquette which distinguishes the professional man from the trader. The general sense of the members is always opposed to unworthy methods of seeking and conducting business. It may be that under the stress of circumstances many would allow themselves some latitude in this respect; but the thought of the effect it will have on the estimation they will be held in by others, acts as a strong deterrent. The solitary worker has no such safeguard; he can easily present his conduct to himself in the best light, and there is no one else to be considered. The fear of public opinion may not lead to a very high type of morality, but it is world-wide and it is the basis of our civilisation. We judge our neighbours less leniently than we do ourselves, and we feel obliged to conform to the standard we set up for them, because we know they will apply it to us, and look down upon us if we fail to reach it. It is sometimes hard for beginners to be debarred from advertising themselves, but it is to their advantage in the long run that the honour of their profession should be maintained."

Electric Supply in Paris.—At a meeting of the Société Internationale des Electriciens on the 6th inst., MM. J. Laffargue and F. Meyer read a Paper dealing with the Paris central station and isolated electric plants. After a brief glance at the central stations of 1889 M. Laffargue gave a general description of the Paris central stations as they are to-day, and will be shortly. The Compagnie Edison are laying down at the Avenue Trudaine station a 900 H.P. direct-coupled Brown dynamo. The Société d'Eclairage are laying down a 600 H.P. Corliss engine driving a Desroziers dynamo, also a 300 H.P. Laval steam turbine. The Compagnie Parisienne d'Air Comprimé et d'Electricité are constructing a third station on the Quai Jemapes. The output of this additional generating centre will be 2,400 kilowatts to start with, and it will contain three 800-kilowatt 500-volt external-collector machines. The Company serving the Secteur des Champs Elysées is erecting a fourth 400-kilowatt 3,000-volt alternator, and the Company serving the left bank is at work on a 4,000-kilowatt station at Issy; distribution will be carried out by 3,000-volt alternate currents, and the plant will comprise ten 400-kilowatt alternators. M. Laffargue also showed several load curves, the total load curve of Paris showing a maximum output of 6,778 kilowatts, which takes place at about 6 o'clock. [For London, the maximum load, as given by Mr. Crompton in his Presidential Address to the Institution of Electrical Engineers in January last, was 11,600 kilowatts at 5:30 p.m. (December 24, 1894)]. During 1894 the total output of the Paris central stations amounted to 7,883,434 kilowatt-hours. According to M. Laffargue the horse-power of the isolated electric-lighting plants in Paris aggregates 25,760 H.P., including 700 gas engines of a total of 2,250 H.P. and some 500 H.P. of compressed-air motors.

Electricity in Berlin Suburbs.—There have been for some time past all manner of reports in the German Press with regard to the electrical plant about to be put down in the suburb of Berlin situated on the banks of the upper Spree. The fact of the matter, however, is that the Allgemeine Elektricitäts-Gesellschaft has already bought a large site at Wilhelminenhof for the erection of the generating plant, and acquired concessions from different authorities for the distribution of electric energy. It is first intended to run the wires out in the direction of the villages of Grünau and Köpenick, and the first portion of the machinery is already in course of construction. It is expected that by July 1st next the supply of current will be commenced. At present only two steam dynamos of 1,000 H.P. each are contemplated, but later machines of 3,000, 5,000 and 10,000 H.P. are expected to be laid down. The undertaking has in view the supply of current for power rather than for lighting purposes. There are already several industrial establishments in the district, and it is anticipated that many more will be erected when it is known how cheaply the current will be supplied. The charge for current is fixed so far as lighting is concerned at 6d. per unit, and for power purposes at 1·2d. per unit. These prices will be subject to a discount. Ignoring the discount the charge per brake horse-power-hour would then be from 1 to 1·1d., according to the efficiency of the motor. This figure compares favourably with those obtained from a large number of Berlin establishments where steam or other motive power is used, but the Allgemeine Elektricitäts-Gesellschaft hopes to still further reduce this price as the plant increases. The distribution will be overhead, and large girder poles will carry the conductors. The "drehstrom" system will be employed at a potential of 5,000 volts, and there will be transformer sub-stations in the different districts.

Current Electrical Science.—No. 10 of *Wiedemann's Annalen* contains the usual amount of interesting matter. F. Kohlrausch, than whom we could have no better authority, writes on several improvements in WHEATSTONE'S BRIDGE. He uses a long wire wound on a roller along a flat groove, the material of the roller being marble, or wood boiled in paraffin. To increase the accuracy of the readings resistances are introduced at each end of the wire, amounting to 4·5 times the resistance of the wire itself. When the inequality between the two resistances to be compared does not exceed 20 per cent., and the scale can be read to 1 in 10,000, the error of a determination does not exceed 1 in 25,000. A commutator with six blocks admits of putting in the additional resistances on one or both sides. In another Paper, which forms a continuation of previous researches, E. Wiedemann and G. C. Schmidt revel in their newly-explored field of CATHODIC LUMINESCENCE. This seems to be a most fruitful subject, and pregnant with future issues. The glowing of solids and "solid solutions" under the influence of cathode rays has, indeed, occupied considerable attention in England ever since Crookes propounded his "radiant matter" theory, but since the "luminescence lamp" has become an accomplished fact, the interest in this matter has considerably increased. The most beautiful colours observed are the red of mixed magnesium and manganese sulphates, the yellow of cadmium sulphate, the green of calcium fluoride and manganese, the dark blue of quinine bisulphate, the violet of lead sulphate, and the brilliant white of zinc sulphate, or sulphide, and cadmium iodide. The "solid solutions," in Van't Hoff's sense, containing traces of manganese sulphate in combination with other substances, vary in hue with different solvents, but not with different concentrations. Luminescence ranges over all temperatures from $-80°$C. to $+500°$C., but the intensity of the glow, and the duration of the after-glow, is greatest at the lowest temperatures. The sulphates of iron, nickel and copper extinguish the luminescence, even in small quantities. We cannot now pursue this fascinating subject any further, but hope to give the substance of other remarkable Papers on cathode rays, by Lenard and Lehmann respectively, in the next N te

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THE INTEGRAL OF $r_n d\theta$.

BY W. A. PRICE, M.A.

In a Note from Mr. W. H. Everett, printed in your issue of October 4th, an expression $i\int\frac{d\theta}{r}$ was given for the magnetic force at any point in the plane of a plane circuit carrying

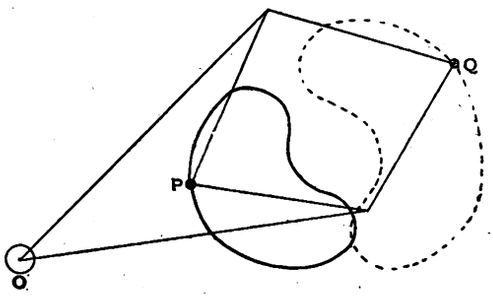

FIG. 1A.

a current of electricity i. This quantity can be measured for any point by an apparatus somewhat similar to Amsler's planimeter. Suppose, in Figs. 1A, 1B, that O is the point at which the force is to be determined, and that the full line represents

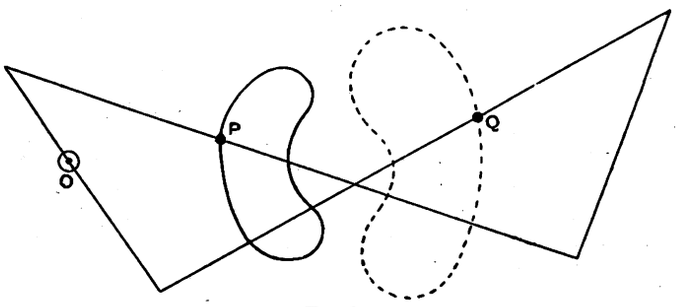

FIG. 1B.

the electric circuit. If P be carried round the full line curve, a pencil Q connected to P by Peaucellier's (Fig. 1A) or Hart's linkage (Fig. 1B) draws another curve, shown dotted, which is the inverse of the locus of P with respect to O. If $r\theta$ be the

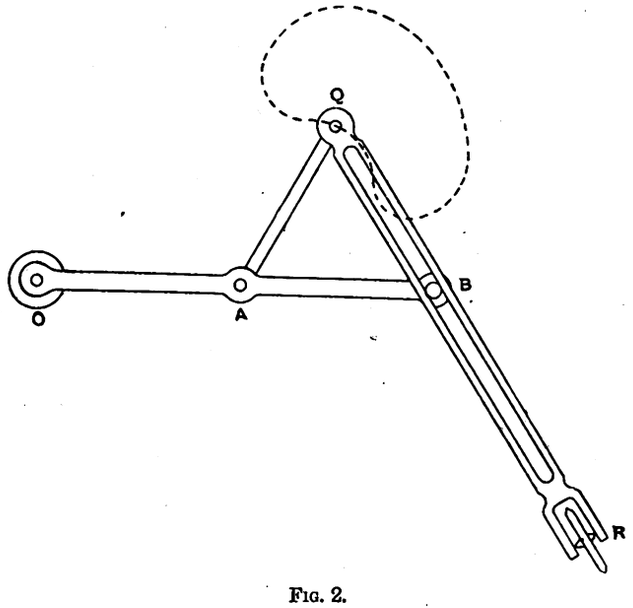

FIG. 2.

co-ordinates of P, and $\rho\phi$ those of Q with respect to O, then $\rho=\frac{a^2}{r}$, and $\phi=\theta$, and $\int\frac{1}{r}d\theta=\frac{1}{a^2}\int\rho\,d\phi$.

The value of $\int\rho\,d\phi$ can be found by an instrument constructed thus: O A B is a rigid link turning freely about the fixed point O. At A, the middle point of O B, is pivoted another link, A Q, equal in length to O A and A B; a third link, Q B R, pivoted at Q, moves so as always to pass through B, and carries a wheel at R rolling on the paper on which the

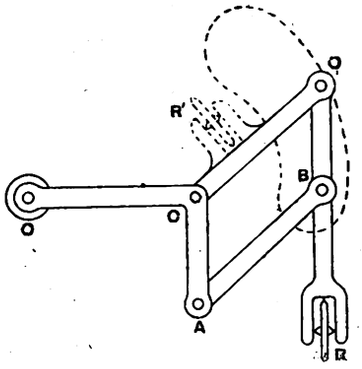

FIG. 3.

curve is drawn. The rotation of the wheel R as Q is carried completely round a closed curve measures $\int\rho\,d\phi$, and so $\int\frac{1}{r}d\theta$

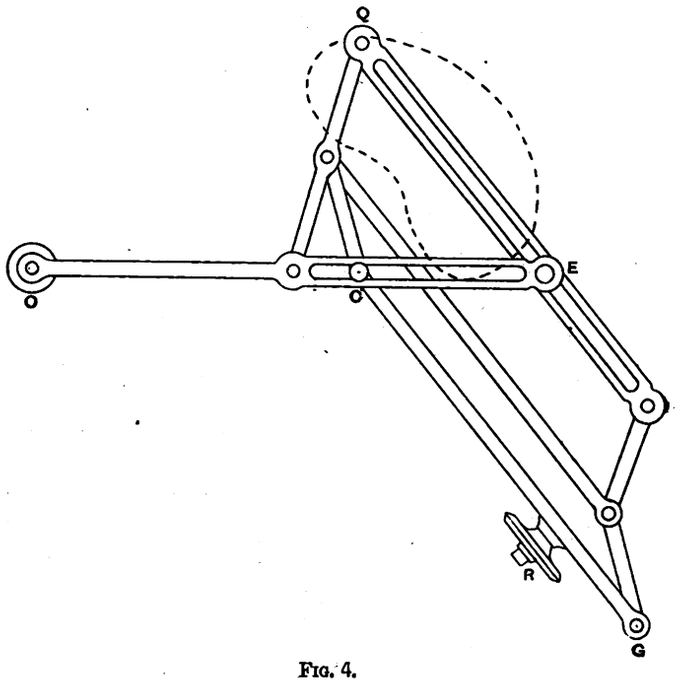

FIG. 4.

for the original curve. Other integrators performing similar operations are the following. In the one shown in Fig. 3 the

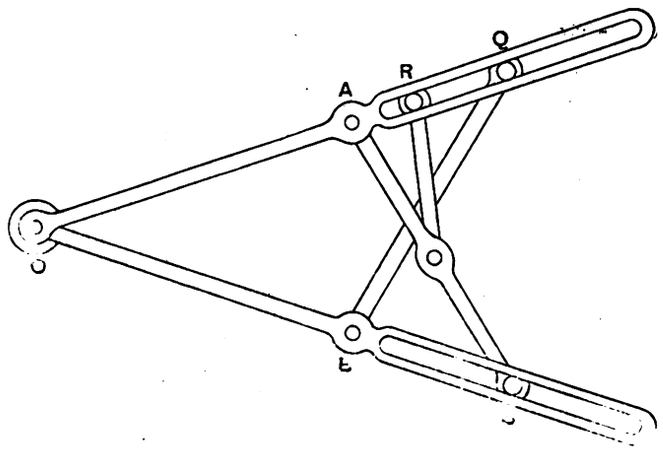

FIG. 5.

wheel at R measures $\int\rho^2\,d\phi$, $\rho\phi$ being the co-ordinates of Q with respect to O. This result is obtained much more simply by Amsler's machine, which omits the links A B and Q B B,

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well as the projection C A, and places the wheel in the position shown dotted at R'.

The wheel of the machine shown in Fig. 4 gives the measure of $\int \rho^3 d\phi$. Here C is always the foot of the perpendicular dropped from Q upon O E, and C G is constrained to lie always parallel to Q E.

In Fig. 5, R is always the foot of the perpendicular drawn from S upon O Q. O S always = O Q, O A = O B = B Q = A S, and $2 . O A . O R = O Q^2$. If $\rho\phi$ are the co-ordinates of Q with respect to O, the co-ordinates R are $\frac{\rho^2}{2a}\phi$, and the curve described by a pencil at R, while Q travels round any curve, has a radius vector always proportional to the corresponding radius vector of the locus of Q.

By applying the instruments of Figs. 2, 3 and 4 to the original curve, or that derived from it by the operations of Figs. 1 and 5, the values of $\int r^{-6} d\theta$, $\int r^{-4} d\theta$, $\int r^{-3} d\theta$, $\int r^{-2} d\theta$, $\int r^{-1} d\theta$, $\int r\, d\theta$, $\int r^2 d\theta$, $\int r^3 d\theta$. $\int r^4 d\theta$, $\int r^6 d\theta$, are all obtained.

The geometrical proof of these constructions was given in *The Electrician*, page 612, Vol. XXXIII.

THE ELECTRIC EQUIPMENT OF MESSRS. SIEMENS' WORKS.*

BY ALBION T. SNELL, ASSOC.M.INST.C.E., M.I.E.E.

This is one of the largest installations in this country for supplying electric power for factory purposes, and is doubly important because tests have been made of the efficiency of the plant, and have been published in a very complete form. The area covered by the works is 6¼ acres, and of this approximately 5 acres are covered by shops and other buildings.

The author visited Messrs. Siemens Brothers' works in September, 1895, and was shown round the shops, the various points of special interest being explained to him. He is also indebted to a Paper by Mr. Alexander Siemens, read before the North of England Institute of Mining Engineers in December, 1894, for much of the information here.

Electrically, interest centres around this plant both on account of the use of continuous currents, and also because the pressure of supply is only 120 volts. This low pressure is to be explained to some extent, perhaps, because the firm's stock machines are wound for this pressure, and, therefore, it would have been inconvenient to select a higher one.

Scheme.—This plant has been designed to replace by gradual instalments 18 isolated steam engines, capable of indicating collectively 1,446 H.P., corresponding to about 1,150 B.H.P., available for driving the machinery. At the present time (October, 1895) five of the old engines are still in use; three in the gutta-percha department, one driving a portion of the cable-making machinery, and one in connection with some of the hydraulic pumps of the lead-covering presses.

The new central station has an output of about 1,200 I.H.P., which, at an efficiency of 86 per cent., as ascertained by test, gives 1,030 E.H.P. at the main switchboard. This corresponds roughly to 1,000 E.H.P. at the motor terminals, or about 900 B.H.P. on the motor shafts.

Boilers.—At the central station, shown at 12A in the plan (Fig. 1), there are five "Gunboat" type boilers, *i.e.*, double-flued multitubular boilers, each 18ft. long by 9ft. in diameter. They work at 140lb. pressure to the square inch, and have a total capacity of about 2,000 H.P. actual. They are fired by hand, and supply steam to the machinery of the central station, to the steam engines driving the gutta-percha shop, and also for heating purposes.

On the roof of the boiler house is placed a number of condensers, each capable of dealing with 25 I.H.P. These consist of two cylinders, one placed inside the other. In the annular space formed between them the steam passes from the engines, while cold water trickles down the outside of the larger and the inside of the smaller cylinder. The condensing water thus heated is used to feed the boilers and to supply the gutta-percha and india-rubber washing tanks, and the condensed steam is allowed to run to waste. This arrangement has been adopted in order to meet the special requirements of the works.

In the engine room at the back of the engines there are four sets of double-acting automatic steam pumps for supplying the circulating water, and for maintaining the necessary vacuum in the condensers. The feed pumps are placed above the boilers in the boiler house.

Engines and Dynamos.—The engine room is shown at 12 in Fig. 1. It measures 42ft. by 80ft., and contains four steam dynamos, each capable of giving a current of about 1,500 amperes at 120 volts pressure, when running at 350 revolutions per minute. The four dynamos are exactly alike, being two-pole drum armature machines of the Siemens H.B. 24/36 type, shunt-wound and fitted with switch and resistance for varying the exciting current by hand. Three of the dynamos are driven by Willans III. type compound-condensing single-acting engines and the fourth by a Belliss compound-condensing double-acting engine.

Main Switchboard.—The main switchboard is divided into two main panels, the right-hand one being coupled to dynamos Nos. 1 and 2, and the left-hand one to dynamos Nos. 3 and 4. In the centre is a commutating device by which the omnibus bars of the two panels can be put in series or in parallel, so that power may be supplied either at 120 volts to all the circuits, or to some at this pressure and to others at 240 volts, *vide* Fig. 2, in which the arrangement is shown in diagram.

The positive circuit from each dynamo passes through a main switch, fuse and ammeter, calibrated in kilo-amperes, before entering the positive 'bus bar. There is also a magnetic minimum-current cut-out, shown at E in Fig. 2, in the positive circuit of each dynamo, so that when the current from any machine falls below a certain value the circuit is opened automatically. The positive feeders are all connected through an ammeter, switch and fuse, and the returns pass through fuses before entering the negative 'bus bar. The return current is measured by three Aron meters between the dynamo negatives and the 'bus bars, and there is thus a complete record of the output of the station from day to day. Some of the departments are served with two or more positive mains on the same switch in the station, but subdivided at the shops by distributing boards.

The right-hand panel serves the lead-covering shop, fitters' shop, yarn-winding shed and dynamo shops, gutta-percha department, dynamo-testing shop, fire-engine plugs, submarine cable shop; and there is one spare circuit.

The left-hand panel serves the saw mill, office lights, india-rubber department, winding shop, stranding shop, cotton-covering shop, carbon department and instrument shop; and there is one spare circuit.

The whole of this work is remarkably solid. The 'bus bars have a cross-section of about 6 sq. in., and the several connections are of corresponding size. The main connections to the recording meters are made from copper bars 1 sq. in., one turn of which passes below the pendulum bob and forms the retarding field. The fuses are all made from flat strip white metal. Copper coupling pieces are used for making all other connections between the dynamos and the circuits.

It is interesting to notice that there are D.P. fuses on both mains, but switches on the main positives only. Also there are no switches at the distributing boards, but they are placed on the positive conductors at or near to the motors which they feed. Both arc and incandescent lamps are supplied from the same mains which supply the motors.

To prevent leakage from the conductors to the lead sheathing of the main cables, a tube of india-rubber is drawn over the ends for about 8in. or 10in. and lashed with wire to the conductor at one end, and to the lead at the other. This precaution entirely prevents surface leakage between the copper and the lead. The same plan is followed out at all the distribution boards.

Distribution System.—Each department has its distribution board, to which the current is brought from the central station by one or more cables, and is fitted with an Aron meter to record the current used, and in some cases with an

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ammeter to enable the foreman to gauge the work being done. Each board has two 'bus bars, from which the several service circuits are taken to separate motors in the department through D.P. fuses, the switches being placed at the motors in the most convenient positions.

All the main cables are lead-covered, served with jute, and armoured with steel ribbon. The insulation between the copper conductor and the lead is desiccated jute, impregnated with bituminous compound. These cables are laid direct in the ground without any protection, and have given no trouble. The total length of wire between the switchboard and the distribution boards is a little over 6,000 yards, the area of the cross-section of the copper conductors varying from 0·25 to 1·5 sq. in. The service wires from the distribution boards to the motors are all insulated with vulcanised rubber and braided. They are carried in various ways according to the conditions, in most cases being cleated to boards run along the walls or ceilings. Casing is not generally used, except with the smaller sizes of wires.

Motors.—There are about 85 motors, varying in size from one-sixth of a B.H.P. up to 100 B.H.P., their total capacity being equivalent to about 1,500 B.H.P. The available output at the switchboard of the central station is 1,030 E.H.P., and it is estimated that nearly 900 B.H.P. could be taken from the motors at one time. But as the engines and dynamos are capable of exceeding the rated output by from 25 to 30 per cent. for short periods without any risk of injury, it is possible to increase this limit when necessary.

The motors are all of Messrs. Siemens' make, and are of various kinds to suit the requirements of the work. The majority are of the two-pole under-type, with drum armatures. The larger ones, which work under varying loads, are chiefly shunt wound. A few are compound wound for giving constant speed, but the majority are simple shunt machines. Those which run a fixed load are wound preferably in series.

All of the motors are either encased in sheet-iron boxes or are protected by iron framing covered with iron netting. This precaution serves to protect the motors from loose

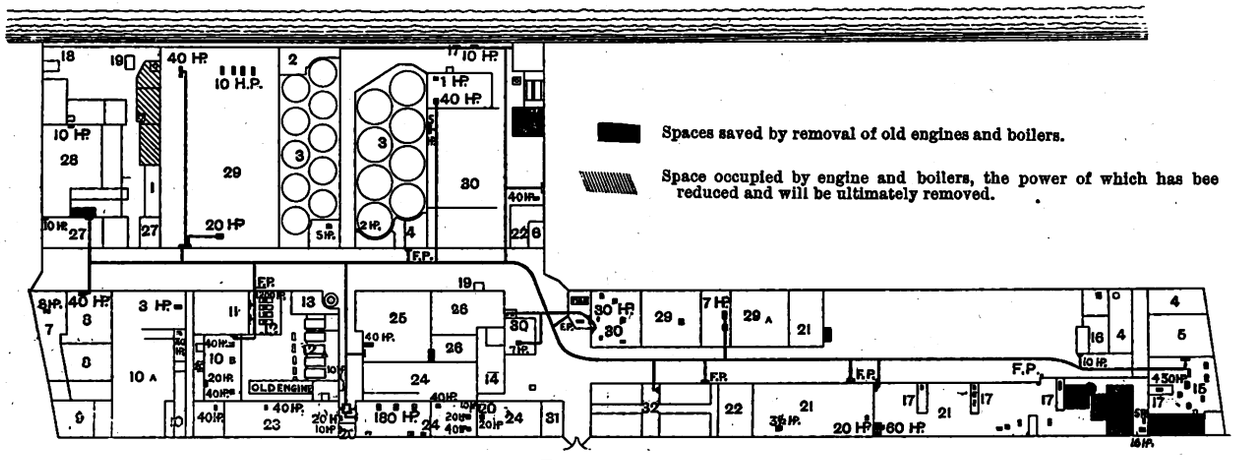
Spaces saved by removal of old engines and boilers.
Space occupied by engine and boilers, the power of which has bee reduced and will be ultimately removed.
OLD ENGINE
F.P.
Entrance.

FIG. 1.—Plan of Messrs. Siemens Bros. & Co's. Works, Charlton. Reference Nos. :—

1. Packing Room and Tinsmiths' Shop.
2. Cable Testing Rooms.
3. Cable Tanks.
4. Laboratories.
5. Calibrating Shop.
6. Fireman's Lodge.
7. Lamps and Switches, with Pattern Shop above.
8. Packing Case and Joiners' Shops.
9. Core Testing and Instrument adjusting Rooms.
10. Cotton Covering, above Core Tanks.
10A Core Tanks.
10B Core Tanks, Gutta Percha Shops over.
11. Copper Wire Store.
12. Central Electric Generating Station.
12A Boilers.
13. Condenser Room.
11, 12, 13 (Upper Floor) Gutta Percha Core Covering.
14. Hydraulic Testing Shop.
15. Dynamo Testing Shop.
16. Chemical Department.
17. Electric Cranes.
18. Steam Cranes.
19. Weigh-Bridges.
20. Lifts.
21. Dynamo Shops.
22. Stores.
23. Gutta Percha Shops, with Stranding Shop above.
24. India Rubber Department.
25. Wire Winding Shop.
26. Carbon Department.
27. Instrument Department.
28. Insulator, Overhead Line and Battery Department.
29. Submarine Cable Shop.
29A Yarn Winding Sheds.
29B Yarn Stores.
30. Millwrights' Shop.
31. Time Office.
32. General Offices.

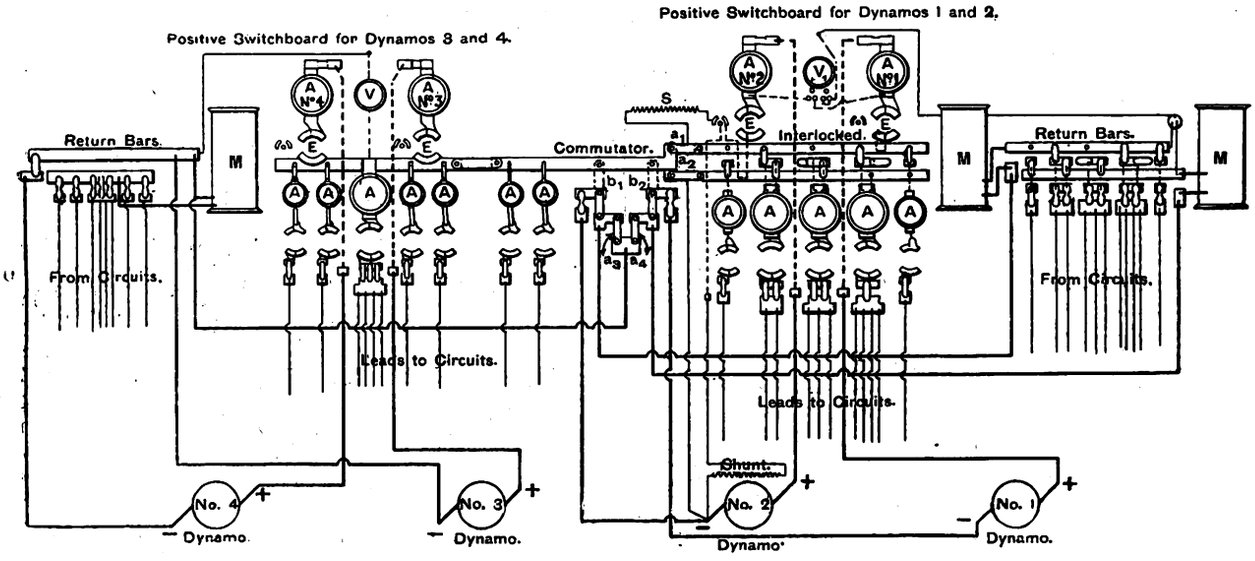

FIG. 2.—Diagram of Main Switchboard Connections, Central Station Messrs. Siemens Bros. & Co's. Works.

A, ammeters ; V, voltmeters ; S, shunt breaking resistances ; E, automatic minimum current cut-outs ; M, Aron meter.

To put Nos. 1 and 2 in parallel, in series with Nos. 3 and 4 also in parallel, open switch links marked a_1, a_2, a_3 and a_4, and close those marked b_1 and b_2.

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pieces of iron which might be attracted by their magnets. It has the disadvantage of making the motors rather difficult of access for examination, &c.; but since they are dotted all over the works—in fact, just where they are of the most service—adequate guards are necessary under the Factory Acts to protect workmen from accidental injury.

Some of the larger motors are fitted with Meneely roller bearings, which have proved to be very efficient and economical as regards oil consumption. For example, a 40 B.H.P. Siemens 15/20 machine, running at 360 revolutions per minute, having two bearings $2\frac{3}{4}$in. in diameter by $7\frac{3}{16}$in. in length, and one $3\frac{1}{4}$in. in diameter by $6\frac{7}{16}$in. in length, requires one pint of oil per month for the three bearings. This roller bearing is shown in Fig. 3, as it is adapted to a cable stranding machine.

The starting resistances are made of German silver coils placed inside iron tubes packed up tight with fine sand, Sand is an excellent non-conductor of electricity and a good conductor of heat, so that ample radiating surface is provided, while the whole constitutes a sound mechanical device. The design is patented by the Company.

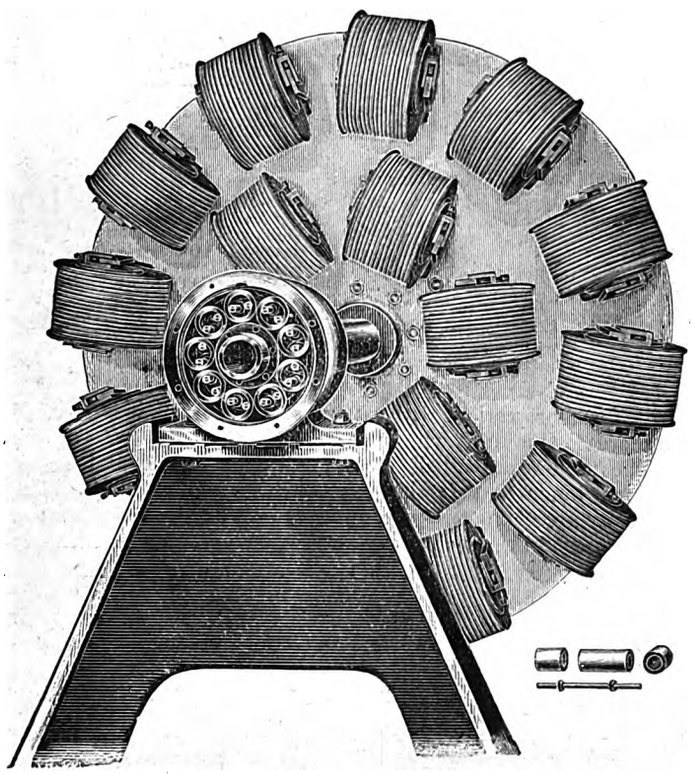

FIG. 3.—Meneely Roller Bearing, adapted to a Cable-Stranding Machine.

The motors are coupled to their work in a variety of ways, according to the position of the driven machine. In the majority of instances motors drive lengths of shafting by belting, and power is distributed by belts to several machines. This, for example, is the plan adopted in the dynamo erecting shop, where there are two motors, one of 40 B.H.P. and one of 20 B.H.P., each driving lengths of shafting. At one end of the main dynamo shop is a new vertical turning and boring machine (Fig. 4 on opposite page), built by Smith and Coventry, which will tool a circle 18ft. in diameter, with 6ft. between the bed plate and tool bridge. The table is 12ft. in diameter and revolves on an annular race in addition to its spindle; its motion is consequently very steady and free from vibration. An adjustable foot-step bearing is provided for raising the table from the annular race when it is desired to run the table at a quick speed. The table is driven by spur-gearing, the large wheel being cast with the table. The main driving gear consists of a 7-stepped pulley with back gear so arranged as to give 21 changes of speed to the table. The feed gears are driven by a friction gearing, by means of which any rate of feed can be given to the tools up to $\frac{5}{8}$ths of an inch. The massive cross slide is hung from screws in the main uprights, and can be raised or lowered by power. The tool-bars are counterbalanced so as to make them easily worked by hand. Both tools are under the control of the workman from either side of the machine. The total weight of the machine is 46 tons, the cross slide with tool-holders accounting for 12 tons. This tool is driven by a separate 5 H.P. motor, but in ordinary working it is found that about 4 H.P. is sufficient. The motor is coupled by belting to a countershaft, from which the various motions are derived by other belts. Two of the travelling cranes in this shop are each served by a single motor, from which the several motions are driven through gearing controlled by hand chains hanging from the bridge. The third travelling crane has three motors, one for each motion, the whole of the switching being controlled by chains.

In the fitters' shop there is a large shaft lathe, driven by a motor, which is coupled through a speed-reducing gear enclosed in an oil-tight box to a countershaft, whence the lathe is driven through belting and coned pulleys in the usual way, the motor being placed above the machine on an adjacent gallery. A vertical driller has the motor placed on top of the pillar, and is geared through spur gear and belting. A shaper has the motor laid on the ground behind the machine, and coupled through a box gear and belting. A portable emery wheel has the motor belted direct to the spindle of the bob. In the saw mills, the 40 H.P. motor which drives the main shaft by belting is erected on iron brackets fixed to the wall,

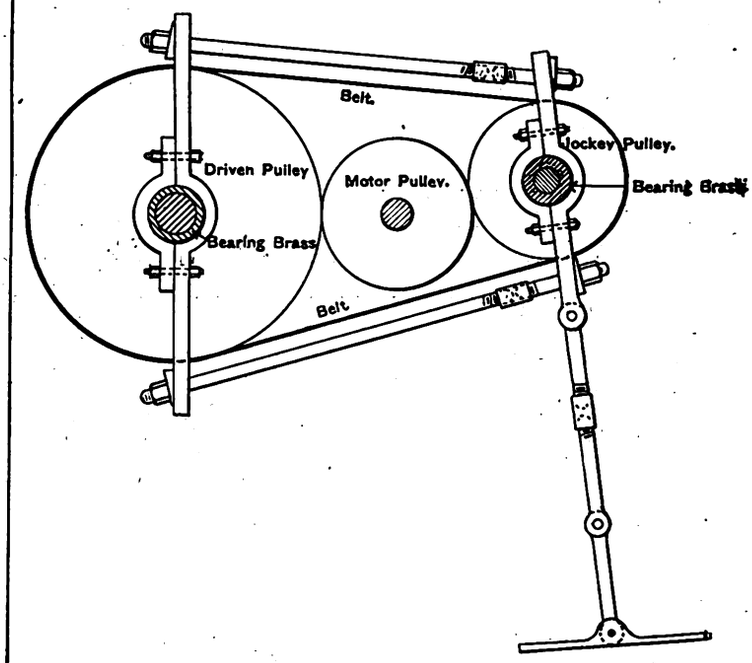

FIG. 5.—Friction Gear in use with Motors.

about 8ft. above the floor. A hoist, capable of carrying a load of two tons, used for serving the various floors of one of the main buildings, has the motor erected at the top of the well, and the switching gear is in the cage, connections being made by a flexible conductor. In the rubber department the incorporating rolls are driven in pairs by 40 H.P. motors through spur gear. Two callendering machines for rolling sheet rubber are each driven by a 15 H.P. motor through a double-threaded worm and wheel running in oil, while the raw rubber washing rolls are driven by a 40 H.P. motor through spur gear connected to a horizontal shaft coupled to each machine by means of a clutch gear. Two incorporating rolls, used for mixing the vulcanising and separating materials with the rubber, are driven by friction gear of special interest. The arrangement of the pulleys is shewn diagrammatically in Fig. 5. The motor pulley is built up from compressed paper, and both driven and jockey pulleys are well finished in cast iron. The belt serves to produce the pressure between the driver and driven pulleys, and to prevent the side thrust on the motor shaft. The device works very sweetly, and should find favour where motors are in use.

Looking at the motors and gearing as a whole, it is necessary to bear in mind that the alteration from scattered steam

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engines to electric motors was made gradually, and that it was not possible to adopt some of the improvements which would be advisable in laying out new plant. It is possible, therefore, that in some cases it would be more economical to use separate motors for machines which are now driven off shafting. It must also be borne in mind that many of the motors have been taken from stock, and have not been specially designed for the work.

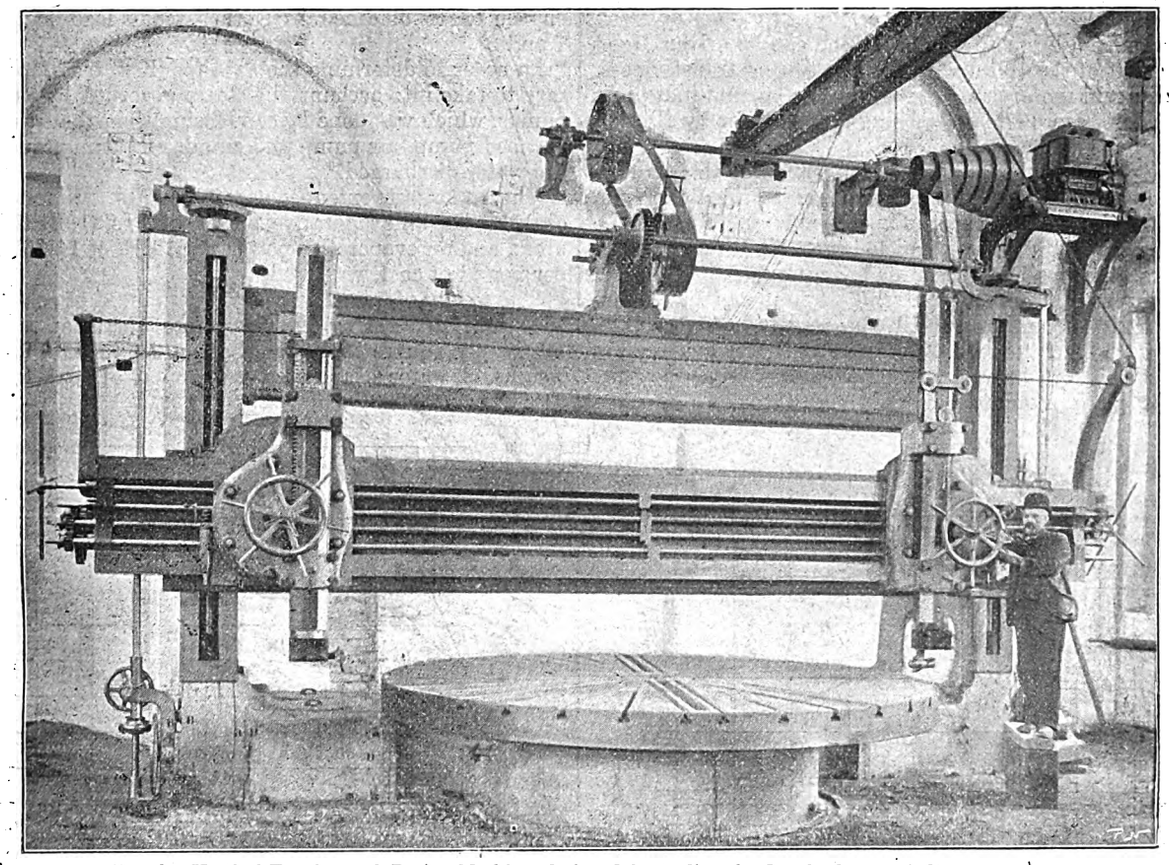

FIG. 4.—Vertical Turning and Boring Machine, designed for tooling the fly-wheel type of alternators, &c.

An interesting detail, showing the adaptability of electric power for factory work, is found in a series of plug contacts arranged about the buildings to serve a portable fire engine with electric pumps. This fire engine is built in the regular style as regards outer appearance (*see* Fig. 6), and is capable of throwing a 1in. jet of water 80ft. high, or two such jets about 65ft. The plugs are built in iron columns, and look like hydrants.

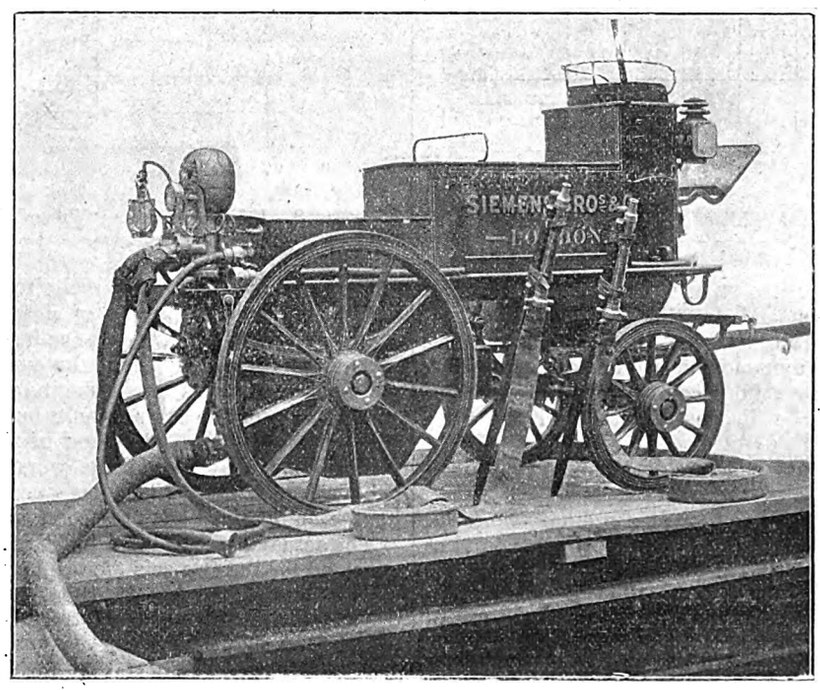

FIG. 6.—Electric Fire Engine.

The testing shop is a splendid example of how electrical testing should be carried out, and affords all the facilities for any class of testing. The plant comprises four motors, each of 75 B.H.P., belted to line shafting, one motor of 100 H.P., and four

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of 85 H.P. each. It is therefore possible to get almost any combination of power for driving dynamos, and the speed can be adjusted to a nicety, and maintained constant for any required period. The author knows of no testing shop which presents quite the same facility in this respect.

There is also a large alternator, which can be driven direct from the shaft of the 100 H.P. motor, for testing transformers, alternate-current motors, and for calibrating current indicators and voltmeters, any periodicity being arranged for by altering the speed of the driving motor.

Working.—Owing to the gradual conversion of the plant to the central electric power station system, it is difficult to form a comparison between the cost of power now and that at the commencement of the change which began on June 20, 1892. But Messrs. Siemens Bros. have made very exhaustive tests of the cost of power supplied from the station, and have been public spirited enough to publish the results in a very complete form. It is interesting to notice that the old engines were served by ten stokers and nine engine drivers, whilst the electric plant requires now only eight stokers, of whom

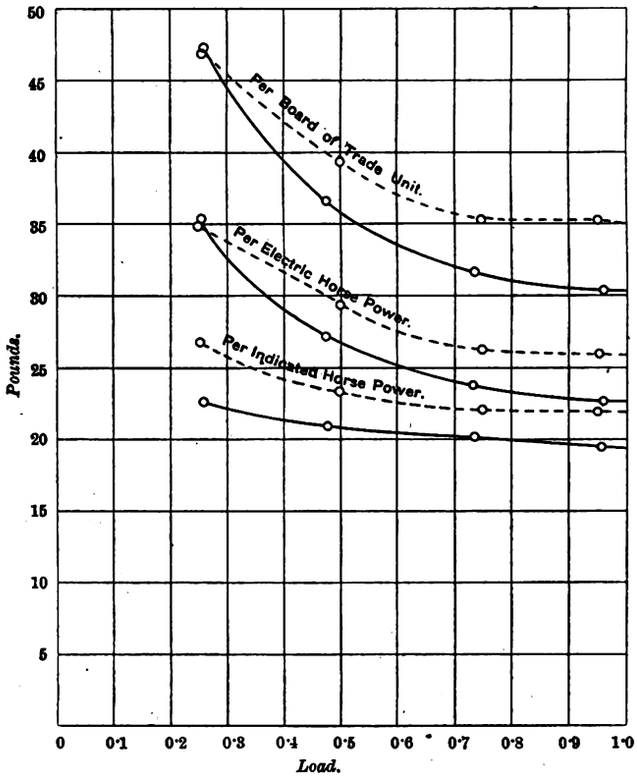

FIG. 7.—Steam Consumption. Willans' Set ————————.
Belliss' Set - - - - - - - - -.

three attend to the old boilers still in use, and five engine drivers, three of whom attend to the remaining isolated engines. The electrical part of the machinery is controlled by one electrician and one dynamo and switchboard attendant. When the arrangements are fully completed the remaining old auxiliary boilers will be dispensed with, and a further reduction in the staff will be effected.

The tests were carried out under the direction of Dr. Eugen Obach.

The boiler tests extended over a month of ordinary working. In the first place, the weight of steam generated per pound of fuel was ascertained, when the plant was supplying power both for driving the motor and for lighting the shops. Then the weight of the steam required per Board of Trade unit delivered to the distributing boards was found by exhausting the steam from each of two out of the four engines successively into the main condenser, and measuring the overflow from the air pump, care being taken that no water entered from other sources. This was determined for each engine under the conditions of quarter, half, three-quarter, and full load, and also when running on the ordinary day load. And further, a set of tests was made to see whether the steam consumption per Board of Trade unit was the same under a varying day-load as under a perfectly steady load giving the same average output. This was found to be the case, the point obtained from the day-load test falling exactly on the curve obtained from the steady load tests (*see* Figs. 7 and 8).

In order to determine the data for these tests, it was necessary to take into account the steam absorbed by the auxiliary pumps, which was done by condensing the exhaust steam from the feed pump, air pump and circulating pump, and weighing the water discharged.*

The boiler tests extended over 988 hours. Nixon navigation coal, having an evaporative power of 14,221 British thermal units, and an evaporative power at 212°F. of 14·65lb. of water per pound of coal, was used.

The weight of water evaporated per pound of coal (including coal used in lighting the fires) into steam at a pressure of 127lb. per square inch was ascertained to be 8·923lb. The weight of water evaporated per pound of coal from and at 212°F. was 10·083lb.

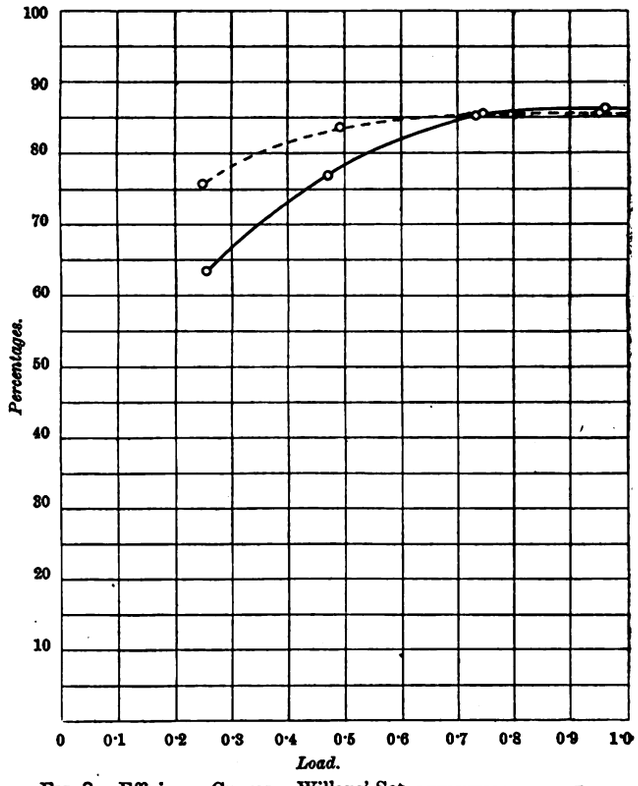

FIG. 8.—Efficiency Curves. Willans' Set ————————.
Belliss' Set - - - - - - - - -.

Experiments were also made to measure the steam consumption of the two types of steam dynamos when running on a steady load, viz., resistance frames.

The results are shown in the curves in Figs. 7 and 8. It will be seen that the Belliss engine consumed more steam than the Willans for the same output, but it must be borne in mind that this engine was the first of the type built by Messrs. Belliss, and that it had the worst position as regards the exhaust. Mr. A. Siemens has since stated that better results have been obtained with a second engine.

The actual cost of a Board of Trade unit has been carefully prepared for the two sets of steam dynamos for a period of six months ending October 31, 1894.

The figures on which the results are based are given in Table A on next page.

The output from the station during this period had been at the rate of 1,797,120 Board of Trade units per annum, which represented a load factor of 28·5 per cent. It must be noticed that the costs, severally 0·5893d. and 0·6429d. per B.T.U.,

* For a full description of the method of making these tests, reference should be made to the *Proceedings* of the North of England Institute of Mining and Mechanical Engineers, December 8, 1894.

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Table A.—*Five-Hours Tests of a Willans III. Compound Condensing Engine (No. 2) of 300 I.H.P., Coupled to Siemens H.B. 24/36 Dynamo, 1,500 Amperes and 120 Volts, at 350 Revolutions per Minute.*

Experiment.	Indicated horse-power.	Volts.	Amperes.	Watts.	Electric horse-power.	Board of Trade Units.	Pounds of coal per			Pounds of steam per			Efficiency. Col. 5. / Col. 1. Per cent.
							Hour per indicated horse-power.	Hour per electric horse-power.	Board of Trade Unit.	Hour per indicated horse-power.	Hour per electric horse-power.	Board of Trade Unit.	
1	95·75	120·7	376·2	45,407	60·87	227	2·29	3·945	5·28	20·5	35·2	47·15	63·6
2	149·2	120·05	712·3	85,511	114·6	427·5	2·35	3·06	4·10	21·0	27·3	36·6	76·8
3	209·8	119·75	1,106	132,443	177·5	662·2	2·24	2·656	3·55	20·03	23·7	31·7	84·6
4	268·9	118·2	1,459	172,453	231·2	862·3	2·18	2·545	3·41	19·5	22·7	30·45	86·0
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

Five-Hours Tests of a Belliss Compound Condensing Engine (No. 1), 300 I.H.P., coupled to a Siemens H.B. 24/36 Dynamo, 1,500 Amperes and 120 Volts, at 350 Revolutions per Minute.

Experiment.	Indicated horse-power.	Volts.	Amperes.	Watts.	Electric horse-power.	Board of Trade Units.	Pounds of coal per			Pounds of steam per			Efficiency. Col. 5. / Col. 1. Per cent.
							Hour per indicated horse-power.	Hour per electric horse-power.	Board of Trade Unit.	Hour per indicated horse-power.	Hour per electric horse-power.	Board of Trade Unit.	
1	79·4	120·02	376·0	45,127	60·49	225·6	2·99	3·91	5·24	26·7	34·9	46·8	76·0
2	144·75	120·05	747·6	89,749	120·3	448·7	2·72	3·28	4·39	24·2	29·25	39·2	83·3
3	212·8	120·32	1,116·8	134,373	180·12	671·9	2·48	2·94	3·94	22·2	26·26	35·2	84·7
4	217·6	121·22	1,418·0	171,890	230·4	859·5	2·51	2·95	3·95	22·4	26·33	35·3	85·1
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

were for power delivered at the main switchboard. The average loss of power in the cables is not more than 3 per cent., and the motors have an average efficiency of not less than 90 per cent., so that the net cost per brake horse-power at the motor shaft may be taken with considerable accuracy at 0·515d. per hour during this six months. The items upon which these figures are based are as follows:—

	Per Board of Trade unit.	
	Willans.	Belliss.
	d.	d.
Coal (including cost of delivery and removal of ash), 17s. 5d. per ton. Willans, 3·41lb.; Belliss, 3·95lb. per Board of Trade unit	0·3180	0·3680
Water (7½d. per 1,000 gallons)	0·0228	0·0264
Stores, oil, waste, boiler-fluid, &c. (taken from last six months' consumption)	0·0416	0·0416
Wages, stokers, trimmers, drivers, labourers, electrical assistant (half-time), and switch-board boy	0·0977	0·0977
Steam for auxiliary pumps, feed (only 0·7 taken), air and circulating, water 0·003d., coal 0·026d.	0·0290	0·0290
Repairs to central-station plant and motors	0·0802	0·0802
Total cost per Board of Trade unit	0·5893	0·6429

Messrs. Siemens have had the capital cost of the old isolated steam engine plant taken out and compared with that for the central station electric plant, and find that the capital outlay per brake horse-power was 30 per cent. higher in the first case than in the second.

Summarising the tests, it seems to be abundantly proved that power distributed from an electric central power station costs less than when derived from independent steam engines; but whether it will pay to convert an existing plant from the old to the new system depends upon local circumstances, and the question can only be determined after carefully weighing all the factors of each problem on their merits.

Electrical Engineering in Russia.—Large new iron and steel works are being established at Ekaterinoslav in the Donetz district of Russia by a recently-formed Russo-Belgian Company—the Société des Forges et Aciéries d'Ekaterinoslav. The new works will be interesting, as not only will they be lighted throughout by electricity, but it is also intended to operate the whole of the machinery electrically.

MUNICIPAL TELEPHONY.*

BY A. R. BENNETT.

In this country we have had no actual experience of municipal control of telephone systems, although Glasgow and several of the other Scottish towns are desirous of making a move in that direction; but abroad things have been different, especially in Norway, where, in one town of importance, the telephone system has been owned and managed for the last six years exclusively by the Town Council; while in Christiania the municipality has contributed largely to the capital of the local telephone company, and, being represented on its Board by three town councillors, exerts a powerful influence on its management. These experiments have been so decisively successful that municipalities in other countries are taking steps to imitate them. Thus we find that the Town Council of Rotterdam is actually engaged in the construction of a telephone system of its own. The Rotterdam Municipal Exchange is to be opened in October, 1896; it is to be metallic circuit throughout, and the annual subscription is to be £6. 3s. 5d. for distances of five kilometres. The Town Council of Amsterdam has also resolved to build a new exchange, but neither the date of opening nor the subscription has yet been fixed.

The author then proceeds to discuss the present position of telephony in the United Kingdom. After depicting the monopoly conferred upon the National Telephone Company, first by its ownership of the master telephone patents, and then by the refusal of the Post Office to grant further licences, the author deduces as a consequence that telephonic charges in the United Kingdom are greatly in excess of those which prevail in most other countries, and approximate to double the figure at which they would stand if the earning of a fair dividend on the amount of capital invested in the construction of the exchanges were the accepted principle of the Company's action.

Unfortunately, even by the admission of the Company itself, its capital consists to a large extent of "water" on which dividends have to be paid; consequently, the charges levied on the subscribers must be higher than would be the case if companies or other bodies unhampered by surplus capital were permitted to take a share in the supply of British exchange telephones. Before the late Select Committee the National Company admitted that its capital was watered to the extent of £1,292,000. This amount, in the opinion of some who have studied the subject, should be at least doubled; but, accepting the Company's own figures for the nonce, and likewise the statement that the Company's lines numbered 73,338, it appears that £17. 11s. of "water" exists for each line owned by the National Company. Well, the late Dundee and District Telephone Company's lines cost £15 each; the late Mutual Telephone Company's (double lines), £16. 16s. each; the Christiania Telephone Company's, £12 each; the Trondhjem Municipality's,

* Abstract of a Paper read before the Northern Society of Electrical Engineers, November 11th.

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£10. 2s. 6d. each. It is plain, therefore, on the National Company's own showing, that the "water" which exists for each line erected by the Company *exceeds the proper cost of the line*, and that each line must stand in the Company's books at much more than twice its actual cost. Such a state of things cannot exist without inflicting grave injury on the telephone subscriber as an individual, and on the commercial interests of the country as a whole, yet it is a state of things that the Government, through its Postmaster-General, did its best to justify, support, and perpetuate.

Unquestionably, to whatever cause the fact may be ascribed, the development of telephony in the United Kingdom has lagged behind that attained in many other countries. In Germany, Belgium, Norway, Sweden, Denmark, and other countries we find a large proportion of the towns connected by trunk lines, so that the subscribers may call up their correspondents in all parts of the country. In many cases the trunk lines have now passed the boundaries of the different countries, and the merchants of several of the capitals and of the chief ports and centres of industry in different countries may communicate telephonically. I am, of course, aware that trunk lines exist in this country and that communication has been established between London and Paris; but there is this important difference. On the Continent the charges made for the use of the trunk lines are extremely reasonable: thus in Germany, one can telephone all over the country for the sum of 1s. per three minutes; and even lower rates prevail in other countries. In the United Kingdom the charges are so heavy (and after January 1st next, when the Post Office will assume control of the trunk lines now worked by the National Telephone Company, they will be still further, in many cases, increased) that trunk-line communication remains a luxury. No doubt the Post Office could point to a considerable telephonic traffic between London and Paris, and perhaps between London and Manchester, Liverpool and Glasgow. But an analysis of this traffic will show that the lines are not used as a rule by the commercial or manufacturing communities, but by stockbrokers for the purpose of buying and selling stocks. Communication between London and Paris is almost exclusively to this end, and, I believe, the same applies to the use which is made of the new trunk line between London and Glasgow.

It may be remembered that the late Postmaster-General stated in the House of Commons that telephones in this country must always remain a facility to be enjoyed by the rich, and that even if by low rates a very large circle of subscribers could be obtained, the technical and engineering obstacles in the way of connecting them to an effective exchange were insuperable. Of course no practical telephone man believes that, even in this country; and abroad the statement of Mr. Arnold Morley has created much amusement, for foreigners have in their own cities, and even in their own villages, proofs before their eyes that the statement is inaccurate.

I recently made a minute inspection of the telephone system of Trondhjem, which is the third town of Norway, and possesses about 30,000 inhabitants.

The original telephone exchange was commenced in 1882 by a Mr. L. Spörck, who had obtained a concession from the Town Council. Mr. Spörck secured a considerable number of subscribers. But the service given was not entirely satisfactory, and in 1889 the Town Council determined to purchase Mr. Spörck's system, and thereafter manage the telephone business itself. Mr. Spörck having been paid the sum of £1,833 for all his rights, the Town Council proceeded to reconstruct his system in the most substantial and modern manner. The capital expenditure, including the aforesaid purchase-money, now stands at £7,979, with which sum 780 exchange and eight private lines have been constructed. The total number of lines being thus 788, it follows that each line has cost the town on an average £10. 2s. 6d. The population of the town being 30,000, there is one exchange telephone to each 38 inhabitants. In the United Kingdom the proportion is one in 636.

The rates fixed by the Town Council are as follows:—

	Per annum.
For a telephone exchange line connecting a place of business not exceeding 1½ kilometres (about 1 mile) from the central station	£3 6 7½
For a second business connection for the same person or firm...	2 13 3
For a private house, not exceeding 1½ kilometres from the central station	1 13 4

Should lines exceed in length 1½ kilometres these charges are increased by 5s. 6d. per annum for each 100 metres in excess. These charges include all payments. The Town Council supplies all the lines and instruments and maintains them. It is necessary to take particular note of this fact, because in some places in Norway and other countries subscribers buy their own instruments and pay the cost of their lines, circumstances which have sometimes been put forward as applying universally to all cheap Continental rates, but they are the exception, not the rule. At the middle of last October the value of the subscriptions on the books averaged £2. 14s. 4d. per telephone per annum.

The telephone business is managed by a telephone committee composed of two aldermen, one member of the committee being always a practical engineer. The committeemen retain their position for four years, and are thus able to obtain a thorough grasp of the business. Acting under the committee is a manager and engineer who has qualified in the latter capacity in the Trondhjem Technical School, and acquired considerable telephonic experience in other Norwegian towns. The capital is provided out of the rates, but interest at the rate of 4½ per cent. per annum is charged against the telephone system, so that the ratepayers not only lose nothing by the concern but even make a good profit. It should here be mentioned that the tariff given above is subject to alteration by the Town Council if such a course should appear desirable, so that the income may be adjusted to the expenditure, and any increase of cost in working thrown upon the telephone subscribers and not upon the ratepayers. It is, however, satisfactory to note that the tariff has sufficed hitherto not only to cover the working expenses, to provide interest on the capital, to create a reserve fund of 5 per cent. per annum on the capital expended, to insure all the employés against death, accident, and sickness, but to leave a small surplus every year.

The author then goes into the accounts of the Trondhjem municipal exchange at some length. In 1894 the estimated receipts were 34,900kr., the actual receipts were 35,507kr., or an excess of actual over estimated revenue of 607kr. The actual expenditure, on the other hand (including interest on capital, depreciation, and insurance premiums), only exceeded the estimated expenditure by 10kr., the figure being 34,310kr. In the 1895 Budget a profit of 2,700kr., or £150, was anticipated [1 krone = 1s. 1¼d.; 18 krones = £1].

Having told you the terms on which the telephone is supplied in Trondhjem, I shall now proceed to let you know what the subscribers obtain for their money. The subscribers are connected to the exchange chiefly by single aerial wires of phosphor-bronze, but some have copper wire carried in suspended cables. Communication is obtainable at present only between the hours of 8 a.m. and 10 p.m., Sundays included, but the early establishment of an all-night service is contemplated. There are 11 towns in the neighbourhood of Trondhjem where exchanges exist and with which trunk lines afford communication. These outlying exchanges are owned by local companies, not by the Trondhjem Municipality. The charge for speaking to them is 2d. for 5min. for subscribers, and 3½d. for non-subscribers. It is possible to speak for 5min. over a trunk line 47½ miles long for 2d. The Norwegian Post Office is also constructing, for the use of the Trondhjem subscribers, and has nearly finished, two metallic-circuit trunk lines to the North. These lines are of 3mm. silicum bronze. A trunk line to Christiania (349¼ miles) is also to be commenced in 1896. There is not at present any communication between the telephone system and the telegraph office, so that the subscribers are not able to forward telegrams from their own houses, but this defect is also to be remedied very shortly, the Town Council having promised to connect with the telegraph office whenever the Government desire it.

Subscriptions are payable half-yearly in advance. The subscriber is only required to sign an agreement for six months, and can discontinue his line at any time by giving notice of that duration. When the subscriber shifts his office or his house the cost of the labour of reconnecting him at the new place is charged, but the necessary material is provided free.

It has sometimes been said in extenuation of the high charges in force in this country that the low rates on the Continent are possible because the construction work is badly done; that cheap material is used, and no efficient technical supervision provided. I have already had occasion to emphatically disagee with these assertions, as in my book on "The Telephone System of the Continent of Europe" I give several instances in which the cheapest rates coincide with the best workmanship and most modern material and apparatus. Trondhjem is another case of this nature. The rates are very low, as we have seen, and yet the workmanship and material is extremely good. The wire used is of phosphor-bronze, 1·25mm. in diameter, being the same as generally used by the National Telephone Company in this country. Not only is the wire of the same nature and of the same gauge, but it is procured from the same makers, Messrs. Felten and Guilleaume, of Mülheim-on-the-Rhine. As Trondhjem is about 830 miles north of London, it follows that the freight incurred on the wire is very considerably in excess of that paid in England, so that the low rates in Trondhjem are certainly not attributable to the excessive cheapness of the wire used. This wire is supported principally upon iron structures, most of which are fixed on the house-tops, although some, as will be seen from the figures, are planted in the ground.

Fig. 1 shows the roof of the Trondhjem Telephone Exchange, with the six iron structures provided to receive the subscribers' lines. In Fig. 2 we have a roof fixture, from which the members of this society will deduce that telephone house-fixtures are not necessarily ugly. This fixture is on the Trondhjem Museum. Fig. 3 shows a pole line along the Nordre Gade.

These photographs will show that the Trondhjem telephone fixtures are of a substantial nature. They are, in fact, made of

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English angle iron, 2in. in the web by ¼in. thick. The cost of the iron alone, unpainted, in the larger ones is about £15. The preparation of the roof for fixing, and the labour, increases this cost materially. As English iron is employed, on which freight has to be paid to Trondhjem, these overhouse fixtures cannot be cheaper than those employed in this country.

The subscribers are supplied with the beautiful instruments manufactured by the Norske Elektrisk Bureau of Christiania.

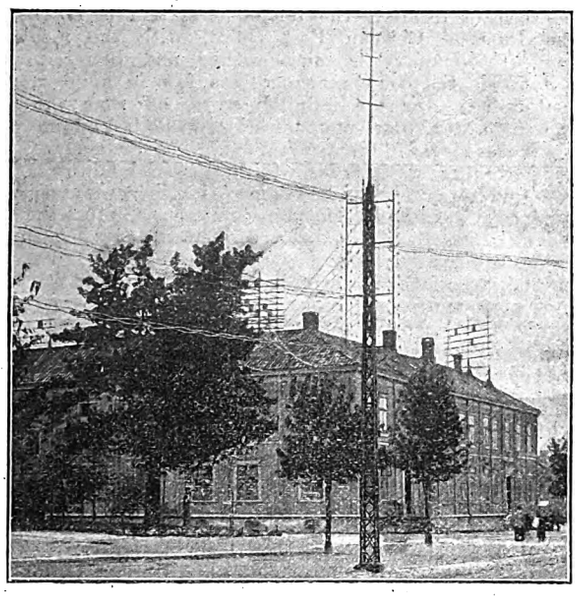

FIG. 1.—Trondhjem.—Iron Lattice Pole, with view of Central Exchange.

These cost £2. 12s. 2d. each, delivered free in Trondhjem, in lots of not less than 100, exclusive of battery. Such subscribers who desire it are supplied with instruments made by Messrs. L. M. Ericsson and Co., of Stockholm, the price of which is higher, viz, £2. 17s. 8d., in lots of 100, delivered in Trondhjem. The Trondhjem instruments, therefore, cost more than those supplied to telephone subscribers in this country, while their workmanship is superior.

The insulators used for supporting the wires are made at Porsgrund in Norway, and cost 2d. each without the bolt. They are of

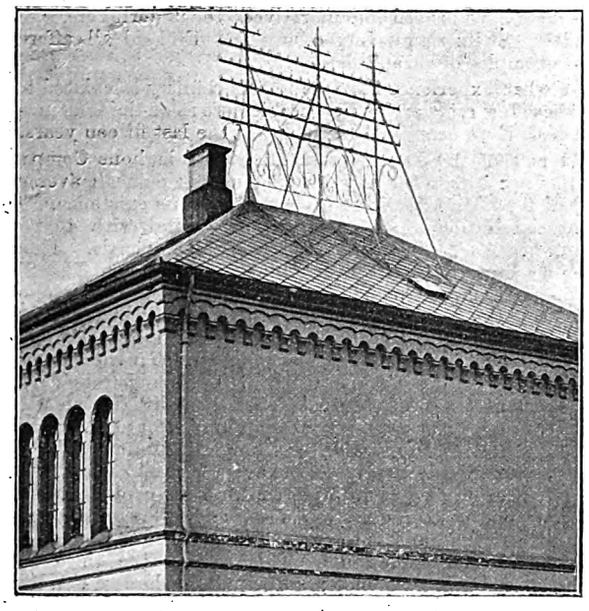

FIG. 2.—Trondhjem.—106-Wire Standard on the Museum.

a double-shed pattern. On some of the more crowded routes the subscribers' wires are led in suspended cables. Two of these cables contain 50 wires each, and are of the Pattinson type, that is to say, the wires are insulated with desiccated cotton saturated in paraffin wax, and protected by a heavy leaden tube. Others contain 25 wires and are insulated with india-rubber protected by lead in the sanie way. These last cables were supplied by Felten and Guilleaume

The working staff consists of five linemen, who work from 7 a.m. till 6 p.m., with one hour off for dinner. Their pay is £43. 6s. 8d. per annum, with an extra allowance of £6. 13s. 3d. to the oldest man, who acts as foreman. The Town Council insures each man for £111 against death, and also for allowances in case of accident or sickness, the premium paid being 9s. 11½d. for each £55 of wages. Although the pay of these men may appear low, it is extremely doubtful whether that of the telephone linemen in any town of equal size, 30,000 inhabitants, in the United Kingdom averages so much. The operating staff consists of young ladies, eight of whom, with the superintendent, are on duty at one time. At present their duties average a little less than 9½ hours per week day, but as this is considered too long three new operators are about to be appointed. Their pay at present varies from £2. 4s. 5d. to £2. 15s. 5½d. per month, but the scale of wages sanctioned by the Town Council provides for an ultimate increase to £3. 6s. 7½d. per month. The pay of the lady superintendent is at present £40 per annum. In addition, there is a staff of reserve operators, consisting of young girls who have learnt the business, but who, pending vacancies on the permanent staff, are only called in on emergencies. They receive a small retaining fee and are paid for work actually done at the rate of £2. 4s. 5d. per month. As each subscriber asks on the average from eight to nine connections per day, the girls have plenty to do during the busy hours. Each girl has 14 days' holiday per annum on full pay, and is insured against sickness. It will be seen that whatever may be thought of the workmen's wages, the lady operators receive considerably more than their English sisters. It is certainly a strange comment on

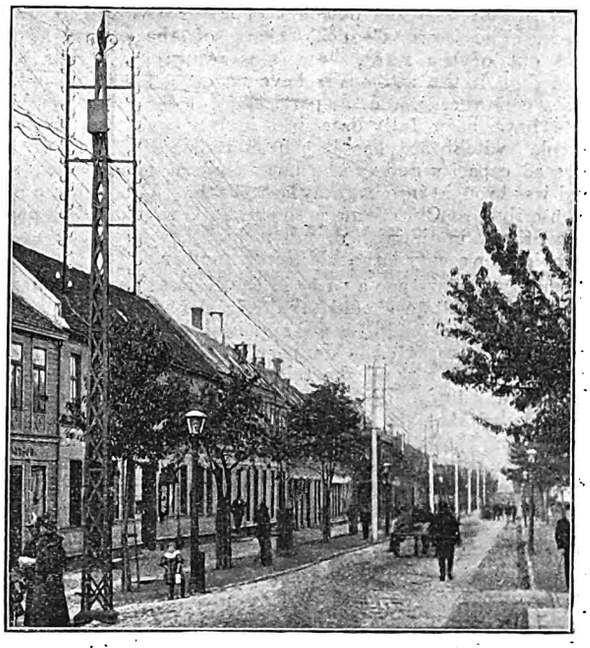

FIG. 3.—Trondhjem.—Route along the Nordre Gade.

the talk we have heard of the greater cost of telephonic work in this country to find that girl operators in Trondhjem are paid better than those of London, Manchester, or Glasgow.

In estimating the cost of working the Trondhjem exchange it is necessary to explain that the Town Council have no wayleave charges to bear. They use the townsmen's roofs by agreement, but in every case at present the proprietor is content with his roof being kept in repair, and exacts no annual payment. Of course it is a serious matter to keep so many roofs in good order, but certainly the Trondhjem Town Council is exceptionally fortunate in escaping money payments in addition.

In another respect the Trondhjem municipality is more fortunate than telephone undertakers in this country; the 10 per cent. royalty payable to Government on exchange telephone subscriptions has no existence in Norway. Not that 10 per cent. added to the Trondhjem tariff would make much difference. The average payment would then be £2. 19s. 9d. instead of £2. 14s. 4d. Even a 10 per cent. royalty only assumes alarming dimensions when the subscriptions on which it is levied are high.

The switching arrangements at Trondhjem at present consist of eight 100-line boards, by Ericsson and Co., Stockholm. There are no special features about them. The ring-off drops are connected in the cords in the usual way. This arrangement is somewhat antiquated, and will next year be superseded by a multiple board. A cross-connecting and lightning-guard board is also provided, the lightning guards being of carbon blocks lying on a

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carbon plate in connection with the earth, and kept from contact with it by strips of mica. All the work in the exchange has been carried out with excessive neatness, and there is no suggestion of cheapness or neglect about the place.

The second instance of municipal control of telephone systems in Norway is that of Christiania. In my work on "The Telephone Systems of the Continent of Europe" I give full particulars of the Christiania Telephone Company, which has been a most successful concern. On an inclusive subscription of £4. 8s. 11d. it has for many years past paid a dividend of 5½ per cent. per annum on the capital invested, after putting aside large reserve funds, writing off values of buildings and system, and providing benevolent funds for its male and female employés. The accounts given in my book for the years 1893 and 1894 bring out these details very clearly. At the end of 1894 the Company possessed 4,627 exchange lines in Christiania and it simmediate suburbs, in addition to being owner of a large system of trunk lines connecting Christiania with the neighbouring towns in every direction. At the end of September, 1895, the number of exchange lines had increased to over 5,000. The management of the Company is invested in four directors, who meet every week, and a managing council consisting of fourteen shareholders, which meets every month. This council is elected by the general body of shareholders, and in its turn elects the four directors. The Town Council, which owns a proportion of the shares, is represented directly on the board of the Company by three town councillors, one of whom is a director, and the other two members of the managing council. The municipality consequently exerts a great influence on the Company's policy, which is to provide the best possible communication at the lowest rates commensurate with the payment of a fair dividend to the shareholders. The Town Council's share of the capital is contributed out of the rates, but as a return of 5½ per cent. is obtained on it the ratepayers have no cause for discontent. The outside construction and the particulars of the subscribers' instruments have been fully described in my book, but the original multiple switchboard has just been replaced by one of largely increased capacity and of the most modern type, which switchboard was brought into use only last month. Although the number of subscribers at Christiania is so great the rate at which new ones join continues undiminished, and it has therefore been necessary to provide for a very large additional number.

About two years ago a party in the Norwegian Parliament suggested that the State should take over the whole of the telephone companies, and a committee was appointed to examine the proposal. The committee reported in January, 1894, by a majority in favour of the State acquiring all the telephone exchanges as well as the existing trunk lines. But there was also a minority report which recommended that the State should only acquire the long trunk lines, leaving the local exchanges and the shorter trunk lines in the hands of the private companies and municipalities already working them. When the report of the committee was published, the Norwegian telephone companies and municipalities owning telephone systems formed themselves into a Defence Association. The Defence Association adopted the minority report. For two sessions no action was taken on the report of the Committee, the number of the advocates of State acquisition being estimated at only about 20 per cent. of the members of Parliament; but just before the conclusion of the last session, in July, 1895, the permanent Parliamentary Committee, which controls the posts, telegraphs and railways, recommended that the Government should adopt the minority report of the original Committee, and thereupon the Ministry decided that the Government should acquire the longer trunk lines only, leaving the local exchanges and shorter trunk lines, as they are at present, in the hands of municipalities and private companies. Private or municipal enterprise has, therefore, been definitely left in Norway to deal with the telephonic question, and from the energy and technical skill which the Norwegian telephone engineers have exhibited in the past there can be no doubt of the result; and it may be assumed that Norway will continue to develop her telephonic system to an extent of which most people in this country have no sort of conception.

There can be little doubt that State telegraph departments are not the best managers of telephonic facilities. In my Paper read before the British Association at their recent Ipswich meeting I gave many statistics and particulars on the progress of telephony in the chief European countries, from which it appeared that the greatest development and the lowest rates, together with the most liberal concessions to the public, are coincident not with Government control but with private enterprise. This view of the case has, since the meeting at Ipswich, been confirmed independently in a very singular manner.

Jutland is covered by telephone exchanges, there being scarcely a village not possessing one, while trunk lines connect all these together, and cover the country with a very network of wires. In Schleswig-Holstein there are scarcely more than half-a-dozen telephone exchanges. The Chamber of Commerce of Flensburg, one of the chief towns of Schleswig-Holstein, has recently forwarded copies of maps to the Imperial Government in Berlin pointing out to the Government what I am now pointing out to you, that in Jutland, where telephonic enterprise is entirely in the hands of private companies, the country is covered with telephonic exchanges and telephonic trunk lines; that subscribers there are never charged more than £4. 3s. 4d. per annum, while in the majority of cases the charges do not exceed from £2. 10s. to £3. 10s. per annum. But in Schleswig-Holstein, south of the Danish frontier, the telephone system is in the hands of the Imperial German Post Office, with the result that, although the country is much richer and better populated than Jutland, telephone exchanges are few in number, possess few subscribers, and are infinitely worse off than the Danish in respect to trunk-line communication, while the annual charges are never less than £7. 10s. per annum. The Flensburg Chamber of Commerce present these facts to the Imperial Government and petition that measures may be taken to improve the development of telephones in Schleswig-Holstein, and especially that the present excessive charges should be reduced, pointing out that the social conditions of Schleswig-Holstein are practically the same as those of Jutland, and if the rates of between £2. 10s. and £3. 10s. are remunerative in Jutland, they should be made equally so in Schleswig-Holstein. With the petition was forwarded a list of some of the Danish companies giving particulars of their capital, number of subscribers, and dividends, from which it appears that the last range from 5 per cent. to 16 per cent. A more apposite and striking example of the differences between the management of Government departments and the results which follow the application of local intelligence, skill, and the employment of local capital, it would scarcely be possible to find, for only a few years ago Schleswig-Holstein belonged to the kingdom of Denmark, and was politically what it still is geographically, a part of the peninsula of Jutland. Had it remained Danish, Schleswig-Holstein would doubtless be to-day as well telephoned as Jutland is, for private enterprise would not then have been killed by Government monopoly.

The German Telegraph Department is a highly organised concern, but it suffers from over-centralisation. The headquarters are in Berlin, and nothing can be done, however trivial, in any town or village in Schleswig-Holstein, or any other part of the vast territory controlled by the Department, without previous consultation with, and permission obtained from, Berlin. Local conditions are ignored, and the smaller towns and villages can only obtain telephonic facilities by guaranteeing the Post Office, over whose management they have no control, against loss.

It must not be supposed that low rates are peculiar to Norway. Of the 31 exchanges in Holland, all but three enjoy rates ranging from £4. 19s. 1½d. per annum down to £2. 9s. 7d. per annum, and these rates have proved remunerative to the undertakers. Sweden, Denmark, Switzerland, Luxemburg and Finland all afford additional examples of cheap telephony.

But what experience have we in this country calculated to show that these low rates are as practicable here as on the Continent? A good deal, if we examine the history of the last fifteen years.

The rate of the Dundee and District Telephone Company was £5. 10s. per annum for any distance, and it paid an average dividend of 9 per cent. during the 4¼ years of its existence. To buy it out the National had to return its capital with 40 per cent. added, besides paying bonuses to the chief officials. The cost of the lines erected by the Company was £15 each. The Sheffield Telephone Company paid good dividends for many years on a £7 rate. But the best and most recent example occurred in your own city of Manchester, where the Mutual Telephone Company constructed an exchange in 1891, at rates which varied from £5 for shareholders in the Company to £6 for non-shareholders. The cost of connecting the Mutual subscribers by double wires was £16. 16s. each; the average subscription, after deducting 10 per cent. for Post Office royalty, was only £4. 12s. per line, a figure which approximates closely to the average receipts in Christiania; and yet, after putting aside 5 per cent. on the capital expended for deterioration, paying directors' fees, and all working expenses, sufficient surplus was left to pay a dividend, had it been so desired, of 2·29 per cent. per annum. This was in the third half-year of the exchange's existence; subsequently the revenue increased rapidly, and with it the profit. At one time the Mutual Company had 1,389 lines working, but such a formidable rival could not be tolerated.

There is only one other aspect of the situation to which I will call attention before concluding; it is the woeful effect which the existing monopoly is having upon our electrical industry. Abroad, immense quantities of telephonic apparatus are required to meet the rush of subscribers, and everywhere—in France, Germany, Belgium, Switzerland, Sweden, Norway—we find extensive factories already in existence which are devoted entirely to the production of telephonic switchboards and apparatus, and more are continually coming into being. We have nothing of the kind in this country.

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Why? Because all important orders for instruments and switching apparatus are, and always have been, placed abroad, principally in America, and, as a consequence, no development of a British telephonic instrument industry has been possible.

PHYSICAL SOCIETY.

At the ordinary meeting of this Society on November 8th, Prof. A. W. Rücker (Vice-President) in the chair, Mr. W. H. EVERETT read a Paper

"On the Magnetic Field of any Cylindrical Coil or Plane Circuit."

The method of treatment is based on the formula for the force due to an element of current. A single integration applied to one component of this force gives for any point in the field due to a plane circuit the force perpendicular to its plane, and a double integration gives the longitudinal force at any point due to a cylindrical coil of any cross-section, the depth of winding being supposed inconsiderable. For coils in which the latter condition does not hold, an approximate solution can readily be found. The force parallel to the plane of a circuit and the transverse force due to a coil are investigated in a similar manner. The general results are of a very simple form, and admit of easy approximate calculation. Special formulæ are deduced for coils of rectangular cross-section, the general expressions being in this case integrable. Appended to the Paper are some numerical results giving the values of the forces at different points, due to coils of various dimensions.

Prof. PERRY said he considered the Paper to be a valuable one, particularly as illustrating a practical mathematical method of integrating.

Mr. TROTTER said the Paper was of interest to him, as he considered that several of the author's results might be applied to the solution of problems on illumination—for example, of the illumination of a room by a circle of lamps.

Mr. RHODES regretted that it had not been possible to supply a proof of the Paper before the meeting. The method in which the author obtained the force outside a solenoid, as the difference of the forces due to two solenoids, reminded him of the method employed in calculating the attraction of, say, a truncated pyramid.

Prof. SILVANUS THOMPSON said the author had mentioned several previous Papers on the subject, but had not referred to one by Prof. Viriamu Jones, in which the force due to a solenoid is obtained in terms of elliptic integrals. Another method of attack was to calculate the work done when a unit pole is carried through the solenoid and back outside to the starting point.

Prof. AYRTON said he also regretted the absence of a proof of the Paper. He considered it of great importance to have exact and simple methods of calculating the forces due to a solenoid.

The CHAIRMAN (Prof. Rücker) said he had made a somewhat similar calculation in connection with the magnetic effect of sheets of basalt below the surface of the earth.

GAS ENGINE STATIONS FOR TRUNK LINE RAILWAYS.*

While on their annual tour of inspection last month the directors of the Pennsylvania Railroad were taken to the works of the Westinghouse Company, at Brinton, near Pittsburgh, and shown the latest advances in electric railway apparatus. At that place they were addressed by Mr. Westinghouse, who had on request prepared special data upon the operation of railways electrically by power stations employing gas engines. In the course of his remarks Mr. Westinghouse said:

"A strong argument heretofore used against the adoption of the electric system for main lines has been due to the fact that the investment required to make the change would be heavy, without materially decreasing the consumption of fuel and other costs of operation, an objection which it is believed can be met by the development and use of gas engines of large sizes instead of steam engines, for the generation of the electric current."

After presenting arguments to show that the gas engine would use but one-eighth the fuel of an ordinary locomotive to produce similar power, Mr. Westinghouse continued:

"The Pennsylvania railroad to-day, it is said, consumes about 5,000,000 tons of coal per annum on its lines east of Pittsburgh, taking, approximately, 20 loaded trains each day for its transportation, and consequently the return of 20 empty trains, and requiring for the service of the Company alone fully 3,000 cars and a proportionate number of locomotives. If this power were to be generated by gas engines, only about one-eighth, or 600,000 tons of coal per year would be required, effecting a saving of over 4,000,000 tons of coal, now costing the railway company above $5,000,000, a saving which would justify a large enough capital expenditure to cover the complete equipment of the railway. To carry out an arrangement of this character, stations having electric generating plants with gas engines and producers, could be located at intervals of from 10 to 12 miles, so that there would always be two or three stations furnishing current for any particular part of the line. The electric locomotive for hauling such trains would be entirely different from the present locomotive, and could obviously permit of changes in operation, for no electric locomotive need have a greater weight and capacity than needed to haul from 25 to 30 cars. It can be operated by one man and will be of such a shape that it can be conveniently used as a caboose car and for the carrying of tools and appliances for cases of emergency. Instead of putting the whole motive force in front, and thereby subjecting the road-bed, bridges and cars to excessive weights and strains, a second locomotive can be conveniently placed in the centre of long trains, thus subdividing the force applied for its propulsion, thereby reducing to convenient limits the quantity of current required for the operation of a train, though, as has already been demonstrated, electrical locomotives can be made which will have greater hauling capacity than any steam locomotive which has yet been produced. The electric operation of railways permits readily of a more frequent and rapid train service than is possible with steam locomotives, and it is not impracticable to attain, upon properly constructed and guarded tracks, very high speed, so that a very frequent service of very light trains between such cities as New York and Philadelphia, Baltimore and Washington could easily be provided, to the great advantage of the public and to the profit of the company undertaking such a plan of operation."

* From the *Electrical Engineer* of New York.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

TUESDAY, November 19th.

BOARD OF TRADE.

11 a.m. Conference at the Westminster Town Hall, between the Board of Trade and the objectors to the proposed revised electric light regulations.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "The City and South London Railway: Subaqueous Tunnelling by Shield and Compressed Air," by James H. Greathead.

WEDNESDAY, Novmeber 20th.

ROYAL METEOROLOGICAL SOCIETY.

7:30 p.m. Ordinary Meeting at the Institution of Civil Engineers, 25, Great George-street, Westminster.

SOCIETY OF ARTS.

8 p.m. First Ordinary Meeting. Opening Address of the 142nd Session, by Major-General Sir John Donnelly.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Meeting at 20, Hanover-square, W.

FRIDAY, November 22nd.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. (1) "An Exhibition of Photographs of Spectra," by Dr. G. Johnstone Stoney. (2) "A Direct Reading Platinum Thermometer," by R. Appleyard. (3) "Historical Note on Resistance and its Change with Temperature," by R. Appleyard.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Society of Arts.—The following are some of the arrangements for the ensuing Session:—The first meeting will be held on Wednesday evening, November 20th, when the opening address will be delivered by Major-General Sir John Donnelly, K.C.B. Previous to Christmas there will be four ordinary meetings, in addition to the opening meeting. On November 27th there will be a Paper on "Locomotive Carriages for Common Roads," by H. H. Cunyughame. After Christmas there will be Papers on "The Making of a Great University for London," by Prof. Silvanus Thompson, and on "Standards of Light," by W. J. Dibden. The following are some of the courses of Cantor lectures arranged for Monday evenings at eight o'clock: W. Worby Beaumont, M.Inst.C.E., "Mechanical Road Carriages," three lectures, December 2nd, 9th, 16th. Dr. J. A. Fleming, F.R.S., "Alternate Current Transformers," four lectures, January 20th, 27th, February 3rd, 10th. James Swinburne, "Applied Electro-Chemistry," four lectures, April 27th, May 4th, 11th, 18th.

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AMERICAN STREET RAILWAY FINANCE.

Americans are prone to statistics, which they mostly hurl at us "in the loomp," ill-digested and ill-arranged, without any attempt at elucidation or philosophical generalisation. For a little *brochure* recently published by the Street Railway Publishing Company of New York there can, however, be nothing but commendation. Into a little over one hundred well-printed pages Mr. EDWARD E. HIGGINS has succeeded in compressing a mass of statistical material relating to "Street Railway Investments" in a way which renders it well-nigh attractive and undoubtedly renders it instructive.

Before Mr. HIGGINS' figures and deductions can be strictly applied to this country, a coefficient should, perhaps, be applied to them. It is possible, however, that its non-application would not give rise to so grave an error, as might at first be thought probable. In changing over from horse to electric traction in England there would not in all probability be the undue inflation of capital resulting from the elegant financial process known as "watering," from gross extravagance in the matter of extensions and electrical equipment, and from the high cost and crude nature of the electrical equipment; causes which have been fruitful of grave overcapitalisation in America. On the other hand, with us the work would have to be far more solid, and the traffic, we are afraid, would not respond to the increased facilities offered to the same degree that it has in the United States. "The municipal transportation industry in the United States is intrinsically profitable;" says Mr. HIGGINS; it is not so here, at any rate so far as tramways are concerned. With us there has been up to the present no "national passion for rapid transit" such as exists in America. "The average American is careless of small economies. He has no time to 'split a nickel'; he despises a penny"; not so the average Englishman. Hence, while we are inclined to think that the net result to the

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tramway investor in changing over from horse to electric traction in this country will be better than that which has obtained in America, it will not be markedly so. We may not so wantonly and extravagantly over-capitalise, but we shall not witness such an extraordinary, such a sudden, such a permanent upward bound in the traffic returns.

The world has probably seen nothing comparable to the sudden revolution in, and extension of, tramway traction which began in the United States in 1888, and in five years drove the horse nearly out of the business. Let us see by the light of Mr. HIGGINS' compilation how it has been done and how the revolution looks from the £ s. d. point of view. "It is safe to say," he remarks, "that the gross mortgage indebtedness of our street railways is to-day double what it was in 1888; that the capital stock has been increased in an even greater ratio, and that the gross capitalisation per mile of track is so far in excess of that of 1888 that the entire difference cannot be explained on the score of cost of reconstruction and change of motive power." This difference has mainly been caused by the purchase in the sanguine mood begotten of an electric traction "boom," of the old horse lines for far more than they were worth and their conversion at an extravagant price and in a crude and hasty manner into electric lines. Then there were too rapid extensions, and the gains of promoters. It is some satisfaction to learn that the bonds "have not yet found the ultimate investor," and are still held largely by bankers, brokers and syndicates.

The basis of the electric tramway "boom" in the United States was as follows. Cable and electric systems of motive power "were first introduced in the belief that the actual reduction in operating expenses would be sufficient to yield satisfactory returns on the additional investment required. This expectation has not been precisely realised. Total operating expenses have been somewhat greater than before, instead of less, because of the sudden and amazing increase in traffic. . . . But the operating expenses per car mile and per passenger carried, and the percentage of operating expenses to gross receipts, are, in general, sensibly reduced." And this "in spite of unexpectedly large repair accounts." Mr. HIGGINS' general conclusion is that American "street railways, as a whole, have been profitable even when operated by horses, and that the general adoption of electricity and the cable has invariably brought about a substantial increase in gross receipts and almost invariably an even greater proportional increase in net." As he quite rightly remarks, "the real question becomes, therefore, whether or not there has been serious over-capitalisation of the permanently safe net earnings." Some clue as to the proper answer to this important question and to another one—less important perhaps, but quite as interesting—is afforded by Mr. HIGGINS' statistics and comments relating to a batch of six electric railways serving, in 1892, "cities" of from 25,000 to 35,000 inhabitants, the six lines being in 1890 all run by horses.

It is decidedly interesting to learn exactly whence came all the money necessary for "power-houses," "car-barns," "welded-tracks," "radial-trucks," "vestibule-cars," and 25 H.P. "T.H.W.P. single-reduction" motors, not to mention trolley poles and wires, feeders and copper "earth-returns." On p. 28 of Mr. HIGGINS' excellent compilation we have it all in plain English. "In facing the problem of adopting electricity as a motive power the managers of horse railway properties, both in this and in other classes, soon learned that it was necessary to provide nearly enough money to entirely rebuild and re-equip their roads *de novo*. The actual selling value of their tangible assets shrank to insignificant proportions. Electric motors were too heavy for the old cars, and the latter had no selling value; the introduction of heavy electric cars made it necessary to reconstruct the road-bed and to sell the old rails at scrap prices; the old barns and car houses were usually sacrificed; and fortunate was the manager who could obtain for his horses even one-third of their original cost. Nevertheless, the old security holders had to be provided for, and, naturally enough, the new investment was added to the old, and the capital liabilities were made to represent what was really the cost of building duplicate roads plus the cost of extensions. If this had been all; if new securities could have been sold at par; if the prices for apparatus and construction work had been on an entirely cash basis; and if the promoters had not generally required large profits, the percentage returns on the new capitalisation, even with the duplication of investment account above described, would probably have been in nearly every case increased, particularly in the larger places. Unfortunately, however, there were many cases where these exceptionally favourable conditions did not obtain. The most common form of financing these enterprises was to issue mortgage bonds having a par value somewhat greater than the valuation placed upon the old properties, plus the estimated requirements for making extensions and equipping by electricity. Stock was then issued, frequently for about the same par value as the bonds, although the proportions varied according to the fancy of the promoters. The theory of the latter was that the sale of the bonds at a moderate discount would provide all the necessary money for the entire work, and that the net income would largely exceed the fixed charges, so that substantial dividends could be earned on the stock." Well, we are very desirous of seeing electric traction develop in this country, but not on these terms nor anything like them. Perhaps we in England have reason to be thankful that, owing to the municipal purchase clause, financial hocus-pocus of this order is out of the question, and that owing to the small mileage of our existing tramways the larger portion of our *in futuro* electric tramways will not be converted horse lines, but entirely new ones. But, even on American showing, the conversion of horse lines can be made to pay, if the change over be done with due care and caution, and by the light of the experience gratuitously accumulated for us by our good friends across the Atlantic. Let us examine the combined figures of the six systems just referred to. In 1890 the average capital liability per mile of track—not capital outlay, be it observed—was £2,780; in 1892 it was £8,740, or more than threefold. But the change from horse to electricity resulted in a great increase in net earnings. In 1890 the *total* net earnings of the six systems averaged £1,075, and in 1892 £3,246. The average mileage of the six systems had, however, increased nearly 50 per cent., so that the final outcome of the adoption of electric traction was that the percentage ratio of the net earnings to the total capital liabilities was in 1892 only 3·8 as against 5·2 in 1890.

Mr. HIGGINS' tables and statistics and comments, therefore, while they are in themselves exceedingly good, and while they throw invaluable and instructive side-lights on American electric tramway finance and its results up to date, need afford nothing but encouragement to investors and financiers at home. The particular case which we have investigated in some detail is not a favourable sample, even of American tramway management. Its moral is, it seems to us, that if you are content to change over from horse to electric traction in a reasonably careful, reasonably honest way, your net earnings per mile will increase at a greater rate than your capital expenditure per mile, provided you do not straightway add some 50 per cent. more miles to your system.

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REVIEWS.

Elektrotechnisches Worterbuch. English-French-German. By J SACK and ARTHUR WILKE. (Leipzig: Oskar Leiner.)

There is a great need for a really reliable and fairly complete electrotechnical English-French-German dictionary. Electrical engineering is peculiarly international, and whilst few electrical engineers can be said to be conversant with French and German, most of them can by dint of heroic perseverance, frequent use of a dictionary, and unlimited guessing, make very tolerable sense out of even a German electrical article. The modest little dictionary before us bears evidence of considerable care in its compilation, and its authors have evidently followed the developments of electrotechnical language in England and America very closely. In the preface Herr Wilke, who took over the task on the death of Herr Sack, makes a plaintive appeal for forbearance on the part of those who seek and cannot find the particular word they want. He is inclined to lay the blame for any shortcomings in this respect upon us Anglo-Saxons, who are for ever word-coining, picking up handy expressive terms wherever we can find them, defying etymology, and puzzling poor Teutonic lexicographers. Herr Wilke's rule has been to omit all words which are printed in the technical journals in inverted commas; hence "booster" goes by the board. It does one good, however, to hear such adepts at the art, as Germans are, complaining of our *Wortbildungskraft*.

With a view to the improvement of the second edition and not in a spirit of captious criticism, we will point out one or two minor errors. Words such as "to condensate," "conductibility," do not strike us as exactly the best electrical English, although they are to be found in Webster. *Empfindlichkeit* would probably be better translated as "sensitiveness" than as "delicacy" or "sensibility." "Dissimulated electricity" for "bound electricity" is somewhat of a curio; as is also "far-leading dynamo" for "long-distance transmission dynamo." The intrinsic brilliancy of the, to us, new term "foot-candle" does appear very great.

Cours Élémentaires d'Électricité. By BERNARD BRUNHES. (Paris: Gauthier-Villars et Fils.)

This volume is a reprint of the course of lectures on theoretical electricity which is delivered by the author to the first-year civil engineering students of the Institut Industriel du Nord de la France. The subject is treated in an elementary manner, but lucidly and rigorously. The typography and illustrations are excellent. M. Brunhes' course of lectures should prove of considerable use to those who are desirous of acquiring a clear idea of the fundamental principles of electrical science.

Digest of British and Foreign Patent Laws. By ALFRED J. BOULT, M.I.Mech.E., Chartered Patent Agent. (London: Bemrose and Sons.)

This is a handy well-arranged little volume of some 400 pages, giving a very concise digest of the patent laws of Great Britain and other countries. English patent law is adequately summarised in 50 pages. As the author points out, it is inevitable that as years go on "the extent of patentable subject matter in any particular branch" should grow less, and however much patentees may dislike the whittling down of their epoch-making inventions, they will do well from a business point of view to restrict their claims within narrow limits on the well-know principle that half a loaf is better than none. Allusion is also made to the "waves of feeling" that sweep over the Bench; at one time claims are subjected to the severest scrutiny, at another time there is a mania for "benevolent" construction. To-day novelty is judged in some measure by commercial results; if the patented article is largely sold, the probability is that it will be held to have been patentable. The author is evidently somewhat sore at the Quixotic generosity with which England carries out the provisions of the International Convention. We certainly lose by the comparative savagery of foreign countries in the matter of the treatment they mete out to English inventors, but we should lose still more by reprisals. Those responsible would, however, do well to see to it that whenever any of the offending countries are anxious for some political or commercial concession from this country, the bringing of their patent laws into conformity with the spirit and letter of the International Convention is made a *sine qua non* of the concession. The complexities and perplexities which confront a patentee who wishes to obtain valid long-lasting foreign patents give a fund of meaning to that well-worn formula, "owing to considerations connected with foreign patents it would be unwise to supply the full particulars desired."

Étude sur le Transport de l'Energie à Grande Distance par l'Electricité, et sur les Transmissions Électriques par Courant Continu. By GEORGES DUMONT and GUSTAVE BAIGNÈRES. (Paris: A. Grélot.)

This is a reprint, with additions, of a Paper read by the authors in November, 1894, before the Société des Ingénieurs Civils. It is divided into three sections, dealing respectively with long-distance transmission, distribution for power purposes, and actual examples of electric plants. The subject is treated in a somewhat academic manner, but scattered up and down the hundred odd pages of the volume there are many useful data derived from actual tests.

Brush Arc Light System. By H. C. REAGAN, JR. (New York: N. W. Henley and Co.; London: E. and F. N. Spon.)

Mr. Reagan's little *brochure* is one of the best of the kind we have seen. It is intended, of course, for American readers, but its extremely clear explanation of the action of the Brush arc-light machine, and its equally clear diagrams, should render it of considerable educational value to dynamo men and assistant central station engineers wherever machines of the Brush type are used.

Electric Light for Country Houses. By JOHN HENRY KNIGHT. (London: Crosby, Lockwood and Son.)

This little book deals with the electric lighting of small country houses, not of ancestral halls. The way to set about a job of this kind is made plain and the probable cost of the work is given. To those contemplating lighting their houses by electricity and wishing to know "something about it" before entering into negociations with a firm of contractors, Mr. Knight's notes should prove of considerable use.

Leçons Elementaires de Télégraphie Électrique. By L. MICHAUT and M. GILLET. Second edition. Entirely recast. (Paris: Gauthier-Villars et Fils. 1895.)

This is intended as a manual for Morse operators, and should give them a clear insight into the scientific basis of land-line telegraphy.

THE CARBORUNDUM WORKS AT NIAGARA FALLS.

BY ORRIN E. DUNLAP.

Carborundum, the new abrasive, is now being turned out at a factory at Niagara Falls. Carborundum was discovered in 1891 by Mr. E. G. Acheson, President of the Carborundum Company. For several years Mr. Acheson had been on the look-out for some method of crystallising carbon, as he recognised that such a material would prove of great value as an abrasive. It was not, however, until the year 1890, when he became associated with an electric lighting company in Monongahela City, Pa., that he had an opportunity of carrying out experiments. In his first experiment he used an iron bowl lined with carbon and filled with a mixture of carbon and clay, into which a carbon rod was introduced. The bowl and carbon rod served as electrodes, by means of which a current sufficient to fuse the mixture was supplied, the object being to cause the carbon to be dissolved in the melted silicate of alumina, and, by cooling the same to the point of solidification, cause the contained carbon to crystallise. When the current was applied and the mixture heated up, a violent chemical reaction appeared to take place. When cooled down the mass was carefully examined, with the result that a few bright blue crystals were found. These crystals were carbide of silicon, or, as they are called commercially, carborundum. The latter name is made up from carbon and corundum, as it was supposed before a

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chemical analysis was made that carborundum was a compound of carbon and alumina.

The manufacture of carborundum as now carried out at Niagara Falls is as follows:—The materials used are coke, sand (which is very rich in silicon), salt and sawdust, the two latter being used to facilitate the operation of the furnace. These are mixed in proper proportions and introduced into the furnaces (*see* Fig. 1), which are of brick built up into four walls so as to form a kind of rough brick box, no mortar or cement of any kind being employed. In the centre of each end wall of the furnace is a large bronze plate, to which are connected the cables carrying the current. When complete the internal

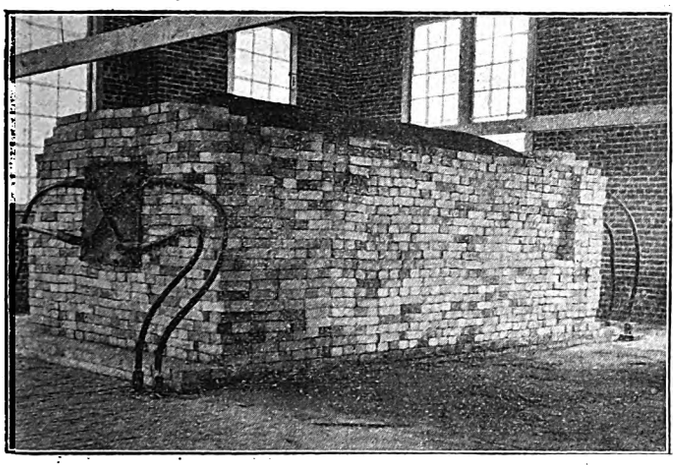

FIG. 1.—Carborundum Furnace at Niagara, before firing.

dimensions of the furnace are about 15ft. long, 6ft. wide and 5ft. high. Connecting with the inner surface of each plate are 60 carbon rods, each of which is about 30in. long and 3in. in diameter. The rods project through the walls of the furnace and form the terminals. When the furnace has been built up in this way the mixture is introduced, about ten tons making the charge. Through the centre of the mixture a core formed of small grains of coke is built, and this serves to form a continuous electrical connection between the terminals. When the current is turned on the core is soon raised to a high temperature. About an hour after the application of the current,

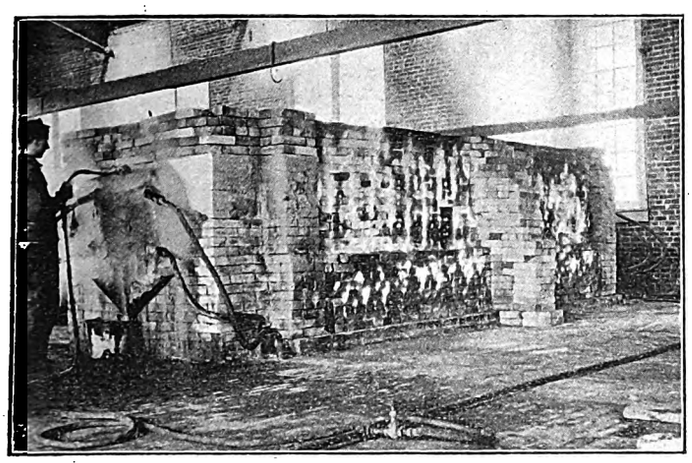

FIG. 2.—Carborundum Furnace in operation; flames on side; man keeping down temperature of terminals.

carbon monoxide gas is given off freely, and when a lighted match is applied this burns with the well-known lambent blue flame and envelops the whole furnace (Fig. 2). The current is kept on for about 24 hours, and then the furnace is allowed to cool down, after which it is opened. When this is done it presents an appearance beautiful in the extreme, the core (*see* Fig. 3) being surrounded by a cylinder of beautiful carborundum crystals varying in colour from yellow to violet. The crystals in immediate contact with the core are in one solid mass; as the distance from the core is increased, the size of the crystals rapidly diminishes, until at about 15in. all crystallisation ceases and an amorphous material is encountered of a whitish gray colour, for a distance of two inches, when suddenly a black mass composed of the original mixture, now held together in a cemented state by the fusion of the salt, is met with. The crystalline and amorphous material, lying between the core and the outer black mass, is carbide of silicon (C_2Si_2). About two tons of carborundum is produced in one run. It is at once noticed that the core is changed in appearance. It now has a somewhat metallic lustre, all impurities have been driven off and a very pure form of graphite remains. This may be an important by-product of these furnaces. The presence of graphite denotes that the temperature, when the current was on, must have been nearly 7,000°F., which is the point of graphite formation. The makers of carborundum, however, take pains to keep the temperature of their furnaces under 7,000°F., care being taken that it does not run too high, as carborundum is at its best when the furnace work is done between 6,000°F. and 7,000°F.

The product of the carborundum furnaces at Niagara have been a thorough surprise to the discoverer and all others interested in the plant. The yield of the furnaces has been most pleasing, and in some of them truly magnificent crystals three-quarters of an inch across have been found; the largest ever produced in the furnaces at Monongahela City never exceeded one-quarter of an inch.

To prepare the carborundum crystals for commercial use they are ground down in a mill, treated with sulphuric acid to

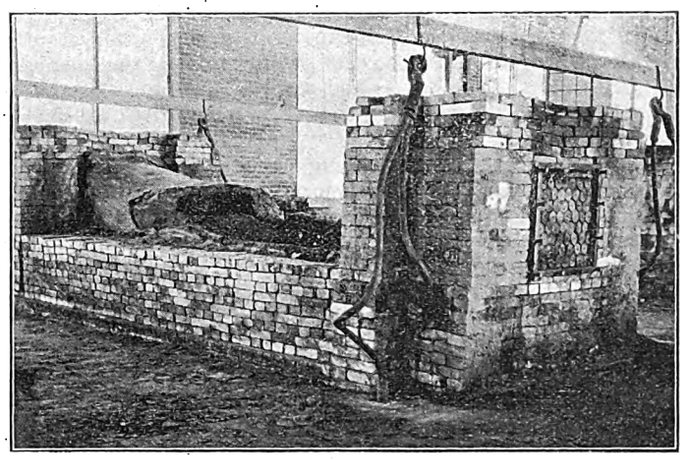

FIG. 3.—Carborundum Furnace, partly discharged, showing central core of carbon, with shell of carborundum crystals.

remove impurities, washed, sifted and stored away to be sold in the form of powder for diamond polishing, lens grinding, &c., or made up into various forms such as wheels, hones, slips, files, rub stones, knife sharpeners, scythe stones, and cloth.

The current for the furnaces at Niagara Falls is supplied from the Niagara Falls Power Company's dynamos, and comes to the factory by an underground cable at a potential of 2,200 volts. In the transformer room at the carborundum factory the potential is reduced to 185 volts. When the current is first turned on it is regulated to the full voltage. After about two hours the resistance of the furnace has become reduced sufficiently low to take a current of about 3,000 amperes at this voltage. When this point is reached the regulation is carried on carefully, so that as the resistance of the furnace decreases, the potential of the current is reduced sufficiently to keep the supply of energy to the furnace at about 746 kilowatts. The dimensions of the core of the furnace are so adjusted that when the current reaches about 7,000 amperes, and the regulation can be carried no further, the resistance of the furnace has become constant. This constant state is reached about four hours after starting, and for the remaining 20 hours the furnace is supplied with a current of about 7,000 amperes at a potential of 105 volts. Both the transformer and regulator were built by the General Electric Company. The former is the largest in the world, weighing 12 tons, and having a capacity of 830 kilowatts. The

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regulator alters voltage by varying the inductance in the circuit. A small pump, run by an electric motor, keeps oil, which is cooled by a coil of pipe carrying water, constantly circulating through the transformer and regulator.

The extreme hardness of carborundum is very nicely illustrated by the story of an early experiment made by Mr. Acheson. Said he to your correspondent: "I made the first test in diamond cutting with carborundum myself. I mounted a disc of iron in a fast-running lathe and charged the surface with fine carborundum crystals. I then pressed a diamond ring against the revolving disc, and in four or five minutes the facet, which had been pressed against the disc, was found to be devoid of lustre, of a milky colour, and scored with lines. The second test was made in a diamond-polishing establishment in New York. This experiment was satisfactory in its way, but my diamond did not look nice, and I wanted it to be repolished. I therefore asked the proprietor of the works to polish the diamond, using carborundum powder instead of diamond dust. He consented to do this under certain conditions. A new lap was to be used, free from all diamond powder; my material would be tried first, and if successful I would have to pay nothing, while if unsuccessful diamond powder was to be substituted for the carborundum, and I would have to pay $5 for the work. The new lap was mounted and a workman commenced to polish the diamond with carborundum powder. Within 20 minutes all lines were removed from the facet, and it was restored to its former beauty. This was a surprise to the proprietor of the place, but none the less so to me."

On account of the remarkable hardness of carborundum, it is a more valuable material than either emery or corundum. Up to the present the Carborundum Company has been unable to manufacture sufficient of its product to meet the demand for large wheels. The buyers and users of these appear to be well satisfied with them, stating that their superiority over emery is very apparent.

Not long ago an interesting experiment of the grinding qualities of carborundum was made by a large iron firm in this country. A large roll of iron was nearly half an inch out of true, and under ordinary circumstances it would have been recast, as the labour of grinding it down by means of emery would have been too great. It was thought that it offered an excellent opportunity to put carborundum to a really severe test, so the mineral was used to turn up the roll. The result was highly satisfactory, for it was found that the work was done in just one-twelfth of the time that would have been required had emery been used.

It is interesting in this connection to note that while the primary value of carborundum is found in its industrial uses, it is none the less worthy to be placed among our jewels, for this beautiful application of electricity has resulted in developing a gem possessing the colours of all gems and the hardness and refractive powers of the diamond.

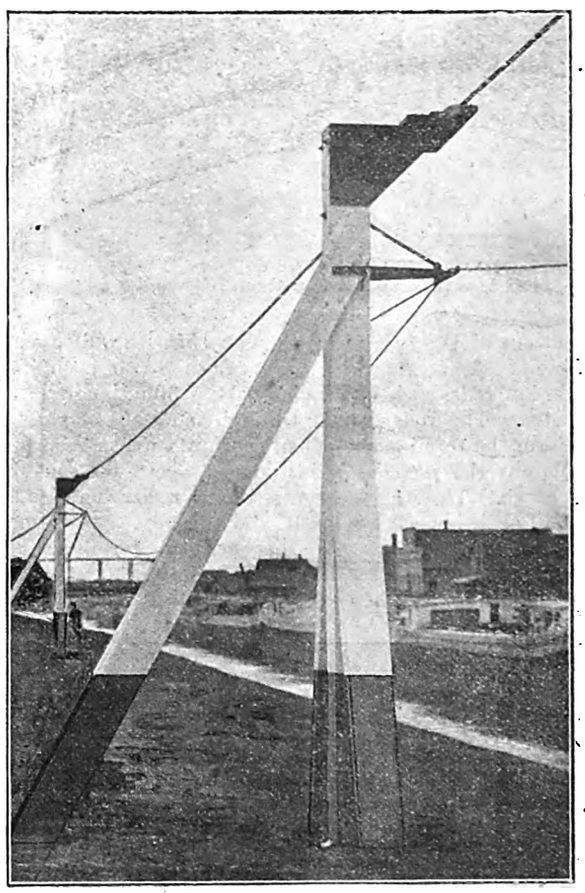
The carborundum furnaces as they stand at Niagara to-day are the greatest power consumers in the world. At a given signal 1,000 H.P. of electrical energy is turned into the granular core already referred to, and there, within a space 9ft. long and 21in. in diameter, which is the size of the core, it is converted or transformed from electrical to heat energy—a remarkable amount of work to be performed in so limited a space.

ELECTRIC PROPULSION OF CANAL BOATS.

BY ORRIN E. DUNLAP.

Considerable attention is now being given in the United States especially in New York State, to the electrical propulsion of canal boats. The device with which experiments were made on October 26th near Tonawanda is the invention of Mr. Richard Lamb. In the first test, which took place near Rochester, New York, on November 18, 1893, the "Frank W. Hawley," an ordinary canal boat, was equipped with a dish-pan screw, and was propelled by electricity by a motor on board, the current being conveyed from the central station by two wires suspended above the waterway, and was received by the motor on the deck of the boat through two underbearing trolley poles. While this test was a success in some ways, it was clear that for successful canal transportation the water in the canal must only be used for floating the boat, and the propelling device or application of power must be foreign to the water.

On the 26th ult. the experimental line was 1·21 miles long and erected along the south bank of the canal at a point where the water is 8ft. deep. The poles are set 125ft. apart. Upon the poles are brackets, as shown in the accompanying illustration, and upon them are saddles having insulating material between them. The saddles are designed to prevent short circuiting of the electric current by rain. A bracket is also provided to support the lower or traction cable. This is not insulated, but at intervals along the line some of these brackets are grounded. A 1¼in. cable of the hardest crucible steel, having a tensile strength of 132,000lb., and weighing 3·67lb. per foot, is supported upon the upper saddles and a ⅝in. steel cable upon the lower. The bearing cable is placed at an elevation of 16ft. from the ground, and the traction cable 3ft. below it. The motor truck is made with two deep-grooved wheels to run on a cable, having a horizontal



Lamb Electric Cable-Hauling Pole on the Erie Canal.

axle between them and below their centre line. Upon the axle is suspended a hanging frame, having attached to it an elliptically-grooved sheave, which is revolved by means of a worm or wedge-gearing, driven by a 25 H.P. electric motor, with vertical shaft, weighing 1,200lb., all attached to the swinging frame of the car. By taking three turns of a ⅝in. cable around the elliptical-grooved sheave, when the electric motor revolves the gearing, the sheave winds up, and at the same time pays out on the ⅝in. cable, thus pulling along the car. The motor in this way gets its tractional friction independent of the weight of the apparatus. The current is returned through the traction cable, which is grounded at intervals, giving a combined ground and metallic conductor for the return current. A 500-volt current is used. It is taken from the main cable through the wheels, thence through the axle to the axle box of the hanging frame. Here an insulated copper wire connects it with the rheostat on the barge. Four insulated copper wires, armoured with steel wire, form the cable that conducts the

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current from the bearing cable to the rheostat on the boat and back to the motor, and at the same time acts as the tow line. From the motor the current goes to the axle of the elliptical groove wheel, thence to the $\frac{5}{8}$in. wire rope, thence to earth. When a motor is to be run without any boats in tow its rheostat and conducting-wire-tow line is placed upon the motor, and a driver seated on a seat on the electric mule operates the same.

The power for the trial of the 26th was obtained from the station of the Buffalo and Niagara Falls Electric Railway. Mr. Richard Lamb acted as motorman, and, after the invited guests had, by their weight, loaded down a large canal boat, he opened the lever that set his "electric mule" in motion, and it at once started up the canal against a strong wind and current, towing the loaded boat at good speed. It ran rapidly to the end of the line, the speed being about three and three-fifths miles per hour. On the return trip the motor drew five boats loaded with people along at the rate of four and seven-tenths miles per hour.

STREET LIGHTING BY ARC LAMPS.*

BY ANDRÉ BLONDEL.

(Concluded from page 42.)

Candle-Power of Lamps.

All the arrangements which I have just reviewed have in actual practice one common fault—that is, the very considerable distance between the lamps, which makes the distribution of light very unequal. This is even one of the arguments against the use of arc lamps which the partisans of incandescent lamps make much use of. This inconvenience is the consequence of the use of powerful lamps (without speaking here of the naturally bad law of distribution of the rays). It may be asked if we cannot reduce this by using less powerful lamps; for instance, lamps of 4 to 6 amperes, which are to-day not at all used in public streets in France, and in particular in Paris, where no lamp taking less than 10 amperes is used. We find sufficiently numerous applications of them in other capitals, as is shown by Table V., to demand that the subject shall be given more attention. The city of Munich, for instance, already uses 48 lamps of 5 amperes; so also at Turin, the public lighting comprises 115 arc lamps of 6·8 amperes by the side of 155 taking 9·6 amperes. At Milan some arcs of 4½ and 6 amperes are also in use. I believe, then, that there are conditions calling for the use of large and of small lamps in electric lighting, as well as in lighting by gas, when properly proportioned, of course. At first sight everything seems to resolve itself in favour of large lanterns, and it is, in short, the current opinion that in lighting by arc lamps one ought to endeavour to reduce the number and to increase their intensity. There are in this two good motives: on the one part the luminous product—that is to say, the ratio of the luminous flux produced to the energy employed—increases with the intensity of the current; on the other part the price of the pillars and of the lamps and the daily up-keep are the same whatever is the power of the lamp. But if we examine the question closer we perceive that the expenses under this head do not in practice enter into the question, except as a very small fraction, while the energy consumed plays an altogether preponderating part in the determination of the annual cost.[31] From this it follows that the variation of the annual price per lamp does notdiffer very much from the law of proportionality with the current.

At Milan it has been possible to fix the following prices to be paid by the city to the Edison Company, prices which to us appear to be very instructive[32]:—

Lamps of	4·5 amperes	.....	0·24 francs	per lamp-hour.
„	„ 10·0 „	.....	0·35 „	„
„	„ 20·0 „	(2 in series) ...	0·75 „	„
„	„ 40·0 „	„ ...	1·50 „	„

In Paris we may be allowed to suppose that the city, which pays 40 centimes per lamp-hour of 10 amperes, might easily treat on this basis for lamps of 5 amperes for 25 centimes per hour, for the candle-power of the lamps varies with the current following a parabolic law sufficiently near to proportionality. We may calculate this provisionally from the numerous measurements of the Antwerp Exhibition and the formula of Palaz[33]:—

$$I^{max} = 20\,i + 0{\cdot}4\,i^2.$$

By supposing that the form of the curve and the effect of the globes remain similar for all intensities, which is very approximately correct, we find thus:—

Amperes.	Maximum intensity in pyrs.	Practical hemispherical intensity.	
		With naked arc.	Under ordinary opal globe.
5	1,100	650	300
6	1,200	800	470
8	1,900	1,100	640
10	2,400	1,400	520
12	2,980	1,750	960
15	3,900	2,300	1,350
20	5,600	3,250	1,900

By substituting lamps of 5 amperes for those of 10 amperes we see that for equal cost the total useful luminous flux is reduced in the ratio

$$\frac{2\times 110}{240}\times\frac{40}{2\times 25} = 0{\cdot}73,$$

but the distances between the lamps would be reduced, on the other hand, in the ratio $\frac{25}{40} = 0{\cdot}625$.

The second solution may then be better than to the first because the diminution of the total flux makes itself above all felt by the reduction of the superabundant lighting, and because the minimum lighting, on the contrary, is augmented. This we believe to be the case more especially when the width of the street is small. It is then very bad practice to put, as is often done, arc lamps of 10 to 12 amperes in streets of 8 to 10 metres in width, with distances between them of 40 to 60 metres. One would prefer in this case arcs of 5 or 6 amperes, spaced at 20 or 30 metres. This last arrangement has besides the advantage of reducing the effects of contrast. Many cities, especially provincial ones, would find it to their interest to adopt lamps of 5 to 8 amperes, instead of lamps of from 10 to 15 amperes, which are to-day almost exclu-

* From *Le Génie Civil*. Translated by Mr. John Hesketh.

[31] This may be represented by an expression in the form

$$p = A + (B + C)\,E,$$

A and B being two fixed coefficients and E the energy consumed. A comprises the sinking fund of the capital employed (lamp-posts and accessories, connecting, fixing, &c.), the cost of up-keep and the salaries of lamp-lighters and cleaners. B is the price of the energy, in kilowatt-hours. C is the additional expense for carbons (which is sensibly proportional to the energy). For an equal output of energy, the cost of the laying of the principal mains (with which we do not trouble ourselves here) may be regarded as being independent of the number of the lamps, the cost of the branches increasing, on the contrary, proportionally to the number of lamps. If H is the number of hours the lamp is used annually, we have as the price per lamp-hour

$$\frac{p}{H} = \frac{A}{H} + (B + C)\,W,$$

W being the power in kilowatts absorbed by the lamp. The first term will be much smaller relatively to the second as the number of hours the lamp is used increases. I find the following results, for instance, at Paris, from figures very kindly communicated to me by M. Clerc, Director of the Drouot Station, and M. Soubeyran, Director of the station of La Rue des Dames:—

Lighting of the Avenue de Clichy.

H = 3,749 hours, A = 0·05, C = 0·0135;

from which $\frac{p}{H} = 0{\cdot}06 + (0{\cdot}0135 + B)\,0{\cdot}49$ kilowatts (the lamps working at 49 volts.

Lighting of the Grand Boulevards, Edison section.

H = 2,610 hours, A = 0·068, C = 0·024,

from which $\frac{p}{H} = 0{\cdot}068 + (0{\cdot}024 + B)\,0{\cdot}55$ kilowatt.

The city pays 0fr. 40C per lamp-hour, or eight times the amount of the fixed charges. The cost of the energy is thus preponderating. By applying the same formula we find that for a lamp taking 5 amperes at the same voltage,

$$\frac{p}{H} = 0{\cdot}06 + \frac{0{\cdot}34}{2} = 0\text{fr. } 23\text{c},$$

and

$$\frac{p}{H} = 0\text{fr. } 234\text{c}.$$

These formulæ made the price per kilowatt-hour come out at 0fr. 70c and 0fr. 60c about, figures which are lower than the mean total nett cost estimated by M. Maréchal (about 1fr. for the Clichy section), but probably higher than the nett cost of the supplementary kilowatt-hour. For companies, public lighting may well be more expensive, because it constitutes a valuable advertisement. It is almost everywhere the same, and municipalities may reasonably profit by this circumstance to obtain good terms for the lighting of their public roads, the only service which directly interests all their constituents.

[32] I am indebted to the kindness of Signor C. Cervi for these returns.

[33] *Traité de Photometrie*, p. 223.

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sively in use.[34] This would only be the extension to public lighting of the movement which was made in favour of small arcs for private electric lighting some time ago.[35]

All these principles I have just expounded with regard to public lighting, apply, with very slight modifications, to the lighting of large spaces of all kinds; in particular of halls, quays, goods stations, &c. Although this investigation is rather removed from my subject, I would like to mention, in passing, two points which appear to me interesting from my present point of view. First, the sometimes preponderating importance that one may be led to give to the vertical illumination; when reference is had more particularly to lighting roads and waggons, the surfaces it is most useful should be well seen being vertical surfaces. Second, the necessity of examining carefully what are the really useful parts of the luminous flux. In an enclosed space, but with a glazed roof, such as a hall, we can consider as useful the flux which falls not only on the ground, but also that which falls on white diffusing surfaces; a greater elevation of the lanterns may therefore be justifiable. On the contrary, for the lighting of uncovered ways all the rays which pass higher than the waggons are lost, and it is therefore a matter of first importance to lower the lanterns or to concentrate their rays at a lower angle by appropriate means, such as those of which I shall speak later.

II.—Physiological Principles.

The value of public lighting cannot be calculated simply, as we have supposed, up to this point from the illumination measured by the photometer, because measurements of this kind do not take into account all the physiological effects which accompany the phenomena of vision. These have for their origin, first, the "diaphragmation" of the pupil—that is to say, the property which the pupil possesses of contracting or dilating instinctively to regulate the quantity of light admitted on to the retina. We know that with the cat "diaphragmation" takes place during the day, even up to the complete closing of the eye. Doubtless it is this fact which allows this amiable animal to preserve the exceptional sensibility of vision for its nocturnal promenades. The diameter of the pupil of man being able to vary on an average from 10mm. to 2·5mm. for the same individual, we see that the surface of admission and consequently the quantity of light received by the retina may vary in the ratio from 1 to 16. An object may then, as I have already shown many times,[36] appear 1 to 16 times more luminous for an equal photometric lighting, according to the opening of the pupil. Again, this opening regulates itself instinctively according to the intrinsic brilliancy[37] of objects situated in the field of vision, and varies in an inverse sense to that brilliancy. We can then, according as one gives to the luminous source little or much brilliancy, realise, with the same quantity of light, a good or bad useful effect on the retina.[38] This effect is easy to demonstrate practically. It is sufficient to look at a room or place illuminated by a brilliant source of light placed in the field of vision, shading and unshading the source alternately by a little screen so as to suppress or re-establish its direct action on the retina. We find a much more satisfactory illumination when the light is shaded. The popular expression that a brilliant light has a "blinding" brilliancy thus only translates this fact of instinctive experience. Second, *contrast*—that is to say, the well-known phenomenon which makes objects situated in the immediate proximity of an illuminated object appear proportionately more obscure than they really are, and still more obscure as the brilliancy of the latter is greater. These two psycho-physical phenomena which modify, the first the absolute and the second the relative, value of apparent illuminations, may make simply physical measurements completely illusory, and all comparisons made without taking them into account are very debatable. This explains the singular fact, very often mentioned and repeated at the commencement of this article, that an absolute increase of light does not always give rise to a relative increase in public satisfaction. Let us replace, for instance, lighting by gas by lighting by arcs, and give 20 to 30 per cent. more total luminous flux. Very often the public will complain and demand an increase in the number of lamps. This is a fact that it is necessary not to lose sight of when it is desired to substitute electricity for gas. The effects of contrast ought to make us not only avoid sources of light of too brilliant a nature, but should make us seek the *uniformisation* of illuminations, for surfaces lighted too brilliantly make the rest appear too obscure. This phenomenon applies more particularly to narrow streets: close to the lamps the façades of the houses are brilliantly illuminated, and in the intervals between they appear black by contrast. The effect is all the more annoying the more powerful the lamps and the wider they are apart. Here, then, is a very important reason for the adoption in our streets of lamps of a candle-power conveniently proportioned so that the space between them may be somewhere about double the width of the streets they light, as I have explained previously. It is one argument the more in favour of lamps taking 5 to 8 amperes. Two very distinct things are, in short, necessary to effect a good public lighting. First, to produce a photometric illumination as satisfactory as possible with a given quantity of light, losing as little as possible of the flux produced. Second, permit the eye to take in as great a part as possible, offering to it only surfaces of feeble intrinsic luminous brilliancy (which obliges us to diffuse light), and, shunning the effects of contrast. In other words, it is important not only to obtain a fixed minimum illumination, but, above all, to realise harmony in lighting. This is often expressed in a vague form when we say it is necessary to realise a good "effect." We are far, as we shall see, from having yet arrived at this harmony in any complete manner so far as our present arc lighting is concerned, and we too often neglect to trouble ourselves about this effect. By knowing how to calculate this beforehand we should very often have been able to considerably reduce expense, and still have obtained the same apparent result.

Conclusions.

We have seen from all the preceding discussion that the conditions generally admitted as bases of schemes of lighting are insufficient, and that it has been necessary to complement them by the consideration of the superabundant illumination. I have come to the conclusion that it would be well to impose the following conditions: Firstly, a mean illumination of the roadway, or, better, a mean illumination of all the usefully illuminated surfaces E_m; secondly, a minimum horizontal illumination at the height of the roadway, E_H; thirdly, a minimum vertical illumination at a certain height—to simplify matters, we may be content to take this illumination at the height of the roadway; fourthly, a mean superabundant horizontal illumination, E_s, in a circle; with a radius of 5 metres, for instance, described round the lantern at a height of 1·50 metre above the ground; fifthly, an excellent diffusion of the light—that is to say, the use of sources of low apparent brilliancy and of intensity proportioned to the width of the street to be lighted. The first condition prevents us being niggardly in the quantity of light furnished and from raising the lanterns too high. The second permits of a minimum degree of visibility being assured on the roadway. The third assures a good illumination of foot passengers and vehicles. The fourth is that which answers to the public taste by giving to them a good sensation of light, so that they are able to read printed matter at the foot of a lamp-post. It prevents, also, the use of too high lanterns. The fifth is absolutely necessary to allow the eye to take in the greater part of the light furnished, and to avoid the disastrous physiological effects just pointed out. The four photometric conditions are in reality always more or less connected, but this connection is too complicated to allow the conditions to be reduced to three only. It is a delicate matter to fix the values to be adopted for the different constants, because of the continual increase of the standard pointed out at the commencement of this article. I have previously indicated as values of the mean illumination to be obtained for secondary streets, 1·5 lux; for important streets, 2 lux. The railways of the Belgian State have even been content with 0·2 lux in lighting their stations, but to-day these figures have already been well exceeded, so that the best way is to be guided in all cases by the figures obtained from existing lighting in cities of equal importance to that to which the scheme under consideration refers. In the particular case of lighting by electric arcs, the following figures, which we have borrowed from M. Maréchal and Herr Wedding, or which I have calculated in a somewhat similar manner, will be of service as a preliminary indication, and will complete those I have given higher up for the spacings and heights.[39] These figures

[34] The use of large lamps may, however, be advantageous in the case where energy is at a low price, and where the cost of carbons and manual labour assume greater importance. This happens, for instance, in lighting railway stations where the current is produced by the company itself.

[35] This conclusion only applies to continuous currents. With alternating currents one is led in general to adopt higher candle-powers, and I explained this (*Lumière Electrique*, October, 1893) by the instability and bad efficiency of small alternating arc lamps. A lower current than 8 amperes is not to be recommended for these, and the best conditions of working can only be realised with arcs of at least 10 to 15 amperes. I will refer again in greater detail to this question of alternating arcs.

[36] *See* more particularly *Les Comptes Rendus de la Société Française de Physique*, 1894, p. 84.

[37] The intrinsic brilliancy at a point is the ratio of the normal luminous intensity produced by a small surface of the lighting body to the area of that radiant part.

[38] M. Charles Henry has contributed an important series of articles to *L'Eclairage Electrique* (November and December, 1894); a complete study of the phenomenon of which I here only mention the principle.

[39] For all cities other than Paris and Berlin it has been impossible for me to obtain sufficiently precise returns to allow even an approximately accurate evaluation. There are as yet, unhappily, only few engineers who interest themselves in this measurement. The first serious photometric tests were initiated at Berlin.

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do not take into account the light diffused by walls; they are then rather lower than the reality:—

TABLE VI.—*Examples of Illumination obtained.*

Constant.	Paris.					Berlin.
	Avenue Clichy. (At 4·95m.)	Boulevards Section Popp.	Rue Royale. 1°	Rue Royale. 2°	Boulevards Section Edison.	Unter-den-Linden.*
	Lux.	Lux.	Lux.	Lux.	Lux.	
E_m	2·19	3·35	3·40	3·38	1·98	...
E_H	0·18	0·49	0·50	0·70	0·33	3·5, about.
E_V	0·16	0·46	0·43	0·66	0·24	...
E_s	16 to 20 lux at 1·50 metres in height.					12 lux at 1·50 metres.

* In the part where there are two rows of arcs.

The highest illuminations which have ever been attained in France seem to be those of La Rue Royale in Paris. These constitute in the actual state a maximum which it is interesting to know. I reproduced the plan of illumination which M. Maréchal has calculated in this case[40] (Figs. 28 and 29). We may compare these with the results given by Herr Wedding for the lighting of the promenade of Unter-den-Linden at Berlin, Fig. 30, which I have borrowed from his work. This represents (in German candles at one metre), the distribution of horizontal illuminations on a plane taken at 1·50 metres above the ground between two lamps of 14 amperes fixed in the centre of the street at a height of 8 metres. It should be noticed, in making the comparison, that one German candle equals 1·22 pyrs. Other figures make the minimum illumination following the axis of the street to be 5·5 lux at 1·50 metres above the ground. Working back we find this illumination on the ground is about 3·6 lux. We thus see that the lamps employed at Berlin, being at the same time more powerful (14 amperes instead of 10) and nearer, the illumination obtained is actually superior to that obtained in La Rue Royale. It is probably exceeded by that of the Fifth-avenue at New York, about which I have not, unfortunately, been able to obtain complete information.

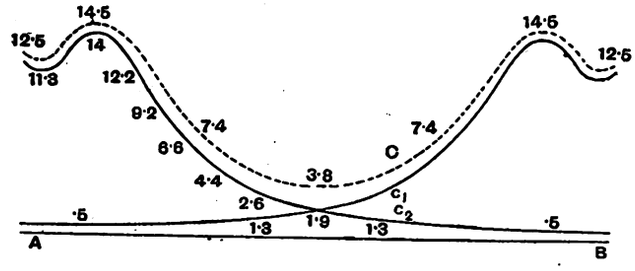

FIG. 30.—Illumination between two lamps on the Unter-den-Linden, Berlin (Wedding). c_1 and c_2 = Individual illumination. C = Resultant illumination.

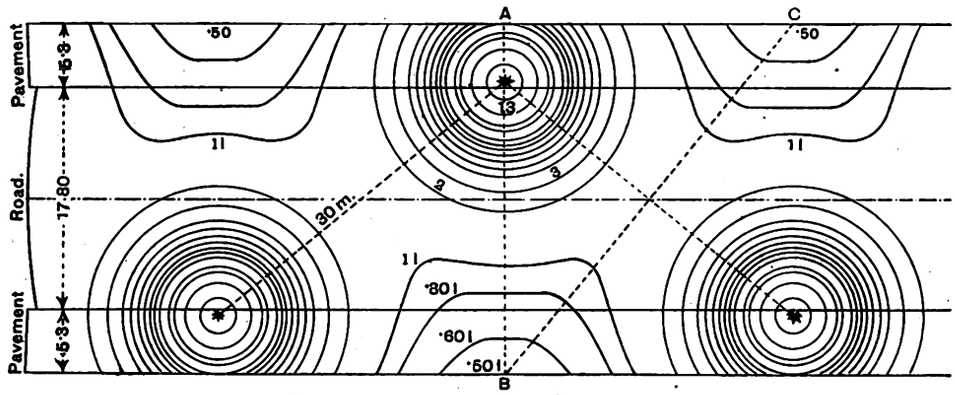

FIG. 28.—Plan of illumination with 10-ampere continuous-current arcs under opal globes, Rue Royale (part comprised between La Place de la Concorde and La Rue St. Honore). (Figure taken from *L'Eclairage à Paris.*)

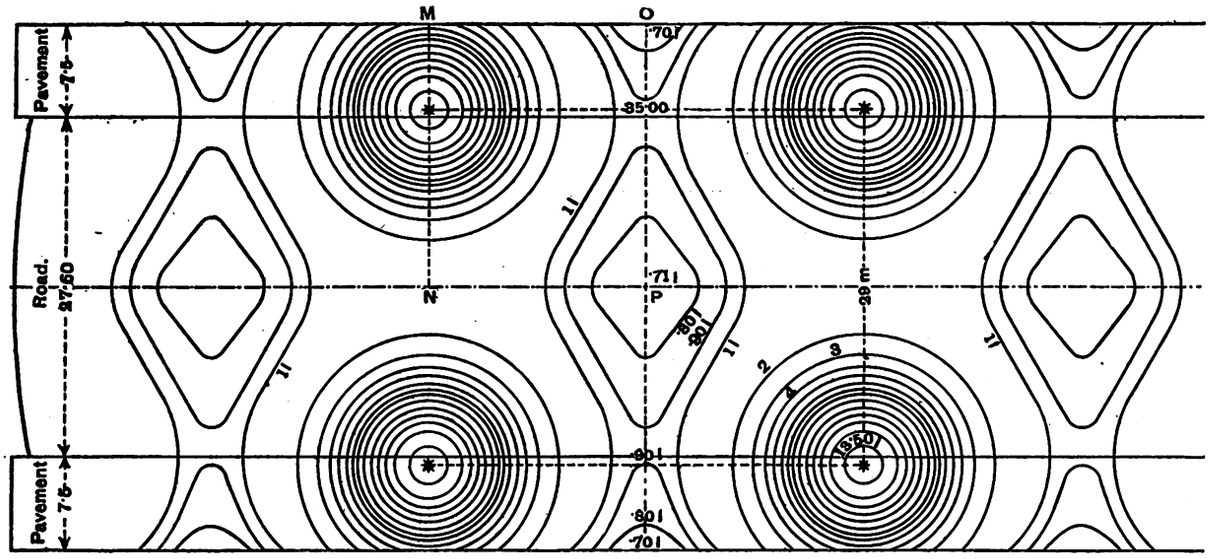

FIG. 29.—Plan of illumination with 10-ampere continuous-current arcs under opal globes, Rue Royale (part comprised between La Rue St. Honore and La Place de la Madeleine). (Figure taken from *L'Eclairage à Paris.*)

Another question arises now; it is this: On what principles should we conclude a bargain with a company for the furnishing of light? or, in other words, What is the merchandise for which we should bargain? Hitherto two systems have been employed; the older consisted in paying for the light at so much per carcel. The more modern consists in paying for the energy at so much per kilowatt-hour. The first system gives rise to much annoyance because of the equivocal manner in which the contracts were drawn up, the expression "carcel" signifying nothing in itself if we do not define the direction in which the intensity is to be measured.

[40] We must add that these figures are rather lower than the reality, for M. Maréchal has wittingly left out of consideration the supplementary effect produced by the arcs on the refuges (*see* Fig. 26).

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This precaution has been taken in some cities,[41] but in many others, notably in Paris, it has been omitted. Under these conditions one was in the hands of the *concessionnaire*, who might at any time pretend that the stipulated intensity referred to the direction of the maximum, following a very convenient habit of gas engineers.[42] To put an end to these discussions we have been led to entirely suppress photometry, and to define the lamps by their current.[43] This is the system adopted at the present day in almost all the new installations. It is seductive in its simplicity, for it lends itself to easy control. But this method presents grave inconveniences which are not always sufficiently recognised. It conduces to a bad utilisation of the energy. In short, there being no clause imposing on the *concessionnaire* a good luminous efficiency, he has no interest in getting a better effect out of his lamps. He will employ, then, by preference, carbons of a larger diameter to reduce the frequency of their renewal, which lowers in an enormous proportion the luminous return,[44] and he will no longer seek methods for utilising the light emitted by his lamps towards the sky. Thus in France there is not at present, to my knowledge at least, a single installation of public lighting by alternating arcs which is satisfactory from the photometric point of view.[45] They all waste half at least of their light, and the *concessionaire* is completely careless about the matter. It would no longer be the same if another mode of evaluation were adopted. The only logical method is the useful luminous flux, which, from what we have already seen, is easily confounded in practice with the lower hemispherical flux. The true basis for a contract for lighting should be then, the quantity of light emitted below the horizon, measured in lumen-hours,[46] just as the energy is calculated in watt-hours. It is, in short, on the number of lumens that the number of square metres to which one may give a fixed mean illumination depends. Practically many criticisms may be raised against this method because of the difficulty of verifying the figures. But it is easy, I think, to avoid this objection by the following combination, which restores the control to where it should be.

1. The contract should be entered into for a certain number of hemispherical lumen-hours per lamp.
2. The *concessionnaire* should then have his type of lamp approved and should explain the conditions under which it is his intention to produce the light and furnish an experimental proof of it by measurements such as are made by the Contral Laboratory of Electricity, whose certificate would be accepted. The fixed quantities would be: the voltage at the terminals, the value of the current, and the diameter of the carbons—which it is a great mistake never to indicate in contracts.
3. These three factors once settled, they can easily be verified so long as the *concessionnaire* does not propose any modification.
4. At each modification of the apparatus, methods or appliances for the production of *the light*, the *concessionnaire* shall notify the new constants and shall have them certified as at the first.
5. If it can be shown that the proposed modifications permit a reduction in the expense at the same time as they produce the same useful flux of light, the city and the *concessionnaire* shall share in halves or in such other proportion as may be arranged the nett economy thus realised.

This combination, as we see, does not in any way complicate municipal lighting, since testing at the expense of the *concessionnaire* will not be repeated except he finds it to his interest, and the municipal control is practically the same as in the case of a contract for energy. On the other hand, this arrangement leaves the way open to progress, and in contradistinction to the greater number of existing contracts, it offers a premium upon the best utilisation of light and upon the employment of means for permitting the light actually lost in the clouds to be sent towards the ground.[47]

[41] For instance, this measurement is taken for the angles 45deg.—55deg. at St. Petersburg, 60deg. at Berlin (these angles being measured from the vertical).

[42] Gas lamps are ordinarily defined by their maximum intensity, which with some is in a horizontal direction, and with others (Wenham, for instance) in a vertical direction, and it is to these figures that one refers in comparing the consumption of different burners.

[43] American engineers and some European engineers have chosen another very original and not less debatable method to simplify this question. They have decided to officially call every lamp taking 10 amperes a lamp of 1,000 candles, even if it only gives 500 or 600 candles, as is ordinarily the case. The utility of such an arrangement is hard to understand, for it is but a useless fiction; from the moment when one ceases to take photometric measurements it is far better to frankly keep to the indications of the electrical constants.

[44] This fact is well known to all those who have used the electric arc. As a typical example I, however, believe it will be useful to quote a practical recent trial made in America, and which has furnished the following figures:—

Kind of carbons.	Dia. Mm.	Time. h. m.	Energy consumed. Watts.	Horizontal Candles.	Ratio of candle-power to energy. Candles per watt.
Union carbon (cored)	11·5	18 53	361	159	0·44
Union carbon (cored)	11·5	12 0	424	316	0·75
Washington carbon (solid)	11·5	9 14	445	359	0·80

The return of light varies, then, almost from single to double, according to the length of time.

[45] I shall return later to this interesting question.

[46] M. Hospitalier proposed calling this the "illumination" (*eclairage*).

[47] At Toulouse the authors of the 1891 contract, who have foreseen a possible modification of the methods of lighting, independent of the processes of production of electricity, have adopted a different wording as follows: "If a new method, apparatus, or appliance shall permit of the reduction in an appreciable proportion of the number of watts necessary for the production of the same quantity of light, the City shall have the right to require the application of the method, apparatus or appliance to the municipal lighting. The watts thus saved shall be employed in feeding new lamps fixed according to the indications of the Mayor." This clause, which some engineers may be inclined to prefer to the one I propose, is excellent in theory, but it has three inconveniences in practice:—1. It does not specify in a sufficient manner that which is to be understood by quantity of light. 2. The form of carbons not having been defined, the company is at liberty to modify them at will to increase their duration without the city being able to interfere, despite the loss of light which would result. 3. The installation of new lamps being at the cost of the *concessionnaire*, he has all to lose and nothing to gain by the anticipated improvements, which can be of advantage to the City alone; far from proposing them, he would seek to avoid them being known and adopted. The wording given by me appears better, and is possibly more equitable, for if the contract is drawn up as it should be to-day—that is to say, on the principle that the public lighting constitutes a sort of "paying advertisement" for the company undertaking it—they ought to expect under this head a more or less large annual loss, and it is only just to let them have the chance of reducing this at the end of a few years.

DOUBLE REFRACTION OF ELECTRIC RAYS.*

BY PETER LEBEDEW.

Ever since Hertz gave us the means of experimentally investigating the consequences of the electromagnetic theory of light, it has been felt desirable to carry out these experiments on a smaller and more convenient scale. The first researches in this direction were made by Prof. Oliver Lodge[1] and more recently by M. A. Righi[2], who worked out a method which has now found various applications. By further reducing of the apparatus I have successfully generated and observed waves which could only be measured by fractions of a centimetre ($\lambda = 0{\cdot}6$cm.), and which come nearer the longest waves of the heat spectrum than the electrical waves originally employed by Hertz. For these experiments the parabolic mirrors can be made so small that prisms of a little over a centimetre are quite sufficient for the demonstration of refraction. It was thus made possible to bring the fundamental experiments of Hertz within the sphere of ordinary optical instruments, and to complete them by showing double refraction in crystals. In what follows I shall first describe these experiments, and shall give the technical details in the supplementary paragraphs. It may be remarked here that M. Righi,[3] by proving circular polarisation in wood blocks, had already discovered the phenomenon of double refraction.

I.—The Apparatus.

In selecting the experimental arrangement, the classical one of Hertz served as a model. The oscillations were generated in the focal line of a cylindrical mirror. In the focal line of the receiving mirror there were two straight-line resonators which were excited by the waves falling upon them, but the linear dimensions were all reduced 100 times. Such a reduction, however, could not be brought about without some alterations, and, therefore, for the primary conductor the form given by M. Righi was adopted, and the excitation of the resonators was not measured by means of a secondary spark, as in the Hertz method, but in the thermo-electrical way of J. Klemencic.[4]

The primary conductor (Fig. 1) consisted of two platinum cylinders P and P_1, each 1·3mm. long and 0·5mm. thick, which were fused

* From *Wiedemann's Annalen*, No. 9, 1895.

[1] *See* O. Lodge, *Nature*, Vol. XLI., p. 462, 1890.

[2] *See* A. Righi, *Rend. Cent. Acc. d. Lincei*, p. 505, 1893; *Memoria d. Acc. d. Bologna*, p. 487, 1894.

[3] *See* A. Righi, *l. c.*, p. 565. The phenomenon in wood blocks which Herr Mack (*Wied. Ann.*, Vol. LIV., p. 342, 1895) pointed out as double refraction were examined by Righi (*l. c.*, p. 563) some time before, and explained in a satisfactory way (p. 563) by the fact that wood possessed different conductivity in different directions.

[4] J. Klemencic, *Wied. Ann.*, Vol. XLII., p. 416, 1891; and Vol. L., p. 175, 1893.

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into the glass tubes G and G_2. The current was led in by sparks passing from the wires D_1 and D_2 to the platinum cylinders. This primary conductor was placed in the focal line of a circular cylindrical mirror[5] 20mm. high, with an aperture of 12mm. and a focal distance of 6mm. In order to have the sparks of the primary conductor passing through a liquid insulator, the whole mirror was placed in a petroleum bath, which was provided with a small mica window to allow the rays generated to pass undisturbed into the open. A suitable screw permitted the regulation of the length of the primary sparks ($l = 0{\cdot}02$mm.). The current was taken from a medium-size induction coil (30 interruptions per second), in the secondary circuit of which was placed a condenser C and a water resistance W, for the purpose of protecting the primary spark from the damaging after-discharge of the coil. By means of a second mirror of parabolic-cylindrical shape with a focal length of 1·4mm., a height of 20mm., and a 12mm. aperture, and which was built exactly like a Hertz mirror, the rays were concentrated on to two straight-line resonators of 3mm. length. On to the opposing faces of these resonators, R_1 and R_2 (Fig. 2), very

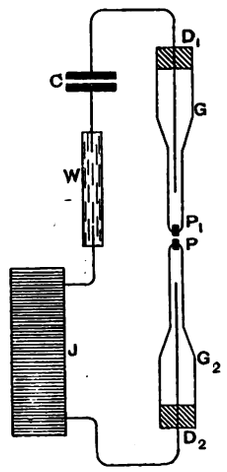

Fig. 1.—Full Size.

thin wires (diameter = about 0·01mm.) of iron and *constantan* respectively were soldered in such a way that two loops of 0·33mm. were formed. To the middle of each resonator (that is to say, at the nodal point of its electrical oscillations) was soldered an elastic leading-in wire, fixed to the ebonite plate E. When the resonators are excited a discharge takes place at each oscillation, partly through the wires of the thermo-element, the heating of which was indicated at once by a very sensitive galvanometer (one scale division = $6{\cdot}10^{-9}$ amperes; resistance = 0·62 ohms) and measured by its first deflection. To protect the delicate thermo-element from air currents the secondary mirror was surrounded by a cover having a mica window. Both mirrors stood on a spectrometer. The focal line of the primary mirror was in a fixed vertical position, while the secondary mirror was fixed to a movable arm of the spectro-

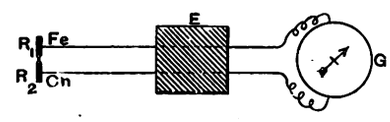

Fig. 2.—Full Size.

meter, and could be turned round the ray as axis. The distance of the two mirrors apart was in most experiments 10cm., which corresponds with the distance of 10 metres in the Hertz experiments. Under these circumstances the deflection of the galvanometer reaches 20 to 30 scale divisions.

II.—The Fundamental Experiments of Hertz.

With the apparatus described, the fundamental experiments of Hertz may easily be repeated.

(A) *Polarisation.*

For the polarisation experiments I employed a square grating of 2 × 2cm., consisting of 20 fine wires. The behaviour of the grating with the lines parallel or crossed was identical with that discovered by Hertz. The extinguishing effect of the grating is of importance, as it indicates at once the existence of disturbing effects (such as the direct distant influence of the induction coil on the galvanometer). In all the further experiments described below, a larger polarisation grating was placed in front of the primary mirror, and each observation was repeated with the grating in two positions. The difference in the galvanometer deflection could only have been conditioned by the electrical oscillations which passed through the grating.

(B) *Interference.*

The length of wave used can without difficulty be determined by the method of L. Boltzmann,[6] employing two flat mirrors. The maximum, which appears at a distance of 0cm., is followed by a well-defined minimum at 0·2cm. to 0·3cm., and this again is followed by a weak maximum at 0·5cm. to 0·6cm. At greater differences of phase no periodical fluctuations are perceptible, which is a proof that the wave examined is heavily damped. From these observations the wave length may be taken $\lambda = 0{\cdot}6$cm., which corresponds with the geometrical measurement of the apparatus.

(C) *Rectilinear Propagation.*

If the mirrors are placed 10cm. apart, experiments on the transparency of insulators, ebonite, mica and glass, and the screening effect of conductors (metals), can easily be made. If the secondary mirror be moved away from the primary one, the galvanometer deflections then decrease a little quicker than the distance increases. The ray has no sharp limits, but its direction can be given correctly to 3deg.

(D) *Reflection.*

For the demonstration of reflection a flat metal mirror of 2 × 2cm. is sufficient. To show the behaviour of anisotropic surfaces the polarisation grating described can be employed with advantage.

(E) *Refraction.*

To demonstrate refraction a small prism of ebonite 1·8cm. high, 1·2cm. broad, with a refraction angle of 45deg., and of a total weight of scarcely 2 grammes, was quite sufficient. In the experiment of Hertz the weight of the prism was about 12cwt. The prism was set up on the spectrometer table, and the primary mirror was placed at a distance of 3cm., while the distance of the secondary mirror from the prism was 7cm. The observation was made in the usual way for the two minimum positions. The secondary mirror was set up at different angles, and the corresponding galvanometer deflection noted. (The influence of the changing condition of the primary sparks can be diminished by a succession of frequent observations.) If the results are plotted graphically, then the position of the maximum can be determined within 3deg. It may here be remarked that a metal diaphragm 1·2cm. across, set up close in front of the prism, scarcely influences the position of the maximum in the refracted ray, though the maximum appears very much weakened. For this reason diaphragms were not used. From the deviation angle of 30, the index of refraction of ebonite was calculated to be $n = 1{\cdot}6$. The square roots of the different dielectric constants for ebonite, as furnished by different observers,[7] range from 1·4 to 1·8. Even if we, like Hertz, do not attach too great importance to the indices of refraction found under the conditions described above, yet we are entitled to conclude that in this case, within the limits of observational errors, the Maxwell law prevails.

III.—Double Refraction.

The dimensions of the apparatus described permitted of the fundamental optical experiments being made with crystal line media. Of the different crystal line materials used, the natural rhombic sulphur was found excellent for its high insulating properties, as well as on account of the sufficient divergence of the two rays. As the dielectric constants for different directions are known from the measurements of L. Boltzmann,[8] the orientation of the sections will always relate to the large (D_g), the mean (D_m) and the small (D_k) dielectric axis.

(A) *Prismatic Diversion.*

Two prisms exactly alike, 1·8cm. high, 1·3cm. broad, with a refraction angle of 25deg., were cut out of two nearly similar crystals. The refracting edge of the first was parallel to the large dielectric axis (D_g), and the edge of the second parallel to the small axis (D_k). The deviation angles of the electrical oscillations parallel to the refracting edge were determined in the same way as for the ebonite prism, and from this the index of refraction was calculated. The measurements gave the following figures: $n_g = 2{\cdot}2_5$; $n_k = 2{\cdot}0_0$. The square roots of the dielectric constants, as measured by L. Boltzmann, are as follows: $\sqrt{D_g} = \sqrt{4{\cdot}77} = 2{\cdot}18$; $\sqrt{D_k} = \sqrt{3{\cdot}81} = 1{\cdot}95$.

These experiments lead, therefore, to the conclusion that electric waves are doubly refracted in crystalline sulphur, and that also for this substance Maxwell's law holds good within the limits of observational errors. Unfortunately there was no third crystal at my disposal out of which I could have cut a prism for the determination of n_m.

[5] A circular cylinder was preferred to the parabolic shape of Hertz, on account of the greater ease of construction.

[6] L. Boltzmann, *Wied. Ann.*, Vol. XL., p. 399, 1890.

[7] *See* Landolt's Tables, Second Edition, p. 196, 1894.

[8] L. Boltzmann, *Wiener Berichte*, Vol. II., 70, p. 342, 1874.

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(B) *Nicol's Prism.*

The refractive indices found permit of the angle of total reflection in ebonite being calculated for the mean refractive index of sulphur, and a Nicol prism can be made for electric waves. This was done in the following way: A parallelepiped (2×1·8×1·2cm.) of crystalline sulphur, whose dielectric axes are parallel with the edges, was cut in two along a section running through D_g, and forming with D_k an angle of 50deg.; between these was placed an ebonite plate about 1·8mm. thick. A ray falling in the direction of D_m is resolved into two components, which respectively oscillate parallel to D_g and D_k, the first of which is totally reflected on the ebonite plate, while the second passes through undisturbed. With this Nicol prism the well-known optical experiments can be easily repeated.

If the mirrors are set up opposite each other with their axes parallel, then the ray is "extinguished"[9] as soon as D_g becomes parallel to the electrical oscillations. (It was proved by moving the secondary mirror, that in this case the ray is diverted.) If the prism was turned through 90deg. about the ray as axis, then the radiation passed through it, which was shown by a galvanometer deflection of 20 scale divisions. If the mirror axes are crossed, the galvanometer shows no deflection as long as the Nicol remains in the ordinary position; a turn through 45deg. is sufficient to produce at once a deflection of 15 scale divisions.

(C) *Quarter-wave Plates.*

The experiment with a quarter-wave plate, which forms the basis of all interference phenomena in crystalline plates, can easily be made in the following way: Out of a sulphur crystal is cut a square plate 2×2cm. and 0·6cm. thick, so that D_g and D_k lie in its plane. For the wave-length $\lambda = 0{\cdot}6$cm. a retardation of $\frac{\pi}{2}$ takes place in this plate. If this plate is placed between the crossed mirrors the following is then observed: If both the dielectric axes are parallel to the focal lines of the mirrors, then the field remains dark and the galvanometer shows no deflection. If now the plate is turned through 45deg., the transmitted ray is circularly polarised, and the galvanometer indicates at once a deflection of 15 scale divisions. If a second quarter-wave plate were introduced in the path of the circularly polarised ray, in such a way that the dielectric axes of both plates are at right angles to each other, then the galvanometer remains at rest, and the field is again dark.

Experiments with thicker crystal plates show no phenomena analogous to the well-known optical ones. This is easily explained by the considerable damping of the wave-motion employed. Though the experiments described are not very numerous, they are sufficient to prove the correctness of the view pronounced in 1862 by Maxwell on the behaviour of electric waves in crystalline media, and to show also the identical behaviour of electrical and light waves in this particular complicated case.

SUPPLEMENTARY REMARKS.

In my account of the experiments described above, I thought I could pass over several details which did not touch the basis of the experiments, but for the repetition of these and further investigations these details may be welcome, and I shall discuss them in the following paragraphs:—

1.—*The Primary Conductor.*

Of the different arrangements for the primary conductor, the one described by Righi was found to be the most suitable. Leads of low conductivity and dilute electrolytes in place of the Righi air-spark did not impair the effect of the primary conductor, but were unsuitable for technical reasons.

A frame, R R R R (Fig. 3), consisting of a glass tube, carried the primary conductor. The two halves, G_1 and G_2, of this latter were cemented with shellac into zinc holders. By tightening the screw V, the length of the primary spark ($l = 0{\cdot}02$mm.) could be regulated to a very fine degree. The most effective primary spark was found to be a very small one, looking like a tiny star. It may here be pointed out that the two halves of the primary conductor must be well secured, as in the formation of the primary spark the petroleum suddenly evaporates, and tries to force the two halves apart, increasing the spark distance beyond the most suitable length. The primary mirror, S S, was fixed to the same frame R R R R. To fix the primary conductor exactly in the focal line of the mirror a template (Fig. 4) was employed. The distance separating the mirror from the primary conductor was made a little under half the length of the radius of curvature, to correct the edge rays. The frame was placed in the petroleum bath B B (Fig. 3). This arrangement has the advantage that for a given period the wave-length is smaller in petroleum than in air, and therefore the diffraction phenomena become considerably smaller at a given dimension of the mirror. The primary conductor has to be continually renewed, as after 100 discharges the platinum becomes useless. Throughout the research the management of the primary requires the greatest skill and attention, as its excitation depends in a very complicated manner on the supply of electricity.

Of the different arrangements which I had the opportunity of testing, the one shown in Fig. 1 proved to be the best. The size of the condenser C and of the water resistance W depends on the induction coil used. The size of the condenser C and of the water resistance W depend on the induction coil chosen and the regulation of its interrupter. For the one I used, which was fitted with a Desprez interrupter, and which, with eight accumulators, gave a maximum spark of 12cm., a Leyden jar consisting of a glass tube 1cm. in diameter and only 5cm. high was sufficient. A water column 5mm. diameter and 20cm. long served as a resistance.

From previous experiments with different primary conductors, I found the most suitable length of primary spark to be approximately proportional to the wave-length. For these discharge phenomena

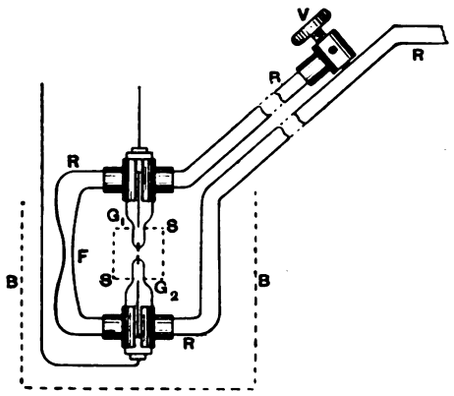

FIG. 3.

there is no quantitative connection between the length of the spark gap and dimensions of the conductor on the one hand, and the amount of radiated energy on the other. However, it may be taken that for double the wave-length the available energy is tenfold, making the determination considerably easier. A reduction of wave-length causes great difficulties, and the smallest apparatus with which I obtained results corresponded to a wave-length of 3mm., but the extremely small amount of energy radiated and the technical difficulties in producing the apparatus prevented further reduction of the wave-length.

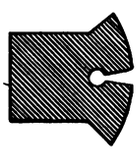

FIG. 4.

If for a given resonator a larger primary conductor is used, as described by Righi,[10] the excitation of the resonator increases. As, however, the main oscillation is a slower one, the large size of the mirror caused the diffraction phenomena to attain such a scale that the bundle of parallel rays became very ill-defined.

2.—*Resonators.*

In selecting a method of observation I compared bolometric and thermo-electric methods, and found the latter to be the most sensitive. This is explained in the following way: with decreasing dimensions the sensibility of the bolometer decreases, while that of the thermo-element remains constant.

The simplest way of making resonators with leading-in wires is to bend the ends of wire into the shape shown in Fig. 5 on an enlarged scale, and to fill up the loops with soft solder.[11]

The construction of the thermo-element from thin wires (about 0·01mm. diameter) appears to be more difficult than it really is. The *constantan* and iron wires sold in the market were about 0·025mm. in diameter,[12] and had to be thinned down in dilute tepid aqua regia till the required section was obtained. An ocular micrometer was used for measuring the wires. The wires[13] of the

[9] The extinction is in this case not a perfect one, as the galvanometer still shows a deflection of about one-fifth of the maximum, which can be explained by diffraction phenomena.

[10] A. Righi, *Memoria d. R. Accad. di Bologna*, p. 500, 1894.

[11] The thickness of the resonator must be less than one-third its length

[12] The wire was supplied by Hartmann and Braun, of Bockenheim, Frankfort-on-the-Main.

[13] The wires of each half of the loop must be very close to each other to get the circumference of the thermo-element rather small compared to the circumference of the resonators, as otherwise the natural period of vibration of the resonators would be much influenced.

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thermo-element were then soldered to the resonators already placed in position on an ebonite plate. As the soldering iron used has to be very small, a gas jet should be arranged in it to keep it hot. As it is difficult, with these small dimensions, to get the thermo-element all right at once, it will be necessary to make several and select the best one. After soldering, the thermo-element will often not conduct current, and it will be necessary to connect the element to the secondary of an induction coil and close the primary for a moment. This creates a permanent metallic contact in the thermo-element. The resistance of such an element was found to be between 0·5 and 2 ohms. To increase the sensibility of the element I have with success cast it in a glass globe and exhausted the latter by means of a Sprengel mercury pump. The result was that the cooling down of the element became slower and the sensibility was considerably increased. The resonators were cast into the glass globe in such a position that they were in the focus of the glass surface, which was afterwards silvered over outside. Although this method has many experimental advantages, to keep in touch with the Hertz arrangement I also made experiments with theresonators in ordinary atmosphere.

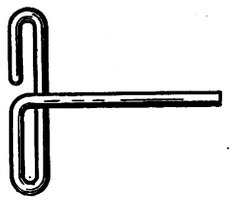

FIG. 5.

3.—*The Galvanometer.*

The unavoidable variations of the temperature of the thermo-element and the regular working of the primary conductor with currents of short duration necessitated a galvanometer of short oscillatory period ($\tau/2 = 3$ secs.). The galvanometer of Du Bois and Rubens,[14] with the special light-needle system and a length of magnet equal to 3mm., has proved to be most suitable. The external magnetic disturbances[15] were weakened about five times by replacing the glass cover by a cylinder of sheet-iron, about 2cm. thick.

4.—*Disturbing Influences.*

If the polarisation grating is so erected that no electrical vibrations can pass into the resonators, galvanometer deflections can still be created by disturbing secondary causes. It is of advantage to reduce these to one or two scale divisions. The magnetic forces generated by the induction coil and the conducting wires can be rendered harmless by giving the induction coil a suitable position, and intertwining the leads. The electrostatic influence of the leads of the primary conductor can create periodical charges in the circuit of the thermo-element, and cause deflections on the galvanometer. These disturbances can be to a certain extent avoided by interwinding the wires of the thermo-circuit, and by fixing a metallic mantle which is connected to earth, round the secondary mirror. Electrical oscillations of a long wave-length, if originated in the leads of the primary conductor (for instance, by side sparks), cause in some cases large galvanometer deflections. The thermal radiation of the primary conductor, which is reflected and refracted in the same way as the electrical oscillation, is so small that no heating of the thermo-element is perceptible.

5.—*The Observations.*

The slow alteration of zero, which is caused by the temperature variations of the room, is no disadvantage, since with its short swing $\left(\frac{\tau}{2} = 3 \text{ secs.}\right)$ the galvanometer deflection can easily be determined within 1 scale division. A considerable amount of uncertainty is experienced owing to the unsteadiness[16] of the primary spark. This can be reduced by taking the observations in a certain succession, and taking the mean. As an instance, the determination of the position of a diverted ray of the sulphur prism (P_g) may serve.

In Table I. the observed galvanometer deflections are given in scale divisions ; ψ^0 gives the positions of the secondary mirror on the circumference of the spectrometer. The arrows show the succession of the observations. During the series of experiments the primary spark was regulated four times.

If one assumes that the primary spark changes regularly, then the observed deflections can be reduced in the usual way to a constant activity of the primary spark. (Twenty scale divisions at $\psi^\circ = 150$.) Table II. gives the deflections so reduced.

In the same way the observations for the minimum position were taken. In Table III. the mean of two observations[17] for the sulphur prisms (P_g, and (P_k) are put together, and in Fig. 6 the same are graphically represented.

Table I.

ψ°	First regulation.			Second regulation.				Third regulation.					Fourth regulation.				
140°	...	13	...	...	14	...	6	...	...	...	...	...	...	13	...	...	...
145°	↑	↓	...	↑	↓	↑	↓	↑	22	↑	8	...	↑	↓	10	7	...
150°	20	13	7	14	22	12	8	21	18	9	7	5	22	15	11	7	...
155°	...	↓	↑	...	↓	↑	...	...	8	↑	3	↑	...	...	...	...	...
160°	...	3	...	...	5	...	...	...	...	...	...	...	...	...	...	...	...

Table II.

ψ°	First regulation.			Second regulation.				Third regulation.					Fourth regulation.				Mean.
140°	...	16	...	...	15	...	12	...	...	..	...	...	...	14	...	...	14
145°	...	...	...	...	...	...	...	...	21	...	20	...	...	...	16	15	18
150°	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	....	20
155°	...	...	...	...	...	...	...	...	11	...	10	...	...	...	...	...	10
160°	...	6	...	...	6	...	...	...	...	...	...	...	...	...	...	...	6

Table III.

ψ_1°	P_g	P_k	ψ_2°	P_g	P_k
140°	14	6	200°	10	20
145°	18	17	205°	14	22
150°	20	20	210°	20	20
155°	10	21	215°	23	17
160°	6	15	228°	18	13

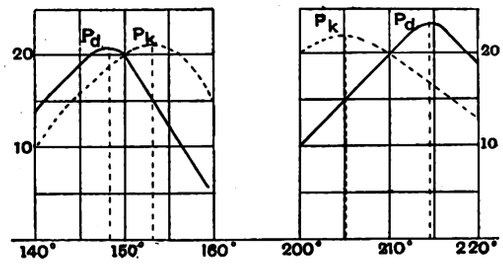

FIG. 6.

From Fig. 6 the maximum is obtained :—P_g, 148deg. and 214deg. P_k 153deg. and 205deg. From this the refractive index calculated ($\alpha = 25$deg.) $n_g = 2{\cdot}26$, $n_k = 2{\cdot}00$. All observations were made and reduced in the same way.

6. *The Sulphur Preparations.*—For the manipulation of the natural crystalline sulphur[18] some precautions are required, as the mineral will crack with the slight heating caused either by the touch of the fingers or by a saw. When the whole crystal can be used for a single prism, it can easily and quickly be shaped by simply rubbing the crystal on a piece of sandpaper. If, however, it is necessary to produce two prisms from one crystal, then it is advantageous to cut (with a fine saw) two cuts about 2mm. apart (alternately) in the given direction. The crystal will crack, of course, under the action of the saw, but the cracks will only take place in the rather thin intermediate layer. Further shaping is done by means of rubbing. By constantly using a goniometer, the angles may be made accurately within one degree.

In conclusion, it may be remarked that the small waves are suitable for an extensive use, as already with medium sized and at the same time optically perfect apparatus the diffraction phenomena can be neglected, and also for measurements, to which no objection can be made, easily obtained quantities of substances suffice. Hence it becomes possible to realise the simple conditions to which we have become used in optical experiments, also for the optical study of Hertzian waves.

[14] H. du Bois and H. Rubens, *Wied. Ann.*, Vol. XLVIII., p. 236, 1893. Supplied by Kayser and Schmidt, of Berlin.

[15] *See* G. Wiedmann, "Lehre von der Electr., Vol. III., p. 296 (1883).

[16] This unsteadiness seems to be the outcome of a fault in the primary conductors, and it shows itself in the quick formation of the primary spark.

[17] The second series of observations was made with a new primary conductor.

[18] The crystals were obtained from J. Böhm, mineralogist, Vienna.

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CORRESPONDENCE.

THE HARGREAVES-BIRD ELECTROLYTIC CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your Journal of the 25th inst. you open an article on the Hargreaves-Bird cell as follows: "A paragraph which affords internal evidence of external inspiration has been lately perambulating." To which I retort: The article gives external evidence of internal spite, and complete evidence that you do not keep up to date with your continental contemporaries, or you would not need to report this at second hand. It first appeared in the *Elektrochemische Zeitschrift* under my own name as the contributor, and was given in response to the request of the editor; so perhaps you will retract the insinuation implied in your opening sentence. But if such a course puts you to any inconvenience you need not trouble about it; I am not at all particular. Again I read: "The figures quoted are of the usual misleading kind; an efficiency of 80 per cent. is claimed, by which the wise understand a reference solely to amperes; volts, we suppose, count for nothing." Then, if you did, you supposed wrong, and there is nothing in the communication to justify you in supposing anything of the kind. I gave all the factors, and took it for granted that I was addressing scientific readers. I did not presume to insult them by supposing that they could not work out the little equation

$$E=\frac{0{\cdot}8\times 2}{3{\cdot}4}=x$$

for themselves. Nor did I presume to occupy valuable space with such elementary matter. I am not in any way responsible for your not being able to understand it. I am too old a soldier to trouble myself much about such small shot as the above. Not a generation ago one "authority" says I *cannot* do it with less than 12 volts, and now you practically insinuate that I ought to do it with two. When I was at school I read the fable of the old man, his son, and his ass. *Verb. sap.*

You conclude your comments on my remarks, that there is a partial oxidation of the nascent hydrogen at the cathode, as follows: "As a matter of fact, we should require unusually good experimental evidence to induce us to believe that any oxidation whatever takes place." If you want the "experimental evidence" why don't you get it for yourself? You surely don't pretend to run a scientific paper without a few appliances for testing the truth of what appears in your pages, do you? Or do you suppose I am going to leave my work to hawk about "experimental evidence" for your satisfaction? For myself, it is enough to know—and it is not of the smallest importance whether *you* believe it or not—that alkali and "bleach" can be made for much less fuel than is needed in the Leblanc process, without the costly intervention of secondary reagents.—Yours, &c., JAMES HARGREAVES.

Farnworth, Widnes, October 26, 1895.

[We are glad that the writer of the above recognises the correctness of our reduction of the efficiency of the process with which his name is associated, from 80 to 50 per cent. or less. We think that, on reflection, he will agree with us that it scarcely falls within the province of a technical paper to investigate reactions inherently improbable.—ED. *E.*]

THE MAGNETIC FORCE IN THE PLANE OF A CIRCUIT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Russell's Paper in last week's *Electrician* is interesting, but I think it unnecessarily complicates the formula I have advocated for finding the force in the plane of a circuit, namely,

$$F=i\int\frac{d\theta}{r}.$$

Surely the simplest way of applying this is to plot a curve having $1/r$ and θ as cartesian co-ordinates, and integrate it. If r is measured in centimetres, θ in circular measure and i in C.G.S. units, the result is in C.G.S. electromagnetic units of force. Another way of expressing the result is

$F=i\times$(total angle subtended)$\times$(mean value of $1/r$),

the value of $d\theta$ being kept constant for every part of the curve; if $d\theta$ is varied proportionate weights have to be assigned to the values of $1/r$ in taking the mean.—Yours, &c.,

W. H. EVERETT.

THE SULLIVAN GALVANOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As I am frequently asked how my Universal galvanometer behaves when used on board ship in a heavy sea, the following report dealing with that, as well as other points in the instrument, may possibly be of general interest. You would oblige me by kindly publishing the same:—

S.s. "Dacia," October 27, 1895, off Cadiz.

DEAR MR. SULLIVAN: I am very pleased to be able to send you a very satisfactory report on your marine galvanometer. All the way out we have had a very heavy sea, so I have been able to give it a pretty severe trial. In every way I find that it is very superior to the old ironclad Thomson marine galvanometer. Not only is the narrow coil just three times as sensitive as our Thomson, wound with 30,000 units, but, owing largely to the inertia of the coil, your instrument has been remarkably steady, while the Thomson suspension has been vibrating under the vibration due to the propeller to an extent which makes it very trying, and indeed almost impossible to read with any great degree of accuracy in a heavy sea. There is no creeping, and the spot seems to return to zero. This coil is, however, very sensitive, and as I have not taken quite the same pains in making the balance absolutely perfect as yet there is still a movement of about 5 to 10 divisions on either side of zero, when the ship is rolling very heavily, though only for moderate rolling there is little or no movement.

I have been very successful in balancing the wider coil and find both of them more easy to balance than the Thomson suspension, as the latter is affected by the magnetic dip when held in different positions, which has not to be taken into account when balancing your coil. It is a treat to watch the two suspensions at the same time and to see how perfectly your instrument keeps its zero. Even when perfectly balanced the Thomson suspension is displaced considerably from the scale zero, and is affected by the slightest vibration. When the ship changes its course, moreover, the zero changes and has constantly to be checked. This weak point alone gives a great deal of trouble, more especially when testing the insulation of short lengths of cable, which I am glad to find your instrument is free from. Owing to the ship rolling very heavily and carelessness in leaving the wide coil suspension insufficiently guarded on the table, while experimenting with the narrow coil, the wide coil suspending wires were both broken by sliding down the table against a key, so I very soon had occasion to try my 'prentice hand in re-suspending it. This was easily effected, with the result I have already mentioned. I can quite believe that the wide coil is more suited for excessive vibration, but though the "Dacia" is moderately affected in that way by the propeller, both your wide and narrow coils are exceedingly steady. The sensitiveness of your narrow and wide coils, as I am now using them, is represented by 360 and 205 divisions respectively, compared with 130 divisions obtained under the same conditions with the Thomson. . . .

I told you that I had not quite balanced your narrow coil suspension, but I have not the least doubt but that it will be perfectly immovable, like the wider coil, when I can find time to touch up the balancing again.

We are now entering Cadiz Harbour, and I am likely to be busy, so I must reserve a more careful and detailed report until I return to England, which, if the weather is suitable for our cable repairs, will be in about five weeks from present date, only I know you will be pleased to have another favourable report on your galvanometer.

Notwithstanding a sort of parental fondness which one has hitherto had for an only child, I am not sorry that our first has had his nose put out of joint at last, for my affection has often been sorely tried by the trouble the young rascal has given me. I have often marvelled at the patience an electrician has to exercise on board ship when following the erratic movements of his Thomson galvanometer, in order to obtain a correct insulation test, and I am sure many a one will cordially join with me in congratulating you on having turned out such a practical and satisfactory instrument.—I am, Yours faithfully, (Signed) JOHN RYMER-JONES.

P.S.—If it will be any advantage to make use of this letter you are perfectly at liberty to do so.

I may add that the above corroborates a previous report received from another independent quarter, but I must not further trench upon your space in this matter.—Yours, &c.,

29, Ladbroke-square, W., H. W. SULLIVAN.
November 12, 1895.

Royal Institution.—At the general monthly meeting of members held on the 4th inst, the managers reported that the late Mr. John Bell Sedgwick had bequeathed £300 to the Royal Institution in aid of the fund for the Promotion of Experimental Research at Low Temperatures. The special thanks of the members were returned to Sir Frederick Abel, Bart., for his donation of £50 to the Fund for the Promotion of Experimental Research at Low Temperatures.

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LEGAL INTELLIGENCE.

South Staffordshire Tramways Company v. Ebbsmith and Another.

In the Court of Appeal on Monday, before the Master of the Rolls and Lord Justice Kay, the plaintiffs appealed from an order made by Mr. Justice Hawkins reversing an order of the Court under the Bankers' Books Evidence Act. The plaintiff Company alleged that the defendant Ebbsmith was the promoter and solicitor of a Company (the South Staffordshire and Birmingham District Steam Tramways Company, Limited) taken over by the plaintiff Company; that while Ebbsmith occupied that fiduciary position he formed a company called the Dickinson Tramway Appliance Company (Limited) which was a sham, being in fact Ebbsmith himself; that certain patents were bought up for small sums and assigned by Ebbsmith to the Dickinson Company; and that he then procured the plaintiff Company and their predecessor to purchase articles, the subject matter of the patents, and licences to use the patents, at exorbitant prices and without disclosing his interest in the patents. The plaintiffs claimed damages, an account of the defendant's profits, and a recission of the plaintiffs' contracts as to the patents. On the application of plaintiffs the Master made an order under the Bankers' Books Evidence Act that the plaintiffs should be at liberty to inspect the books of the Staffordshire Joint Stock Bank and their successors for the years 1885 to 1894, containing entries of the accounts of Ebbsmith in that name and in his former name of Joseph Smith, and of the Dickinson Company. Mr. Justice Hawkins reversed this order, and the plaintiffs now appealed. Affidavits were read by which it appeared that the signatories of the Memorandum of Association of the Dickinson Company were the defendant's partners and clerks, and that out of the 1,507 shares in that Company the defendant held 1,500. In 1889 these 1,500 shares were transferred by him to one of the signatories of the Memorandum of Association, who had previously held one share, and subsequently they were transferred to the Corporate Trust (Limited). A certified copy by the Bank of all entries in the defendant's account referring to amounts received by him from the South Staffordshire and Birmingham District Steam Tramways Company (Limited) and the Dickinson Company was put in.

The MASTER of the ROLLS, after hearing counsel, delivered the judgment of the Court, and said that the application was for liberty to inspect the accounts in the books of the Staffordshire Joint Stock Bank of the defendant Ebbsmith and also of the Dickinson Tramways Appliances Company. Taking the first of those two accounts, he had no doubt that the Court had jurisdiction to make the order applied for. The question was how the Court was to exercise that jurisdiction. The defendant had in this appeal sworn an affidavit that the items in his banking account which he had there given were the only items in it which were relevant to the issue in the action, and the Court must accept and act upon what had been thus sworn. The Court must refuse to order inspection before the trial, and would leave the judge at the trial to make any order that he might then think fit. As to the account of the Dickinson Company, no doubt the Court had jurisdiction to make the order asked for. But that jurisdiction must be exercised with the greatest caution, as the Dickinson Company were not parties to the present action. He thought that the person making such an application as this should show to the Court that there were at least strong reasons for expecting that the account in question contained items which would be damaging evidence against the other party to the action. Here it had not been made out that there were any such items in the banking account of the Dickinson Company as would be evidence against the defendant, and he could not see why there should be any items other than those which the plaintiff already knew of. Therefore it seemed to him that, if the order were made, the Court would merely be giving the plaintiff an opportunity to try and find if there were any items which might be useful to him. The appeal must therefore be dismissed.

Lord Justice KAY concurred.

Whiffin v. Crompton Electric Supply Company of Australia (Limited).

An application was recently made to Mr. Justice Stirling in this action that the appointment of the receiver and manager should be continued. It was explained that the business was now being carried on at a profit, and that there were prospects of its being sold either to another Company to be formed for the purpose, or to an existing English Company which might desire to extend its operations in Australia. His Lordship granted an extension for a fortnight.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many origina illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

TENDERS INVITED.—The Corporation of Durban require tenders for No. 40 cast-iron service boxes for connections from concentric mains, No. 120 cast-iron service boxes (or hand-holes) for house connections, No. 60 cast-iron junction boxes for arc lamps, No. 70 cast-iron manhole frames and covers, and No. 60 ornamental cast-iron arc-lamp pillars, 25ft. high. Conditions, &c., from the Consulting Engineer, Mr. W. H. Radford, Pelham-chambers, Nottingham, and tenders must be sent in to Messrs. Webster, Steel and Co., 5, East India-avenue, London, E.C., by the 27th instant. Further particulars appear in our advertisement columns.

——— The Swansea Corporation invite tenders for (1) the supply and erection of destructor and electricity supply station buildings; (2) for the erection of a chimney shaft, 150ft. high, with all necessary foundations and accessories; and (3) for the supply and erection of a dust destructor, including eight destructor furnaces and four water-tube boilers, with all necessary flues, dampers and accessories. Specifications, &c., can be obtained, after the 18th inst., from the Engineers (Messrs. Kincaid, Waller and Manville), 29, Great George-street, Westminster, S.W., and tenders, addressed to the Town Clerk (Mr. Jno. Thomas), The Guildhall, Swansea, must be in by 4 p.m. on Friday, December 6th. Further particulars appear in our advertisement columns.

——— The Metropolitan Asylums Board invite tenders for the execution of wiring and other work in connection with the electric light installation at the Brook Hospital and Ambulance Station, Shooter's Hill, S.E., from specification, drawings, &c., prepared by Prof. A. B. W. Kennedy, which can be obtained at the offices of the Board, Norfolk House, Norfolk-street, Strand, W.C. Tenders must be in by 11 a.m. on Monday next.

——— The Town Commissioners of Fermoy (co. Cork) invite tenders and schemes for the public and private lighting of the district by electricity. Tenders and schemes have to be sent in to Mr. P. J. Lane, Town clerk.

——— The Blackburn Corporation invite tenders for steam alternators and motor alternator, switchboard and engine room connections, street transformer chambers, transformers, &c. Tenders, addressed to the Town Clerk (Mr. Robert C. Fox), Town Hall, Blackburn, by the 30th inst.

——— The Windsor Corporation are inviting proposals for taking over and working their Provisional Order. Proposals to the Town Clerk, 4, Park-street, Windsor.

——— Tenders are invited for the manufacture and laying of a submarine telegraph cable from Puerto Montt to Punta Arenas, Chili. Conditions and specifications may be consulted at the Chilian Legation, 36, Victoria-street, S.W., and tenders must be sent in by December 5th next.

——— The Handsworth Urban District Council invite tenders for an installation of fire alarms to firemen's houses and telephonic calls to out-stations. Tenders must be delivered at the Council House, Handsworth, by the 26th inst.

——— The Midland Railway Company invite tenders for various stores for the year 1886. Included in the list are telegraph instruments, telegraph stay rods, bolts, &c., signal wires, malleable castings, &c. Tenders by the 19th instant to the Secretary, Mr. J. Williams, Derby.

——— The North-Eastern Railway Company invite tenders for various stores, including telegraph apparatus, telegraph wire and line stores, signal wire, castings, bolts, nuts, &c., for the six months ending June 30, 1896. Tenders must be delivered to the Secretary (Mr. C. N. Wilkinson), York, by the 26th inst.

——— The Cheshire Lines Committee invite tenders for the supply of telegraph materials, instruments, wire, &c., galvanised and zinc sheets, pulleys, bolts, screws and various other stores for the year 1896. Tenders by the 30th inst. to the Secretary (Mr. Glegge Thomas), Central Station, Liverpool.

——— The Belgian Minister of War invites tenders for the installation of the electric lighting in the New Military School, Brussels. Tenders to the Ministère de la Guerre, Brussels, by January 15th next.

——— The Hamburg Finance Deputation invite tenders for the supply and erection of an electric lighting plant in the Alte Allgemeine Krankenhaus. Tenders must be sent to the Finanz-Deputation, Hamburg, and are to be marked "No. 704."

——— The French Telegraph Administration invite tenders for the supply, in eight lots, of 46,280 impregnated wood posts. Applications to take part in the tendering are to be sent into the Direction Générale des Postes et Télégraphes, 103, Rue de Grenelle, Paris, by the 18th inst. The adjudication takes place on the 28th inst.

ELECTRIC LIGHTING SCHEMES INVITED.—The Battersea Vestry offer premiums of £50, £30 and £15 for the best three schemes, reports, designs and estimates for a system of electric lighting for the

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parish. Schemes must be delivered to the Vestry Clerk (Mr. W. Marcus Wilkins) by December 12th next.

TENDERS ACCEPTED.—The Edinburgh Town Council received 16 tenders for the wiring of the Waverley Market, the amounts ranging from £459. 5s. to £991. 4s. The lowest tender, that of Messrs. James Milne and Son, has been accepted.

——— The tender of Thomas Parker (Limited), for the supply of two additional armatures at £224, has been accepted by the Walsall Town Council.

——— The Lowestoft Town Council have accepted the tender of Mr. J. G. Ling for putting the Town Hall in telephonic communication with the Sanatorium and stables for the sum of £49. 12s. 6d.

SALES BY AUCTION.—Messrs. Wheatley Kirk, Price and Goulty issue a preliminary notice *re* the sale by auction, at an early date, of the entire contents of the works premises at 45, Broadway, Walham Green, S.W., now in the occupation of Messrs. Russell and Co., who, as announced in a previous issue, have decided to give up business. Further particulars are given in our advertisement columns.

——— The Reading Electric Supply Company having completed their new electricity station, Messrs. Wheatley Kirk, Price and Goulty give preliminary notice of the piecemeal sale by public auction, at an early date, of the entire contents of the Company's old station, the Island, Reading, comprising engines, boilers, combined lighting sets, dynamos, &c. Further information is given in our advertisement columns.

PLANT FOR SALE.—Our advertisement columns contain particulars of a 2 H.P. generating plant, which Messrs. Henry Lea and Thornbery, Bennett's-hill, Birmingham, have for disposal.

BUSINESS FOR SALE.—Electrical engineers can obtain particulars from Messrs. Wheatley Kirk, Price and Goulty of a small electrical business for disposal in London, which would well suit a person with a small connection to add to the present business.

WORKS FOR SALE.—Particulars are given in our advertisement columns of some excellent branch works premises in the west end of London, adjoining a metropolitan station, which Messrs. Wheatley Kirk, Price and Goulty have for disposal.

CHANGE OF TELEPHONE NUMBER.—We regret to announce that we have received official intimation from the National Telephone Company that the telephone number of this Journal will in future be 6949, *vice* 2714. Please note. We are given to understand that our old telephone number will cease to exist, at any rate for some considerable time.

NEW PREMISES.—The Singer Manufacturing Company, makers of the well-known sewing machine, &c., have recently removed from their cramped premises in Cheapside to more extensive offices in St. Paul's Churchyard, E.C., where nearly 100 employés will have accommodation provided. The premises are lighted throughout by electricity, and the manufacturers' room, where a large number of special sewing machines for use in factories are exhibited, will be fitted for electric power, so that the machines can be readily shown at work.

APPOINTMENT.—The Leyton District Council have appointed Mr. A. J. Protheroe clerk of the works in connection with their electric lighting scheme.

POSTAL TELEGRAPH APPOINTMENTS.—Mr. E. Ashton, Superintending Engineer, West of Scotland District, has been appointed Superintending Engineer for the North Wales District, and Mr. D. M. Stewart, Assistant Superintending Engineer, has been appointed Superintending Engineer for the West of Scotland District.

ACCOUNTANCY.—Mr. T. Featherstone Smith, F.I.S., who was for some years with the General Electric Power and Traction Company, has established himself as an accountant and auditor at 15, Walbrook, London, E.C.

DIVIDENDS DUE.—Notice is given that a dividend of 2s. 2d. in the pound in the bankruptcy of Browning and Gardner, lately trading as electrical engineers, at Edinburgh, is payable on and after December 26th next, at the office of the liquidator, Mr. J. H. Buchanan, C.A., 8, York-place, Edinburgh.

BANKRUPTCY.—Mr. Registrar Linklater has approved a proposal by J. T. Todman, lately carrying on business as an electrician at 11, Queen Victoria-street, E.C., for the payment of 7s. 6d. in the £ on his debts. The creditors had previously agreed to the proposal.

Re J. C. HOWELL (LIMITED).—We have received the following :—

"The paragraph appearing in your edition of the 8th inst. has been brought to my notice. I beg to state that the liquidation has been brought about by the wish of the shareholders generally for the purpose of disposing of the business and assets of the Company. Under the liquidation the shareholders have consented to my disposing of the same to Mr. J. C. Howell as from the 1st inst., and negotiations are in progress for this purpose. The liabilities of the old Company will be discharged not by me but by the purchasers.—Yours faithfully, SIDNEY A. ISITT, Liquidator."

WINDING-UP PETITIONS.—A petition by a judgment creditor for the compulsory winding-up of the Mersey Rubber Company (Limited) was directed to stand over for six months by Mr. Justice Vaughan Williams on Wednesday last.

MESSRS. B. VERITY AND SONS.—Mr. H. R. Wood, recently in the employ of this firm, has been replaced in the position of London manager of the electrical accessory department by Mr. Russell, who was formerly second engineer at the Birmingham branch. The latter appointment is now filled by Mr. Allison, late of the P. and O. Steamship Company.

INCANDESCENT GAS BURNERS.—For some months past Charles-street, Cardiff, has been illuminated by incandescent gas burners, with the object of ascertaining if the lighting of side streets could be made by this system without increase in cost. Mr. Harpur, the borough engineer of Cardiff, has stated, in reply to inquiries, that the new burners are unequal to those formerly in use, and that the expenditure is precisely the same. There is no economy whatever, although the new burners are of the most improved type. Mr. Harpur does not think the burners at all suitable for street lighting, and a similar decision has been arrived at by the engineer of the Mile End Vestry. At Mile End it is stated that the mantle of the burners cannot stand the vibration of the street traffic or high winds.

INCREASE IN PRICES.—The advance in the price of Para rubber and in copper has led to a decision on the part of the leading manufacturers of electric cables and wires to revise the prices for these commodities. We mentioned in our last issue that the Telegraph Manufacturing Company had issued a circular to this effect to its customers, and similar circulars are now before us from the W. T. Henley's Telegraph Works Company, W. T. Glover and Co., and Messrs. Johnson and Phillips; and we understand that similar steps have been taken by the India Rubber Company, and that Messrs. Siemens Bros. and Co. have also put up prices to meet the increased cost of raw materials. An additional reason for this step is the fact that the leading manufacturers are full of orders, and are therefore all the less inclined to execute further contracts at the recent low figures, which, we understand, left but a small margin of profit. It has long been a complaint that acute competition has led to such a cutting of prices, especially in the heavy engineering departments, that the margin of profit in many important contracts has been all but *nil*. This is obviously a state of things that cannot continue indefinitely. If manufacturers cannot lower cost of manufacture they must try and raise prices.

AGENCY.—Messrs. Julius Harvey and Co., of Mansion House-chambers, London, E.C., have been appointed by Messrs. Musgrave Bros., hydraulic and general engineers, Leeds, as their representatives for London and district for the home and foreign trade.

DISCLAIMER.—In reference to the prospectus issued by the British Electrical Manufacturing and Engineering Company (Limited), reference to which has been made in our two latest issues, we have received from Messrs. Laing, Wharton and Down the following :—

"TO THE EDITOR OF THE ELECTRICIAN.

"SIR: Notices have appeared in your paper and elsewhere of a company styled the 'British Electrical Manufacturing and Engineering Company, Limited,' in the prospectus of which our name appears very prominently. As this prospectus has been framed and issued to the public without our knowledge or consent, we shall be obliged if you will allow us space to explain the circumstances, as far as we know them, and to correct an inaccuracy which is important to us, and may be misleading to the public.

"Finding that, for our own work exclusively, we could not advantageously run our brass finishing works, and as it is not part of the business of electrical engineers to conduct works of this kind for the *sale* of brass-work, we determined to dispose of the machinery and stock in this department. Accordingly, we had agreed to sell them to the gentleman who appears as the vendor to the 'British Electrical Manufacturing and Engineering Company (Limited).'

"We were expressly assured that no prospectus of any kind would be publicly issued, and as we feel that in the one which has come out, contrary to this assurance, much has been made of a concern which, so far as our share in it goes, is of very slender proportions, and our name is used, appearing so that the public would naturally think we had authorised what is said, we wish to disclaim all responsibility for the announcement.

"It is not true that we have undertaken to give the new Company all our work. The fact is that we have engaged to give them our orders for similar goods to those which we have heretofore ourselves made at our works, provided that they can do them as well as to workmanship, price and conditions as we can get them elsewhere.

"There is beyond these orders no goodwill in the department, and the expression that the Company has acquired the goodwill of our manufacturing department is very misleading.—Yours faithfully,

"LAING, WHARTON AND DOWN."

CATALOGUE.—We have had occasion to notice within the past few months a number of well-devised Electrical Trade Catalogues, and one certainly deserving of favourable mention is that just issued by the International Electric Company, of 55, Red Cross-street, Barbican, E.C. Comprising 200 large quarto pages, illustrated from first to last, and clearly printed, the book contains a mass of information concerning a large variety of electrical apparatus and accessories manufactured by Messrs. Mix and Genest (Limited), of Berlin, who are represented in this country by the International Electric Company. The various articles described and illustrated,

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and concerning which full information is given, are too numerous to be specifically mentioned, but the trade can obtain copies of the book on application to the Company. The Catalogue bears evidence of being printed in Germany, but all the same it is very well printed, and is free from many of the errors so frequently associated with work done out of the country. By the way, no indication is given of its German origin. Altogether the book contains about 900 illustrations, and includes 66 diagrams for bell and telephone installation work. A copious index facilitates reference.

ASHTON-ON-MERSEY.—At the last meeting of the District Council it was decided to support the Altrincham Electric Supply Company's application to the Board of Trade for a Provisional Order.

BANGOR (Co. DOWN).—The Town Commissioners have decided to apply for a Provisional Order.

BARTON REGIS.—At the last meeting of the Board of Guardians a letter was read from the Stapleton District Council inquiring if, in the event of electricity works being established by the Council, they would consider the question of lighting the workhouse electrically. It was decided to reply that the Guardians could not at present incur such expenditure.

BROMLEY.—At the last meeting of the District Council a communication was received from the Board of Trade inquiring what steps had been taken to comply with the conditions of their Provisional Electric Lighting Order.

BURY ST. EDMUNDS.—At the meeting of the Town Council on Tuesday last the Electric Light Committee were empowered to engage an electrical expert to prepare a report on the electric lighting question, at a cost not exceeding 50 guineas.

BUXTON.—At the last meeting of the District Council Mr. Cooper referred to the fact that the Council's Provisional Electric Lighting Order would expire in June next, and urged the members to take the electric lighting question into serious consideration. It was decided to call the Electric Lighting Committee together with a view to taking some concerted action in the matter.

CHELSEA (LONDON, S.W.).—At the last meeting of the Board of Guardians a letter was received from the Chelsea Electricity Supply Company, stating that their sliding scale for electric current supplied to the workhouse premises would be 5d. per unit, 1d. less than the usual rate, and a further reduction when warranted by increased consumption. It was stated that specifications were being prepared for the wiring of the new workhouse buildings in Sydney-street for the electric light.

CHURCH LIGHTING.—The Dean and Chapter of Ripon Cathedral intend to make some experiments in electric lighting, and accordingly Messrs. G. Harrison and Co. have been instructed to put in a small installation for lighting the choir. The contractors have decided to use Brockie-Pell arcs.

COMMERCIAL EDUCATION.—A conference of the leading teaching and examining bodies of the kingdom and of representative county councils which are in a position, under the County Councils' Act, to contribute funds for the purpose of technical instruction, was held under the auspices of the London Chamber of Commerce, at Drapers' Hall, London, E.C., on Tuesday afternoon, under the presidency of Sir A. K. Rollitt, D.C.L., M.P. The teaching bodies represented and the delegates present at the meeting included most of the best known scholastic establishments and masters, and the Commercial Education Committee of the London Chamber of Commerce was represented by, amongst others, the following: Sir A. K. Rollitt, Sir Philip Magnus, Mr. A. T. Pollard (Head Master, City of London School), Dr. Scott (Head Master, Parmiter's School), &c. A resolution was agreed to approving the principle of the co-ordination and simplification of the present system of examinations in commercial subjects, and the matter was referred to the Committee to consider details and formulate a scheme to carry this resolution into effect.

COVENTRY.—Electric current was available for the first time on Saturday last for private lighting in most of the principal thoroughfares of this town. The proposed formal opening ceremony has been abandoned.

DERBY.—The Town Council intend to apply to the Local Government Board for sanction to borrow £4,146. 3s. 11d. The sum is required for extras, &c., in connection with their electric light works.

DOVER.—At Monday's sitting of the Town Council it was decided to apply to the Board of Trade for the necessary powers to enable the Council to construct electric tramways throughout the borough.

DUNDEE.—At the meeting of the Guildry last week the representatives of the Harbour Trustees presented their report of the work done during the past year. After the reading of the report, Mr. R. Taylor suggested that an electric tramway should be put down along their harbour for the use of workmen and merchants going and returning from Broughty Ferry. If the electrical area were extended towards the gas works it would be for the Trustees to consider the laying down of an electric tramway, as electricity would undoubtedly prove the best motive power for the purpose. Mr. A. Leitch said they would be glad to see the Gas Committee of the Corporation extending the electric lighting area so as to embrace the harbour. Many harbours were now being lighted electrically, and their own Harbour Trustees were considering at the present time whether they should light the buoys in the river by that means. If they decided to do so, they would probably put down generating plant of their own, and this would not be in the interest of the community; he would much prefer to see the Corporation's electric lighting area extended and the trustees obtain their current, both for lighting and power purposes, from the Corporation. Mr. Brownlee pointed out that if the trustees desired to be connected up to the electric lighting area that could be done at once. With regard to the tramway there was no doubt that the want of easy access to the east end of the harbour works was badly felt. He was, however, not quite sure that the electric tramway was the best means by which this want could be met, as it would necessitate the erection of a supply station capable of producing a much higher voltage than that required to light the city.

ECCLES.—The Town Council at their meeting on Monday last referred the matter of proceeding with their electric lighting scheme to the newly-constituted Electric Lighting Committee.

EDINBURGH.—At the last meeting of City Council, the Electric Lighting Committee reported that the demand for electric current had been so great that their present generating plant was already taxed to its utmost capacity. They were at present supplying current to an equivalent of 38,000 8-c.p. lamps connected, and they had several customers waiting to be connected up. The capacity of their present plant was an equivalent of 40,000 8-c.p. lamps, and they therefore recommended that another engine and dynamo be added to the plant. The report was agreed to without discussion.

GLOUCESTER.—At a special meeting of the City Council on Tuesday last it was decided to apply for a Provisional Order.

GREAT YARMOUTH.—The electric light is making very satisfactory progress in this town. At the last meeting of the Council the Electric Lighting Committee reported that there was a net profit for the month of October of about £20, and that there were additional applications for 302 16 c.p. lamps, which would bring the number of lamps up to 5,780. It was also decided to put in additional plant at the generating station, and the question of extending the mains to Southtown and Gorleston was deferred for the present.

HARWICH.—The Town and Village Electric Light and Power Company have agreed to take over the Harwich Provisional Order.

HORSELESS CARRIAGES.—At the last meeting of the Staffordshire County Council an interesting discussion arose on the extent of the Council's bye-laws, and the meaning of certain terms. The definition of the term "vehicle" is set forth as "any carriage, cart, waggon, dray, or vehicle of any description drawn or propelled by animal or steam or electric power, but does not mean or include any bicycle, tricycle, velocipede, or other similar machine." After some discussion, it was decided to add the words "unless driven by steam, electrical, or other mechanical power."

HUDDERSFIELD.—At the last meeting of the Town Council it was reported that electric current was at present being supplied to an equivalent of 18,500 c.p. lamps, and that good progress was being made with the work of extending the mains to Lindley, where several large customers were impatiently awaiting the advent of the electric light. It was also stated that for some time past the Electric Lighting Committee had been endeavouring to create a demand for current for motive power, cooking and heating purposes, and thus obtain a day load for their machinery. Although the Committee have already obtained a certain measure of success in this department of their undertaking, in order to further encourage the use of electric current the Committee recently reduced the price of current during the daytime to 2½d. per unit, and for the convenience of those desirous of trying electrical appliances arrangements were made for hiring them on very reasonable terms. It is stated that the cost of generating current has been reduced in a most satisfactory manner, owing to the increased demand and to economies effected.

INSTITUTION OF CIVIL ENGINEERS.—The members of this Institution attended the opening meeting on Tuesday at their new premises which has been built from the designs of Mr. Charles Barry. In addition to the old block in Great George-street, Westminster, S.W., occupied by the Institution, the next-door premises have been included, which gives greatly increased room and accommodation. The contract for the buildings was given to Messrs. Mowlem and Co., Westminster, for the sum of £41,000.

IPSWICH.—At a recent meeting of the Paving and Lighting Committee a representative from the County of London and Brush Provincial Company attended for the purpose of ascertaining whether the Council would oppose the Company's proposed application for a Provisional Order, and if any arrangement could be

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come to with the Council in the matter. After some conversation it was decided that the Company should submit particulars of their proposed scheme as soon as possible. It will be remembered that the Town Council recently decided not to apply for a Provisional Order.

KETTERING.—A special meeting of the Town Council was held yesterday (Thursday) for the purpose of discussing the Lighting Committee's report on the electric light question.

LAMBETH (LONDON, S.E.).—The local journals of this district are gradually coming round to the view that the Vestry would be well advised in carrying out an electric lighting scheme for the district, which is one of the largest in the metropolis.

LECTURES.—The subject of "Horseless Vehicles" has now entered the lecture stage. Mr. G. C. Marks on Wednesday delivered a lecture at the opening meeting of the Birmingham Municipal School Engineering Society on this subject, before a crowded audience. Mr. Marks, by the aid of an excellent series of lantern slides, described many attempts at the invention of a successful horseless vehicle worked by electricity, steam, oil, manual, or pedal power, from the time of the Frenchman, Nicholas Joséph Cugnot, in 1729, down to the present time. Mr. Marks strongly advocated a change in the law as to the classification of bicycles and tricycles driven by electricity or other motive power, and the Chairman, Councillor Martineau, announced his intention of bringing the matter prominently before the Birmingham Corporation.——At Newcastle on Monday the Hon. C. A. Parsons delivered a lecture to the students of the Durham College of Science "On the Application of Electricity to the Transmission and Storage of Power," "Production of Light," "The Melting of Refractory Substances," &c.——Mr. W. B. Sayers delivered an interesting lecture on "Electro-Magnetic Motion" in the U. P. Hall, Bearsden, Glasgow, on Monday last.

LIMERICK.—At the meeting of the Town Council last week it was decided to appoint a committee to consider the various details in connection with the introduction of the electric light, and report to the Corporation on the replies to be sent to the queries from the Board of Trade. The Committee were also empowered to expend £50 in obtaining the opinion of an electrical expert.

LIVERPOOL.—The Markets Committee of the City Council are to consider the question of lighting the market electrically. At the last meeting of the Council, Ald. Walker, the new chairman of the Committee said he thought they should make the first experiment in St. John's Market. At present they had to clean this market once every three years at a cost of nearly £800, and if the electric light were installed it would require cleaning only once in six years.

LONDON COUNTY COUNCIL.—At the meeting on Tuesday the Finance Committee reported the completion of the loan of £5,150 to the Islington Vestry for the purchase of land for electric lighting station. The Fire Brigade Committee reported that the chief officer had asked that the system of telephonic apparatus at the chief office might be made uniform with that at the superintendent's offices. The Post Office had intimated that the charge for making the necessary alterations and providing and maintaining the necessary new switching apparatus was estimated at £67. 10s. per annum, subject to the same stipulations as were agreed to when similar apparatus was fitted at the superintendent's station. Annual charges of £9 would cease, and the net annual charge, therefore, would be £58. 10s. They recommended that the necessary expenditure be authorised, and this was agreed to. Mr. Emden has given notice of the following motion:—"That it be referred to the Highways Committee to consider and report without delay on the expediency of the Council applying to Parliament for power for the Council and the local authorities to construct subways under the streets of London for the reception of tubes and wires of the gas, water, electric and other companies, and to charge rents for the same."

LOWESTOFT.—At the last meeting of the Town Council a letter was read from Mr. T. W. Baker relative to obtaining a Provisional Electric Lighting Order, and it was decided to reply that the Council did not at present intend to apply for an Order.

MANCHESTER.—The City Council on Wednesday last authorised the promotion of a local Bill in the next Session of Parliament for various objects, amongst which is the acquisition of the undertaking of the local Tramways Company. In the Bill the Council reserve the right to adopt an electrical or other mechanical system of traction.

MILL LIGHTING.—Some time ago a portion of the Manningham mills was lighted electrically, and the installation has proved so satisfactory that the proprietors (Messrs. Lister and Co.) recently decided to make considerable extensions. Since 1889 about 2,000 16 c.p. incandescents and 40 arcs of 1,000 c.p. each have been employed, but this number will now be augmented by 2,700 16 c.p. lamps. It is stated that when the extensions are completed this will be one of the largest private lighting plants in the kingdom, consisting of an equivalent of about 8,000 16 c.p. lights. The whole of the work has been carried out by Messrs. T. Preece and Co., of Bradford.

NESTON (CHESHIRE).—A report by Mr. T. H. Marsh, electrical engineer, on the question of the advisability of lighting this district electrically was recently presented to the Lighting Committee of the District Council. Complaints have for some time past been made as to the high price and deficiency in illuminating power of the gas supplied by the local Company. Mr. Marsh reports that, after careful consideration, the general conditions are favourable to the establishment of remunerative electricity works, and he recommends the Council to adopt a high-tension alternating-current system. The initial expenditure is estimated at £6,000, the working expenses at £463. 6s. 8d., and the sinking fund and interest at £360 per annum, while the probable income is estimated at £1,551. 5s. This report was discussed at a meeting of ratepayers on Wednesday last.

NEWCASTLE-ON-TYNE.—At a special meeting of the City Council on Saturday the formal resolution in favour of the promotion of their Tramway and Improvement Bill in the next session of Parliament was passed. It will be recollected that the Council recently decided to obtain powers to work the tramways (except the Westgate-road, Arthur's Hill, Elswick-road, Scotswood-road and Byker sections) by electricity or other motive power.

NEWPORT (MON.).—Some time ago the Town Council hired some spare electrical plant from Messrs. John Fowler and Co. (Leeds), with the option of purchase within three months. At the last meeting of the Council the Parliamentary and Improvement Committee recommended that the spare plant be purchased for the sum of £1,000, this amount to include a sum which had accrued in respect of hire, subject to the sanction of the Local Government Board being obtained thereto. The recommendation was adopted.

PAISLEY.—The Town Council intend to light the Town Hall and Museum electrically. Dr. J. T. Bottomley has been appointed consulting engineer for the work at a fee of 100 guineas.

PLYMOUTH.—At the last meeting of the Town Council it was decided to form an Electric Lighting Committee. The electric lighting question has hitherto been in the hands of a small sub-committee.

PEMBROKE (DUBLIN).—At their meeting on Tuesday last the Town Commissioners decided to apply for a Provisional Order.

PROVISIONAL ORDERS.—The Corporations of Bath, Godalming, Middleton and Wells give the usual notice of their intention to apply to the Board of Trade on or before December 21st next for Provisional Orders under the Electric Lighting Acts 1882 and 1888.

RADCLIFFE (LANCS.).—At the meeting of the District Council on Tuesday it was decided to form a special Electric Lighting Committee to carry out the provisions of the Radcliffe Provisional Order.

ROTHERHAM.—The Town Council have appointed a Committee to consider and report upon the questions of lighting the town electrically and of constructing electric tramways.

RUNCORN.—At the last meeting of the District Council the Electric Lighting Committee recommended that application be made to the Board of Trade for a Provisional Order. The Rev. Dr. Gastaldi, in moving the adoption of the minutes, said they had ascertained that an electric light installation, capable of supplying current to an equivalent of 2,000 8 c.p. lamps, would cost about £11,000. The interest and the sinking fund would amount to about £750 per annum, but they would still save £200 a year if they adopted electric lighting. After considerable discussion an amendment that the application for a Provisional Order should be deferred until the Committee showed that there was a probability of the powers being taken advantage of was carried.

SALE.—At the last meeting of the District Council it was resolved to apply to the Board of Trade for a Provisional Electric Lighting Order, and to oppose the application of the Altrincham Electric Supply Company (Limited).

SANDWICH.—Negotiations are in progress for the construction of nearly two miles of tramways in this town.

SHEFFIELD.—At the annual meeting of the School of Art on Monday last the report stated that the Council had carefully considered the respective merits of incandescent gas lighting and electric lighting, more particularly in regard to the best means of avoiding the excessive heat and vitiated air produced by the present gas supply when classes were in full work, and ultimately it was decided to adopt the electric light, as this was considered to be the best and most efficient mode of illumination. The installation was carried out during the summer vacation at a cost of £200.

SOFIA (BULGARIA).—An electricity generating station is to be erected next year in this town for supplying current for lighting and traction purposes. It is proposed to utilise water power in connection with the scheme.

SPAIN.—Tenders have recently been invited for the establishment of a central station in the town of Piloña (Orense). A company is in course of formation at Tarrasa to establish and operate a central station in the town. An electric lighthouse is approach-

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ing completion at Cabo Villano (Galicia). The little town of Llanes is now lighted by electricity.

STAPLETON.—The District Council has instructed the Electric Lighting Committee to visit Taunton and Bath electricity stations, with a view of obtaining information to assist the Council in its proposed adoption of an electric lighting scheme for Stapleton.

ST. MARNOCH'S (DUBLIN).—The contract for the electric lighting and pumping plant for St. Marnoch's, co. Dublin, to the specification of Mr. Morgan Williams, C.E., has been placed with Messrs. Edmundson (Limited), of Dublin. Motive power will be derived from oil engines.

SUICIDE.—A sad tragedy was enacted at Ealing on Tuesday, when Mr. G. E. Hartmans, aged 28, an electrical engineer, committed suicide while suffering from delirium produced by typhoid fever. Mr. Hartmans was in charge of a nurse, but broke away from her control and secured the revolver with which the fatal act was accomplished. Mr. Hartmans had recently been studying heavily to pass his examination for a captaincy in the Essex Rifle Volunteers, in which he held a lieutenant's commission.

SWANSEA.—The electric lighting scheme prepared by and presented to the Swansea Corporation by Mr. E. Manville having been adversely criticised by an anonymous correspondent of the *South Wales Daily Post*, Mr. Manville, in the issue of the 8th inst., in a lengthy letter to the editor of that journal, replies fully to the adverse criticism of the anonymous correspondent, who is described as "one of the foremost electrical experts in the Kingdom."

TAUNTON.—At the meeting of the Town Council on Tuesday the electrical engineer stated that the demand for electric current was steadily increasing. They had connected an additional 140 16 c.p. lamps during the quarter, and the maximum load on the private lighting circuits was about 20 per cent. greater than it was in the corresponding quarter last year.

TORQUAY.—At the meeting of the Town Council on Tuesday last the Electric Lighting Committee's report, which recommended that steps be taken to establish electricity works in Torquay, and that application be made to the Local Government Board for sanction to borrow £18,000 for the purpose, was discussed. Mr. Kerswill strongly advised the Council to adopt the report, and stated that their consulting engineer, Mr. W. H. Trentham, had slightly modified the details of his suggested scheme. The probable income was now put at £3,600, while the annual expenses and interest were estimated to amount to £2,292, leaving an estimated net profit of £928. A long discussion ensued, and it was finally decided to refer the matter to a Committee of the whole Council.

TRALEE (IRELAND).—The Town Commissioners are considering the question of lighting the town electrically.

TRAIN LIGHTING.—A recent issue of the *Hawke's Bay Courier* contains an account of a trial trip of an express train on the Manawatu Railway. It appears that the railway company have decided to light their express trains by electricity, and a trial run was made to Porirua, about 14 miles from Wellington. Several carriages were lighted, power being obtained from a dynamo placed under the floor of a luggage van, and worked by a belt from the wheel of the car, which also contained a battery of accumulators. After a portion of the journey had been made the kerosene lamps were extinguished and the electric light switched on. The improvement in the light was, of course, at once apparent, and it is stated, so successful was the experiment, that all the principal express trains on the line will in future be lighted electrically. Mr. Turnbull, electrical engineer, had charge of the experimental installation. ——Electrically-lighted cars are no novelty on the London, Brighton and South Coast Railway, and the pullman service of trains, which the Company recently established between Victoria and Brighton, is also fitted up for the electric light.

TYNESIDE.—It is stated that orders recently received for electrical plant and apparatus by electrical engineers and contractors having works premises on the Tyne have been very numerous of late, especially for ship lighting for the new Government cruisers and for vessels ordered by foreign governments and shipping companies.

WEYBRIDGE.—The District Council have appointed a committee to confer with the Weybridge Electric Light Company as to the transfer of their Provisional Order to the Council.

WOKING.—Another meeting of ratepayers in the St. John's Ward was held last week for the purpose of discussing the lighting question, and a resolution in favour of the introduction of the electric light was ultimately passed.

YORK.—At the last meeting of the City Council, the Streets and Buildings Committee reported that Mr. W. H. Preece, C.B., who had been invited to prepare and submit a report on the best system of electric lighting for the city, had written stating that in consequence of the terms of his appointment as chief engineer to the Post Office he was unable to undertake the work. It was therefore resolved to approach Prof. A. B. W. Kennedy on the subject.

COMPANIES' MEETINGS AND REPORTS.

Western and Brazilian Telegraph Company (Limited).

The thirtieth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, E.C., yesterday (Thursday), under the presidency of Mr. W. S. Andrews.

The SECRETARY (Mr. R. M. Cunningham) read the notice calling the meeting and the minutes of the last meeting, which were confirmed as correct, and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I have now to tell you that the result of the half-year's working, on the revenue account to June last, has not been unsatisfactory. Our total take amounted to £84,936, against £77,603 for the corresponding period of the previous year, which reveals an increase of £7,333. Exchange during the half-year averaged 9⅝, against 9½ in the corresponding period of 1894—a very small difference, and one which practically does not affect the figures. There was a slight increase in the number of the words transmitted, although not so large as we have been accustomed to of late, both as respects the internal traffic and the international traffic. The internal traffic increase was larger than the international. The revenue we derive from the new lines to the West Coast, the Pacific and European Company, continued to develop satisfactorily, and, as a fact, they have given us the larger part of this increase; and the receipts from this source, I am pleased to say, affecting the Platino Company and the Company—for we get back from the Platino Company in dividends pretty much what they receive as dividend—promises to continue a very satisfactory rate of progress. If you remember, we estimated that we should receive £5,000 from that source for nine months and a few days to December, 1894. We at the same time rather led you to anticipate that the amount might be increased, and it is satisfactory to state that it was increased, and that the traffic continued to progress. Now, looking at the fact that we had reductions during the half-year under review, the net outcome, I think, is rather encouraging than otherwise; in fact, the point which has been brought before you so often—namely, that of the exchange—really continues to rule the question. If we had a satisfactory exchange we should have little to complain of, and should be a fairly prosperous concern. I hope we may one day be so. With regard to the expenses, they amounted for the half-year to £37,891, against £37,953. There is a small reduction there of £61. Under Abstract A there are seven items showing increases and six exhibiting decreases, and those items are composed of figures affecting very different subjects. The largest item is that of £493 for staff abroad—namely, increased staff and promotions under old agreements of members of the staff who have been with us for a considerable number of years. Together the effect of those features is an increase of £493. As to Abstract A, a still further decrease is shown under the heading of shipping of £581, which is satisfactory. Under Abstract C—the expenses in London—there is a slight increase of £113, and there again this is composed of some ten items, increases and decreases, and the whole thing is so small that it is not worth troubling you with. The upshot of all that is that we carry down £47,045, which, with £2,846 brought over from the previous half-year, leaves us with £49,891. From this has to be deducted £11,223 for debenture interest, and we have placed £5,000 to reserve and £7,876 to debenture redemption. The debenture redemption fund, I may say, has been allowed to run down somewhat, and we have therefore had to make it up. We have also had to pay £1,729 for income tax. Deducting these amounts we are left with £24,061, which now has to be dealt with by the shareholders. This sum enables us to recommend a dividend of 3s. 9d. per share on the Ordinary shares of the Company, or at the rate of 2½ per cent. per annum, against 3s. per share and 2 per cent. per annum for the corresponding period of 1894, and we carry forward £5,803 for the benefit of the current half-year. I should have liked the result to be better, but still, on the whole, it is not so bad. I have now disposed of the question of revenue and expenditure. There will be curiosity in the minds of some of you, naturally, to know the position of the purchase question. Well, that remains pretty much what it was; in fact, the authority which the Government have secured for the purchase of our lines, if not exercised, would have expired in the ordinary course of events this year. The Government, however, who seem to be willing buyers, have applied to the Legislative Assembly for a prolongation of their power to purchase. The Legislative Assembly has approved of the Bill to that effect, and that will, I imagine, be speedily passed by the Senate in the ordinary course of things, so that the Government will continue the power to purchase which it has not up to the present time—I presume on account of financial and political considerations—found it expedient to exercise. Meanwhile, things have not been standing still. A new company has been formed to connect the important ports along the great Amazon river by a submarine cable with the systems of the Government and of this Company at Para. We speak of laying a cable in the River Amazon, but the river more resembles an inland sea than a river, for it varies in width between five miles and 10 miles, although it is generally the larger figure; and during the flood season the river is pretty quiet because the country around lies very low and is very flat, and the water disperses itself all over it. You then have a river, if you can call it so, about 30 miles wide. I am pleased to say that this line of communication is being rapidly completed, as we have been informed by the contractors, and all the apparatus and necessary preparations are being pushed forward vigorously. When this work is completed, which is expected to be accomplished in the early spring, it will, we hope, prove a valuable feeder to this Company. The Government and the mercantile classes of Brazil have for a very long time been desirous of seeing this work completed, and we are informed that the local authorities—the Governors and so on—have rendered every

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assistance they could in furthering the operations of the gentlemen who went out to supervise the laying of the line and the establishment of the stations. I now have to approach a subject which I should have preferred to leave untouched, only that I am anxious that no incorrect impression should find a lodgement in the minds of the shareholders. No doubt, the shareholders have seen the speech which was made by the Chairman of the Brazilian Submarine Telegraph Company at the annual general meeting of that Company, and the discussions in the newspapers in reference to the laying of a submarine cable from St. Vincent, *via* Ascension, and the island—the very much disputed island—of Trinidad to the River Plate. Well now, gentlemen, as I believe many of you are aware, the Brazilian Submarine Company have no lot or part in laying such a cable during the existence of the Western and Brazilian Company, because it would be contrary to subsisting agreements, and because also it would be contrary to the interests of this Company, which would therefore insist on subsisting agreements being carried out. Under this agreement, which is at the present time rather an ancient document, the purchase of the Western and Brazilian Company's lines by the Government of Brazil is foreseen, and, more than that, it is provided for. If the purchase were carried out the agreement, under its own provisions, would, *ipso facto*, cease and determine, and the Brazilian Submarine Company then, of course, as far as this agreement goes, would be free to do as they thought fit. At present, however, we say they are not free to do as they think fit, if such action is contrary to the agreements with this Company. But looking at the provisions of this agreement the notice of the Government to purchase the Western lines was at the least not an improbable eventuality, and I do not think it is too much to say that this question must have entered into the calculations of the Brazilian Submarine Company. Where, therefore, there was such a probable contingency as this being taken into consideration, need there be any surprise or excitement? It is a sort of thing we were all of us led to expect might happen—both we and the Brazilian Submarine Company. The Government of a great country like Brazil, with such an immeasurable future, would, there is no reasonable doubt whatever, in the interests of its own trade and commerce, treat the Brazilian Submarine Company, and all interests concerned, with perfect impartiality, and would doubtless only be guided by two considerations—the justice of the case and the advantage of its own mercantile public. Now, whatever may be said, there is no doubt that the efficiency and the good service of the Brazilian Submarine Company are indisputable, and that from this important point of view the Company would be always capable of holding its own. The Brazilian Submarine Company appear to have thought that the Western Company has not acted in a friendly spirit towards it out in Brazil—I suppose on account of the purchase, which all of us expected. Our instructions have been the direct opposite to anything of the sort. We have always endeavoured, under all circumstances, while protecting the rights of our Company, to maintain the most friendly relations between the two Companies, and we continue, and we shall continue, to act in this direction. It goes without saying that our interests—I mean those of the two Companies—are so far identical that any other policy would be fatuous. I cannot imagine anyone supposing that we could be capable of any other policy—it would be cutting our own throats. We must naturally go on acting and working as if we were a continuing Company; that appears to us the only businesslike course. We think the Companies—not restricting myself to one Company—may look forward with confidence to the conclusion that, whether the Western lines be purchased or not, we are bound to take both alternatives into our consideration provided we do our best to serve the interests and earn the approval of the Brazilian Government and mercantile public by prudent and conciliatory action; we shall be treated accordingly, and may both participate in the great future reserved for that immense territory, which is now, I may say, by the enterprise and far-reaching prevision of its Government, linking up its distant Amazonian possessions through Para with the general network of the telegraphic intercourse of the world. This and other measures of development should have the happiest influence upon the rapidly increasing progress of the country, for population, as a rule, follows in the wake of enterprise. That concludes my observations with respect to this important matter. I may add that with respect to the Company's ships, I have an announcement to make which is rather agreeable—that negotiations are going on with reference to the purchase of one of these ships—subject, of course, to survey, and we have every reason to believe that those negotiations will result in our being enabled to strike off one of these ships from our accounts. I now beg to propose—

"*That the report and accounts to June 30, 1895, now submitted, be and the same are hereby approved and adopted, and that a dividend for the half-year, free of income tax, at the rate of 2½ per cent. per annum, be, and is hereby declared, payable on the 15th inst.*"

Lord RICHARD H. BROWNE seconded the motion.

Mr. DYETT called attention to the following passage in the report:—"The Directors have to notify that the conversion of ordinary shares into Preferred Ordinary and Deferred Ordinary shares will be suspended on and after January 1, 1896, until further notice." He wished to know whether the Chairman could give them an idea whether this would affect them in any way. He afterwards called attention to the stationery account—£68 in Abstract C, and £979 in Abstract A, or over £1,000 for the half-year, and therefore, he said, over £2,000 a year. He thought that that was too much. He also referred to the unclaimed dividends.

The CHAIRMAN, in reply, said: With respect to the shares, Preferred and Deferred, which the honourable proprietor asks a question upon, the reason the conversion is temporarily in abeyance is the difference that would appear if the conversion went on and the dividends were not fully paid. Some shares would be transferred with a certain amount of arrears on them and others with other amounts of arrears. It was in order to avoid the confusion of these accounts when that might arise that it was decided to suspend the conversion, but it does not affect the status of the shareholders.

Mr. FRY said he must protest against the Chairman's statement in this matter. The answer was always the same, but they had always paid their preferred interest.

The CHAIRMAN: This measure was adopted at the suggestion of the Stock Exchange, so I think you will admit that, on the whole, it comes backed up with considerable authority. We do not want it—it makes not the slightest difference to us. The honourable proprietor also asks certain questions with respect to the stationery, and he would very naturally double the half-year's expenditure on that account, but if you take the December half-year and compare it with this half-year, you will find the amount is not doubled. This half-year the expenditure is a little under £1,000, while last half-year it was only £420. With respect, however, to the stationery, as with respect to other things, there is, of course, consumption going on at all our stations. You cannot deal with hundreds and thousands of messages and all kinds of documents which must be used in connection with the work without spending money on stationery. The honourable proprietor is right in drawing attention to it in this way, but he may think that we are not as careful of the expenditure as we might be. However, I do not think there is much expenditure in this Company without its being very carefully looked after. As to the question of unclaimed dividends, we should be delighted if everyone would come and claim the dividends to which they are entitled, but, owing to trusteeships and other causes, these things are allowed by the shareholders to accumulate.

Mr. DYETT thought that some information should be given to those to whom the dividends belonged.

The CHAIRMAN dissented from this view.

The MANAGING DIRECTOR (Major Wood): Many of these people are dead.

Mr. W. GRIFFITH said that the previous shareholder had stated a most interesting point with respect to unpaid dividends. He feared that the item was owing in several cases to old age of the shareholders to whom the money belonged. He had had two or three instances where, in consequence of old age, people got out of business habits, and lived in straitened circumstances although they were possessed of riches. He had had to go to the Bank of England on one or two occasions on this account. He might also state that they would in time probably find the Chancellor of the Exchequer come upon them for these unclaimed dividends—property which the Company had a perfect right to appropriate if no claim was made for it. He had in the case of one or two companies proposed the insertion of a clause in the Articles of Association to the effect that after the lapse of a long period of time, the unclaimed dividends should belong to the Company. Of course, the Company would never think of retaining them when anyone rightfully appeared to claim them, but if no one claimed them the Company would have the benefit of them instead of the Crown. He considered this was a legal point worth consideration, and it was perfectly possible to carry out his suggestion by a small alteration in the Articles of Association. He thought they were indebted to the Chairman for the calm and statesmanlike way in which he had presented to the meeting the condition of their affairs at the present moment. They were an ordinary trading Company, but at this particular moment they were entering into the paths of statesmanship and politics, and it therefore required that their affairs should be under good guidance. He had been in hopes that before this time the Brazilian Government, which had raised expectations and hopes rather of a golden future for them, would have carried out their plans of politics and statesmanship, and have done what would have been not only a just thing towards the Company, but an advantageous thing towards the Brazilian public at large. However, they seemed to be dilatory, and the expected purchase of the Company's property had not yet taken place. On the other hand, they still remained an ordinary trading Company, and it was incumbent on them to be very careful how they carried on their ordinary business. The better their business and the more substantial the character of their concern, the more likely a foreign Government would be to acquire it. He afterwards referred to the balance sheet, and said that looking at the immense character of their undertaking and the fact that their reserve fund was under £30,000, they hardly possessed the sinews of war necessary to enable them to carry on a contest with others. They also owed £40,000 to other companies for messages. He found from their Articles of Association that it rested with the auditors to declare the amount of the net profit. He thought it would have been safer to have carried a much larger sum to the reserve fund, even though the dividend would in that case have been smaller. He alluded to the recent legal decision respecting the liability of auditors, and expressed a doubt whether a firm could be held liable, although an individual might be; and he proceeded to argue in favour of there being two auditors instead of one firm. He would propose at the next meeting that there should be two auditors instead of one.

A SHAREHOLDER: Whom would you suggest should be appointed?

Mr. GRIFFITH said he would be happy to act himself as the second auditor. He took a great interest in the Company, in which he had a large stake, and with which he had been connected for many years. He thought they would all agree with him that they were indebted to the Directors for having piloted them through somewhat dangerous and difficult waters.

Mr. FRY observed that the Western and Brazilian Company were the largest shareholders in the Platino Company, and he desired to ask how the sum of £1,200 Directors' fees would be dealt with.

The CHAIRMAN: I have no hesitation in saying that, having been so long without any fees at all, having given them up for the benefit of the shareholders until the amount paid to the former Directors was liquidated, I shall, as far as I am concerned, require my fees in the future. With respect to altering the Articles of Association in connection with the unclaimed dividends, the hon. and learned gentleman (Mr. Griffith) is quite right in what he says, but we did, I believe, make an effort to get in a clause which would enable us to take possession by effluxion of time of this unclaimed money. The Stock Exchange, however, would not pass it.

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A SHAREHOLDER: They never will.

The CHAIRMAN: I suppose they never will. With respect to the reserve fund being only £30,000, it must be remembered that out of the reserves of the Company a second through line has been laid down all the way from Pernambuco to the Plate. There has been no addition whatever to the capital for that line, which has all been laid out of reserves; and therefore you have an enormous representation of earning plant for your capital. With regard to the creditors, in all these companies these things overlap. The hon. proprietor called attention to this £40,000 of debts. That is simply on message accounts, but had he looked on the other side, he would have seen £64,000 of bills receivable and not discounted, and some £19,000 odd of cash. You therefore see that the outcome of these figures, instead of being anything deplorable, is rather cheerful and encouraging, as it seems to me. We should have liked to carry more to reserve, but under the circumstances mentioned—the duplication of this cable and the payment of all these things out of revenue—we thought we were doing sufficient, and that the shareholders, who have allowed this policy to be carried out practically at their own expense, were entitled to some consideration. Therefore we made a little spring in the dividend, and as far as I am concerned I wish the improvement had been much greater. As regards our auditors, Messrs. Turquand, Youngs and Co. are a very first-class firm, and the whole subject of the auditors was very fully discussed at our last meeting. It was purely a shareholders' question, and it was felt by them—and decided by them entirely without us—that one auditor was sufficient, and, as far as my opinion is worth anything, I think they were right. If you have a first-class firm of accountants, what is the good of duplicating the work? We had that system before. With the firm of Messrs. Deloitte, Dever, Griffiths and Co., and the firm of Messrs. Turquand, Youngs and Co., it seemed a monstrous waste of time for both firms to go all through our figures one after another, just as if no one else had examined them. As a matter of fact, it was two audits instead of one. He then put the motion, and it was carried unanimously.

A vote of thanks to the Chairman and Directors brought the meeting to a close.

West India and Panama Telegraph Company (Limited).

The thirty-seventh ordinary general meeting of the members of this Company was held at Winchester House, Old Broad-street, London, on Wednesday, under the presidency of Mr. C. W. Earle.

The SECRETARY (Mr. R. T. Brown) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: Gentlemen, you have do doubt observed in the report the recurrence of a clause which has become monotonous with us, announcing a decrease in the traffic receipts for the half-year in comparison with those of the corresponding period of the previous year. This is the fourth consecutive report in which we have had to announce such a reduction. During the whole of the half-year every station has been in communication, and the service has been carried on without complaint on the part of anyone. Then it may occur to you to ask, What is this reduction going to lead to, and to what is it attributable? A little time ago I saw the report of a meeting of the Demerara Railway Company, at which the Chairman, a gentleman long connected with the West India trade, and well qualified to speak on the matter, attributed the decline of their traffics to the decline in the sugar trade; and, no doubt, the unfortunate position of the West Indies in the low price of sugar that has ruled for a good many years past has very much prejudiced our traffics as well as those of other undertakings. But in seeking to be quite certain of what is the real cause of the depreciation, I have taken some trouble to look into the traffic accounts, which we divide in this Company into two classes. One we call the international traffic—that is, messages coming on to or going off our lines to other places beyond our system; and the other is called the intercolonial traffic, which is only the messages passing between the different colonies served by us. Well, I find that whereas in the year 1885—ten years ago—our intercolonial traffic amounted to £15,722 for the year, it only amounted during the year 1894 to £8,644, very nearly a reduction of 50 per cent. I may point out at the same time that the international traffic was only about 9 per cent. less in 1894 than it was in 1885. It is quite fair to presume that if our traffics were only affected by the general decline of commercial prosperity in the West Indies, it would have affected both classes of traffic equally; but from these comparisons we see that it is the intercolonial traffic that has been so very much depreciated; and I am informed that the reason of this falling off in our intercolonial traffic is the great increase in the number of "tramp steamers" which ply now to the West Indies. In former days a great part of our intercolonial traffic arose from the messages that passed for finding and chartering ships—agreeing as to freights, and so on. Now, no doubt, the merchant who has a cargo to send away waits for the arrival of what they call "the tramp,' which comes in and plies for freight very much as you see cabs crawling about the streets of London plying for fares. I have no doubt that has caused the great falling off in our intercolonial traffic. As I used the word "monotonous" with respect to the general tone of our report on the traffic, I may mention that a few weeks ago I received a letter from an honourable proprietor in our Company criticising these reports and my speeches in that respect, and saying that really a stereotyped edition might be published, and that with alterations of dates and figures it might be used every half-year; and he wanted to know what we were doing to remedy this state of affairs. Although the letter was rather cynically expressed, I thought it was a fair question to put, and also that the criticism was fair. I therefore invited this gentleman, with whom I had had no previous acquaintance, to meet me at the office to show him what we had done to try and improve our traffics. I explained to him that we had sought all round the shores of the Caribbean Sea for sources where we might obtain traffic to feed our system. We sent our general superintendent down to various places. He interviewed the merchants and consuls in several ports, but although those gentlemen were delighted with the idea of having a telegraph cable laid to their places of business, yet they were honest enough to say that they did not think we should get much traffic. We then asked whether the Government would give us a guarantee or a subsidy, and they replied that the Government would be delighted to grant us a subsidy, but that whether they would pay us was another matter. With the chilling prospects we had from these investigations we thought it was better to leave the matter alone, and the honourable member expressed himself satisfied that we had done what we could. We do not, of course, mention all these negotiations in our report—it is not our business to do so; but still, we are not letting things sleep for the want of inquiry or the want of energy in trying to push the business. With respect to the accounts, there is, as usual, very little to say. The charges are almost on the same scale and lines that they have been for years. In Abstract A it appears that we have spent £12. 9s. less than in the corresponding period of the previous year, and that in Abstract B we have spent £200. 7s. 3d. less; while in Abstract C—which refers to the repairs and renewals of cables—the sum expended was £2,524. 14s. less than in the corresponding period of last year. The whole boils down to a total of £18,000, the amount to the credit of the revenue account, against £16,109, and so far the result may be considered fairly satisfactory. I shall be very happy to answer any question that any member wishes to put to me. I must, however, before concluding, express our regret at the resignation of the Right Hon. G. W. Balfour, M.P., which he was obliged to tender owing to his having accepted the important office of Chief Secretary to the Lord Lieutenant of Ireland. It was a great advantage to us to have with us a man of his power and grasp, and of his great knowledge of the views of Parliament and of Governments. We do not propose to fill up this vacancy from economical motives. It may throw a little more work on the remaining Directors, who are now very few, but still we think that the fees had better be saved, considering our position. I have now to move—

"*That the Directors' report and accounts to June 30, 1895, submitted to this meeting, be and the same are hereby received and adopted, and that, as recommended by the Board, dividends of 6s. per share on the First Preference shares, 6s. per share on the Second Preference shares, and 1s. 3d. per share on the Ordinary shares (the last free of income tax) be and the same are hereby declared.*"

Mr. WILLIAM ANDREWS seconded the motion.

A SHAREHOLDER inquired when the dividend would be paid?

The SECRETARY replied that the warrants would be sent off that day, and the dividends be paid on the following day.

Mr. W. GRIFFITH said he was sure they all regretted the loss which the Company had sustained by Mr. Balfour's resignation. He was glad to find that the Board were economically inclined, and that they did not intend—he would not say to fill up the vacancy at present, but to take the fees which might have accrued from Mr. Balfour's retirement. There was one other point he desired to draw attention to. In these days, when the position of an auditor was somewhat equivocal, when he was considered an officer of a company, and liable to actions in Court, people were becoming somewhat suspicious. The very fact that the judges had declared that Mr. Theobald was liable had caused the public to think that all audits were not what they ought to be. In the case of their Company, the standing of the firm of auditors employed by them was so great that that suspicion could not for a moment be entertained. He had the pleasure of knowing Messrs. Deloitte, Dever, Griffiths and Co., who were gentlemen of the highest repute, but at the same time he thought that the public ought to be considered. If the public found that they were restricting the audit, that they were only having one auditor instead of two, as the Articles of Association permitted, the public might suspect what certainly was incorrect—that there was a desire on the part of their Company to conceal things; but nevertheless he thought they ought to consult public opinion as far as possible by having a shareholder as an auditor, as well as the eminent firm of accountants in question.

The CHAIRMAN: I must say, Mr. Griffith, that I cannot agree with you. I do not think it would be for the advantage of the Company to appoint a second auditor, or that it would have any influence on the public if we did. Nothing can exceed the confidence which is felt in the firm of Messrs. Deloitte, Dever, Griffiths and Co.

Mr. GRIFFITH: I said so.

The CHAIRMAN: I have had experience of another company of the same nature as this, in which duplicating the auditor—I think at your suggestion—caused a great deal of inconvenience, and that was repealed the other day, the company reverting to the system of having only one auditor. I do not think there would be any advantage in our appointing a second auditor, and we have to save every shilling we can. Your proposal, therefore, would not have my support.

Mr. GRIFFITH intimated that he would bring forward a motion on the subject at their meeting.

The CHAIRMAN then put the resolution, which was carried.

On the motion of Mr. GARROD, seconded by Mr. TERRY, a vote of thanks to the Chairman and Directors was passed.

The CHAIRMAN: I thank you for your kind vote. To receive the support of our shareholders is, I may say, one of the few satisfactions we have in administering this Company.

The proceedings then terminated.

Electro-Chemical Company (Limited).

The second ordinary general meeting of this Company was held at the Company's offices, St. Helens (Lancs.), on Tuesday, November 5th, Col. T. J. Holland, C.B., presiding. The following is abstracted from a report of the proceedings supplied by the Company.

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The CHAIRMAN said: Since our statutory general meeting in London last year our registered office has been removed from London to the works at St. Helens, and therefore we hold this meeting at the works to enable shareholders to satisfy themselves as to the progress made in our manufacturing operations in the district in which our principal business will be transacted. We have been much occupied during the past year in making the necessary arrangements to enable us to commence manufacturing operations as soon as practicable, with a due regard to future commercial success, and have been very careful in selecting the best and most desirable site for our works, and very cautious in choosing and ordering the best and most reliable plant and machinery for our manufacturing purposes. If we had hurried matters, and, with the object of making an early start, had selected even the very best of the many sites first offered us for our works, or had hurriedly ordered in plant and machinery, without very careful thought and consideration, we certainly might have gained some credit for starting a few months earlier, but, on the other hand, we should not have been able to look forward with anything like the confidence we now do to the future success of our operations. When it is remembered that we shall require for our manufacturing operations some 1,600 million gallons of water annually, the selection of a site where a very large, continuous and inexhaustible supply of good and pure water, at a minimum cost, from more than one source, is obtainable, must be a matter of vital importance for such works as ours, and I feel sure that by far the best premises available have been selected here at St. Helens, and have, moreover, been obtained on most advantageous terms for this Company. Under all circumstances, therefore, I think even the most impatient of our shareholders must admit that we did well and acted wisely in waiting till we could secure such premises as these. Great care and forethought have also been given to the obtaining of the best and most efficient plant and machinery for our manufacturing purposes. We visited the works of several engineering and other firms, and having satisfied ourselves as to the best, the most efficient modern electrical engineering plant required for our purposes, careful specifications were prepared by our eminent consulting electrical engineer, Mr. James Swinburne, tenders were invited from some of the principal manufacturing engineers in the country; such tenders as Mr. Swinburne recommended were accepted, and contracts were made with the parties concerned; then buildings were adapted to suit the requirements of engines, dynamos, boilers, economisers, electrolytic tanks, and electrical generating plant generally; large water mains were laid for our condensing water to the St. Helens and Mersey Canal, and bleach chambers, caustic pots, furnaces, and other alkali appliances were all put in hand. An exceptionally severe winter prevented our progress quite as rapidly as we might have wished, and the unforeseen, the extraordinary, and the apparently unaccountable dilatoriness of the manufacturing engineers (whose weeks seem each to have numbered about 30 days) in delivering their engines and dynamos caused further delay, when all else was ready. However, all these delays now being over, we are happily at work at last, having made a good start on a good site with good plant, and I trust with good and efficient machinery, all of which I am sure you will be pleased to learn has been purchased, and erected at figures lower, instead of higher, as is usual in such cases, than the original estimates, and we have proved and are daily practically demonstrating to the sceptical chemical world, to the expectant electrical profession, that purer and better bleach and caustic soda can be made by our simple electrolytic process than by any of the older processes, and can moreover be so manufactured at something like 50 per cent. less cost. Now, gentlemen, I know I am addressing a body of shrewd, practical business men; one expects to meet such at a business meeting of this sort, especially in such a county as Lancashire. I am aware, too, that some of those present listening to me are interested in, and understand the details of, alkali manufacture by the older processes, and that others present also attending to my words are electricians, engineers and chemists, and are thoroughly conversant with matters connected with electrical engineering, chemistry, and electro-chemistry, and I know also that all present have to-day themselves personally carefully examined and critically inspected our premises here, their surroundings, their situation generally, their buildings, plant, and machinery; yet, notwithstanding all this information before me—and it is enough to make me very careful as to what I say—I have no hesitation in stating, even before such an audience, without fear of contradiction, for I know every practical man who understands the sort of work we have been engaged in, will agree with me that we, your Directors or Mr. Leith, your General Manager, could not, under all the circumstances, have pressed matters forward more rapidly than has been done, with a due regard to the future success of our operations, and I am confident, too, that all who have had any practical experience in starting large new manufacturing works will also agree with me when I say that, considering the size, the magnitude of these works, and the many most important details, some of them quite of a novel nature, requiring very careful consideration and attention, it is really a matter of sincere congratulation for us all that we have been able to start, and make such a good start too, as soon as has been done. In regard to the sale or working of our valuable foreign and colonial patents, we felt that until we could show our works in active operation in our own country, little or no advantage could be gained by pressing the sale or working of those patents in other countries. These patents have been kept up, and if the process continues to work as satisfactorily as it has begun to do here, and if it proves as profitable as we hope and believe it will do, we have applied for additional patents in India, Russia, Spain, Sweden, Norway, Denmark, Portugal, Turkey, Mexico, Argentina, Chili, Brazil, Uruguay, New South Wales, Queensland, South Australia, Western Australia, Victoria, New Zealand, Tasmania, the Cape of Good Hope, Natal, and the Transvaal. All these patents, together with the Foreign and Colonial patents originally acquired by this Company on its formation, we hope to dispose of in due course at very remunerative prices. Our Russian patent rights have already been sold subject to a short test of the working of the process here at St. Helens, which test will probably take place this month. As the demand for caustic soda and bleach in Russia is very small, we therefore thought it desirable to accept at once the best bona-fide offer from a solvent and reliable party, and have sold the Russian patents for £6,000. Our process has been at work for some time in a paper mill in France, where the plant and machinery for it were erected by our own men under the supervision of our General Manager; the working there has, I believe, given every satisfaction. The practical results of the working in France, like the practical results so far of the working here at St. Helens, have proved even better than those obtained during the two years the process was worked at Snodland, in the county of Kent prior to the formaton of this Company. Considerable interest has also been shown in our process and patents by papermakers and others in Austria-Hungary, Belgium, Spain, Mexico, Canada and Italy, with all of which countries we have lately been in negotiations for the sale of our patents. I hope our plant and machinery will shortly be erected in a paper mill in Italy. We have refrained from issuing licences to papermakers and others to work our process in their paper mills or factories in the United Kingdom until our own works were completed, and until we could clearly ascertain the best, the most economical and the most compact form in which the plant and machinery required should be constructed to fit into the limited space available in the works of alkali users.

I have been asked to say a few words on the Castner electrolytic process recently advertised. So far as I can see, that process does not affect or touch us in any way whatever. Their patents were taken out some two or three years after ours, and therefore they cannot take advantage of any part of our inventions. We use iron cathodes, which last a long time, and cost 1s. 8d. each, or about £1,000 for all our 800 large electrolytic tanks, capable of producing 20,000 to 30,000 tons of 70 per cent. caustic soda and bleach annually. They use mercury cathodes, which will cost them, at a very low calculation, £7 each, and this for a plant with the same number of cathodes as we shall have, and the same sized plant as ours, means over £80,000 for mercury alone. Mercury is a liquid metal readily volatilised, and, as we know from our barometers and thermometers, is highly sensitive to atmospheric, climatic, and thermotic influences, and its evaporation is very dangerous to human, animal and vegetable life. They use heavy oscillating electrolytic tanks, far more costly and less durable than our fixed stationary tanks, and requiring machinery, belting, and power to drive, none of which are needed by our process; and their spindles oscillating machinery, and bearings are liable to get corroded and eaten away as soon as an escape of chlorine gas touches them, and they are surrounded on all sides by chlorine gas, day and night. In fact, theirs is a complicated, elaborate, costly system, working in the midst of the deadly volatilising fumes of mercury, which costs them at least 2s. a pound to produce caustic soda and bleach, the top sale price of which is ¾d. a pound! We use no re-agent or oscillating machinery, no belting, driving gear, or bearings whatever, and our process is as simple as A B C, and works in a perfectly pure and healthy atmosphere. The success of our process has been thoroughly established by practical working on a large commercial scale; theirs is hardly yet out of the laboratory or experimental stage. They may make caustic soda and bleach cheaper than is done by the old Le Blanc process—I daresay they will—but they cannot come near us by at least some £20,000 a year spent on mercury and extra machinery. How, then, can the Castner process affect us in any way?

Mr. R. TAYLOR hoped that future general meetings might be held in London. He considered that Japan was a country in which the Company ought to have a patent. If more shares were issued he hoped the shareholders would be allowed to take them up themselves, as no doubt they would be very pleased to do.

The CHAIRMAN said that he personally also hoped future meetings would be held in London. In regard to Japan, the Japanese patent law was rather peculiar, as none but the Japanese themselves were allowed to take out patents, and all foreigners are absolutely shut out from taking such patents. At the same time he might state that a Japanese papermaker, in a good position in his own country, had already been over to England about the electro-chemical process, and wished to take a patent out in Japan for it; and they were now in negotiation with him. The Directors hoped to avoid the issue of more shares, at any rate for the present.

Mr. C. TYLDEN WRIGHT said that the site selected, the buildings, plant and machinery appeared all that could be desired for large chemical works. He considered that the manufacturing engineers had caused the Company a very serious loss by their dilatoriness.

A SHAREHOLDER asked if the General Manager was able to realise as high prices for their caustic soda and bleach as the United Alkali Company obtained.

The CHAIRMAN replied that they had never sold anything yet under the top prices fixed by the United Alkali Company; they found no difficulty in realising these prices, or in selling their products, on account of the purity of their bleach and caustic soda, which evidently, by the repeated orders they received, met with the approval of consumers; they had already sold about all they could make in 1896 unless the plant were enlarged.

After the Directors' report and accounts had been adopted, and the retiring Directors and auditors re-elected,

The CHAIRMAN proposed that a cordial and hearty vote of thanks be given to Mr. Leith, their General Manager, and to those who had worked under him so ably and well during the past year. Mr. Leith was a very able, experienced, and efficient chemist, electrician, engineer, and alkali manufacturer. The successful position they were in that day was to a very great extent due to Mr. Leith's ability, energy, and hard work, and to those who had worked under him so well.

The resolution was carried unanimously, and a vote of thanks to the Chairman and Directors brought the proceedings to a close.

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Aluminium Company (Limited).

The eighth ordinary general meeting of this Company was held on Monday at the Cannon-street Hotel, E.C., under the presidency of the Right Hon. Gerald William Balfour, M.P.

The CHAIRMAN said: As regards the ordinary business of the Company, the gross profits this year amount to £17,000, against about £19,500 for last year. The difference is owing to the stagnation in the sodium trade, due to a very special cause, which is not likely to recur. The trade revived in the spring, and since then we have been, and still are, full of orders. The chief interest in the Company's affairs, however, centres in the developed value of the Company's patent. At our last annual meeting I alluded to the important question of the depreciation of our patents, and I then said that the Directors felt fully justified in stating that "the figures given in the balance sheet represent their actual value. What we have done is to write off an adequate amount for depreciation from the old patents, and to set down the patents connected with the new caustic process at a figure very considerably below what I believe to be their real value. That, of course, is right, because that value has not been realised. When it is realised I believe the balance sheet of the Company will show very much more favourably than it does now." You will no doubt agree with me that this year's report shows that the anticipations which the Board then formed are being verified. We have during the past year disposed of the Castner patents for the manufacture of soda by electrolysis. We have disposed of those patents all over the world, and the Company stands to receive in respect of them a sum amounting in cash and shares to between £150,000 and £200,000. Of this sum we stand to receive from the Mathieson Alkali Company in America £65,000, and, as the shareholders are aware, a company has been formed within the last few weeks, and we receive from that company in respect of those patents £100,000 in shares and £25,000 in cash. In addition to this, the Company owns another important chemical invention made by Mr. Castner, the exact nature of which I do not think at the present moment it would be advisable to disclose. We have sold the patents for that invention in the United States of America alone for a sum of £10,000 and a third of the capital of the Company which is to be formed there. We have yet to dispose of these patents in England and on the Continent of Europe. I therefore think we are justified, and more than justified, in making the statement as to the value of the patents which we made last year. On the general question of the value of these patents, and the value, therefore, of the shares which we hold in the Castner-Kellner Alkali Company, I would simply content myself by reminding the shareholders of the following facts. In the first place, Messrs. Solvay and Co., who are the greatest manufacturers of alkali on the Continent of Europe, have secured these patents, and are now erecting plant on a large scale to work them, while they have themselves invested in the English Company, after sending their expert over to Oldbury, who remained there watching the process for upwards of a week, night and day. I would remind you, further, that the process has been purchased by the Mathieson Alkali Company in America, with the advice of the greatest expert in chemistry in America, Dr. C. F. Chandler; and as it has been thrown in our teeth that this process has not been bought either by Messrs. Brunner, Mond and Co. or by the United Alkali Company, I will say this: I, myself, would welcome expressions of opinion either from Mr. Ludwig Mond, who first recommended this process to Messrs. Solvay and Co., or Dr. Hurter, who is the chemical adviser of the United States Alkali Company, both of whom had an opportunity of inspecting the process, and, as I have reason to know, formed a most favourable opinion of it. We have not studied this question for three years for nothing. We know the value of what we have sold, and I do not believe we have sold it for a penny more than it is worth. Last year I referred to the arrangement we had made with Mr. Castner, that he should receive 10 per cent. of the profits on anything derived from his patents, and in return give us the benefit of his inventions while he was connected with the Company, and that I regarded this as one of the most valuable assets the Company possessed. I think to-day you will all agree with me in that opinion. We, as a Company, owe a debt of gratitude to Mr. Castner for all that his inventive genius has done for us, but no less a debt of gratitude for the great business capacity which he has displayed. The Chairman then referred to his retirement from the directorship of the Company owing to his appointment in the Government, and expressed the pleasure he felt in having been successful in steering the Company through the most troubled waters which a public company had ever encountered without foundering, and in seeing the vessel brought safely into port.

Sir HENRY E. ROSCOE, F.R.S., seconded the adoption of the report, and announced that a satisfactory site for the Castner-Kellner Alkali Works had been acquired.

A dividend of 5 per cent. for the year ended June 30th last on the "A" shares was declared, and the retiring Directors (Gen. Sir Andrew Clarke and Mr. Castner) were unanimously re-elected, as were also the auditors (Messrs. Broads, Paterson and Co.).

A cordial vote of thanks to the Directors terminated the proceedings.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED). The Directors of this Company recently issued a prospectus to their shareholders inviting subscriptions for £20,000 Four per Cent. Debenture Stock at a premium of 2½ per cent. The stock is redeemable at par on January 1, 1914, or previously on six months' notice, at a premium of 5 per cent. In February, 1894, the Directors created £100,000 Four per Cent. Debenture Stock, of which £30,000 was subscribed for, and it has now been decided to issue a further £20,000.

NEW COMPANIES, STATUTORY RETURNS, &c.

In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1895, pages *304-332, &c., &c.*

BRITISH ELECTRIC TRACTION (PIONEER) COMPANY (LIMITED).—This Company was registered on November 7th with a nominal capital of £100,000, in £10 shares, to acquire the rights comprised in (and for that purpose to enter into and carry into effect) an agreement expressed to be made between the Electric and General Investment Company (Limited) and this Company to acquire, construct, equip, maintain, repair and work any railway or tramway carriages, vans, cars, trucks, boats, or other vehicles and craft appropriate for the carriage of passengers or goods, to obtain any necessary licences for working the same by electricity or other motive power under the Hackney Carriage Acts, or otherwise, and to carry on in the United Kingdom and elsewhere the business of carriers of passengers and goods, electricians, engineers, contractors, manufacturers of and dealers in railway, tramway, electric, magnetic, galvanic or other apparatus, and mechanical and chemical engineers. The subscribers, with one share each, are:—C. Rivers Wilson, G.C.M.G., C.B.; Emile Garcke, electrical contractor; John S. Raworth, civil engineer; Robert Doyle, George Herring, J. Cecil Bull, and J. B. Braithwaite, jun. The first Directors are: Sir C. Rivers Wilson, G.C.M.G., C.B., the Right Hon. the Earl of Suffolk and Berkshire, Emile Garcke and John S. Raworth.

ROGER DAWSON (LIMITED).—The annual return to October 21st has been filed. The whole capital of £15,000, in £1 shares, has been taken up, and 14,993 have been issued as fully paid. The full amount has been called on the remaining seven shares.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30 1/16d. per oz. (Nov. 14th). Consols (2¾ per cent.) 106 1/16—106½ for money, 106 3/16—106½ for account; 2½ per cent. 104—104½ (Nov. 14th). Stock Exchange Settling Days: Consols, Dec. 2nd; Stocks and Shares Continuation Day, Nov. 26th; Ticket Day, Nov. 27th; Pay Day, Nov. 28th.

BRITISH ELECTRIC TRACTION (PIONEER) COMPANY (LIMITED).—Subscriptions are invited by the Electric and General Investment Company (Limited) for an issue of 5,000 shares of £10 each in the British Electric Traction (Pioneer) Company (Limited), which is, the prospectus states, formed "to take steps for the development of electric traction in the United Kingdom and elsewhere on systems which have already proved successful in the United States and on the Continent of Europe." The share capital of the Company is £100,000, in £10 shares, of which the present issue forms one half. £1 per share is payable on application, £1 on allotment and calls not exceeding £2 per share will be made as necessary at intervals of not less than one month. The prospectus will be found fully set out in our advertisement columns. A strong Board of Directors includes Sir Charles Rivers Wilson, G.C.M.G., C.B., and Mr. Emile Garcke is Managing Director. It will be seen that the Company is not committed to the use of any particular system, and that already some important inventions and proposals relating to electric traction have been submitted to the Directors. The only contract entered into by the Company is fully referred to in the prospectus, which contains no objectionable waiver clause. The list opens and closes this day (Friday) for both town and country.

CALL DUE.—To-day (Friday), Amazon Telegraph Company £10 shares—£2. 10s. per share.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended November 10th were £1,009, against £969 in the corresponding week of 1894, an increase of £40. The total receipts for the half-year amount to £16,658, against £16,719 for the corresponding period of 1894, a decrease of £61.

GENERAL ELECTRIC COMPANY OF AMERICA.—It is estimated that the profits on the year's working of this Company will suffice to pay a dividend of 3 per cent.

LIVERPOOL OVERHEAD RAILWAY COMPANY (LIMITED).—The traffic receipts of this railway for the week ended 10th inst. amounted to £1,063. The amount for the corresponding week last year was £892; increase, £171.

VICTORIA ELECTRIC RAILWAY AND LIGHTING COMPANY (LIMITED). The numbers are published of 25 Five per Cent. First Mortgage Debenture Bonds of this Company, amounting to £1,000, which have been drawn for repayment on and after January 2nd next, at the rate of 105 per cent. The bonds will be repaid at the office of Messrs. Sperling and Co., 8, Austinfriars, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended November 8th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,993.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Nov. 6.	Price Wednesday, Nov. 13.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Nov. 9. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	10/0	Anglo-American	43 45	43 45	5 0 0	Jan., Apr., July, Oct.	44	..
£2,993,560	Stock	20/0	Do. Preferred	83½ 84½	83½ 84½	5 7 9	" "	85	83½
£2,993,560	Stock	5/0	Do. Deferred	6½ 6¾	6½ 6¾	.. ..	.. ..	6⅞	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	102 105	102 105	3 17 1	January and July	..	..
180,000	£10	3/0	Brazilian Submarine	13⅝ 14½	13½ 13⅝	5 1 10	Mar., June, Oct., Dec.	14½	13⅞
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111 115	111 115	4 8 4	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	164 168	164 168	4 3 7	Jan., Apr., July, Oct.	..	..
15,000	10	3/0	Cuba Submarine	13 14	13 14	5 14 4	February and August	21⅛	21⅛
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 13 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	4 5	4 5	4 0 0	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104% 107%	104% 107%	4 6 4	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8 8½	8½ 8⅝	4 11 5	Jan., Apr., July, Oct.	..	..
400,000	10	2/6	Eastern	16⅜ 17	16½ 17	3 16 6	" "	8⅜	8⅛
70,000	10	6%	Do. 6 per Cent. Preference	17½ 18½	17½ 18½	3 5 9	" "	16⅛	16½
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock ..xd	126 129	126 129	3 2 0	May and November	128	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 11 11	February & August	..	..
250,000	10	2/6	Eastern Extension	17⅜ 18½	17½ 18	3 17 9	Jan., Apr., July, Oct.	18⅛	17⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128 131	127 130	3 2 0	February & August	..	..
£64,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103 107	103 107	4 15 0	January and July	..	..
£30,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103 107	103 107	4 15 0	" "	—	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108 111	108 111	3 12 9	February & August	..	..
£300,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.) ..xd	112% 115%	112% 115%	3 9 7	May and November	..	..
180,227	10	1/8	Globe Telegraph and Trust	9⅜ 10⅛	9⅛ 10	4 5 0	Jan., Apr., July, Oct.	10⅛	9⅛
180,042	10	6%	Do 6 per Cent. Preference	16⅛ 17⅛	16 17	3 10 7	" "	17⅛	16⅝
150,000	10	5/0	Great Northern	21⅛ 22⅛	21⅛ 22½	3 16 8	Jan., April, and July	..	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1888 issue	104 107	104 107	4 14 4	March & September	..	..
17,000	25	12/6	Indo-European xd	47 50	47 50	5 0 0	May and November	48	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	.. ..	" "	—	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 110	106 110	5 10 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	109 112	109 112	3 12 3	" "	..	..
11,889	8	4/0	Reuter's	5½ 6½	5½ 6½	..	April and October	..	..
2,381	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	127 132	127 132	4 10 11	" "	130	..
15,609	10	2/0	West African Telegraph	5⅛ 6⅛	5⅛ 6⅛	..	January and July	..	..
£228,300	100	5%	* Do. 5 per Cent. Debentures (red.)	104 107	104 107	4 14 4	March & September	104	..
80,000	10	2/0	West Coast of America	1⅛ 2	1 2	..	January and July	..	..
£150,900	100	8%	Do. 8 per Cent. Debentures, 1902	100 105	100 105	7 16 1	June and December	104⅛	..
38,321	10	6d.	West India and Panama	⅞ 1⅛	⅞ 1⅛	..	" "	1	..
24,568	10	6%	Do. 6 per Cent. 1st Preference	10½ 10⅝	10½ 10⅝	5 14 3	May and November	10⅝	10⅜
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½ 9½	8½ 9½	..	" "	8⅝	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	111 114	111 114	4 9 1	June and December	..	..
64,242	15	6/0	Western and Brazilian	10 10½	10⅛ 10½	4 17 0	May and November	..	..
33,129	7½	4/6	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	—	—	..	..
33,129	7½	1/6	Do. 5 per Cent. Deferred	3½ 4	3½ 3⅝	..	—	4	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 18 9	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 18 9	" "	104	..
£1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds..xd	110 115	110 115	6 1 9	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100 103	100 103	5 17 8	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3½ 4	3½ 3⅝	..	—	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ¼	⅛ ¼	..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	⅛ ¼	⅛ ¼	..	Yearly	..	..
484,597	5	2/6	National	6 6½	5⅝ 6⅛	4 1 8	June and December	6⅛	6 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15½ 16½	15½ 16½	3 12 9	" "	16½	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅛ 6⅝	6⅛ 6⅝	3 16 11	—	6 7/16	6⅛
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	105 107	105 107	3 6 2	January and July	107⅛	105⅛
58,000	5	3/0	United River Plate	2⅜ 3⅛	2⅜ 3⅛	..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	92 97	92 97	5 5 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12½ 13½	12½ 13½	1 17 0	—	13	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15½ 16½	16 16½	3 12 9	—	16	15½
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	132 136	131 135	..	June and December	135	132½
19,900	£5	..	Electricity Supply Co. for Spain	— —	.. ..	..	—	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½ 5⅝	6½ 6⅝	..	—	..	—
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	— —	— —	..	—	..	..
8,322	£5	..	House-to-House Electric	— —	— —	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	— —	— —	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 8⅛	7⅞ 8⅛	..	—	..	..
111,000	5	..	London Electric Supply	.. ..	.. ..	..	—	..	..
49,900	£10	6/0	Metropolitan Electric Supply (fully paid)	10½ 11½	10 11	2 14 1	—	11⅜	10⅞
150,000	Stock	4½%	* Do. 4½% Debs.	117 120	117 120	3 15 11	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9½	8½ 9½	..	—	..	..
..	..	..	Rand Electric	7/16 ¼ prem	⅜ ½ prem	..	—	..	..
19,980	£5	2/0	St. James and Pall Mall	8¼ 8⅜	8 8½	..	—	8⅝	8 1/16
20,000	£5	7%	Do. 7 per Cent. Preference	9 10	9 10	3 10 0	—	9⅝	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8½ 8⅝	8 8½	3 2 10	—	8 1/16	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1⅝ 1⅞	1½ 1⅝	10 0 0	—	1⅝	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2 2½	1⅞ 2⅛	5 12 11	—	2	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 18 9	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1½ 2⅛	1½ 2⅛	..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1⅞ 2⅛	1⅞ 2⅛	..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 5 4	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	— —	.. ..	..	..	..	..
110,000	2	..	Electric Construction	¾ 1	¾ 1	..	..	¾	..
12,845	2	2/9½	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 11 0	..	—	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ½	⅜ ½	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¼ ½	¼ ½	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	19 20	19 20	3 15 0	February & August	19½	19
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101 103	101 103	4 8 0	March & September	102½	—
15,995	£10	..	International Okonite Ordinary	— —	.. ..	..	—	—	—
16,000	£10	..	Do. 8 per Cent. Preference	— —	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	2s. 8s.	.. ..	..	..	..	..
37,850	12	12/0	Telegraph Construction and Maintenance	42 44	40 42	5 14 8	March and July	43½	42½
£150,000	100	5%	* Do. 5 per Cent. Bonds	104 107	104 107	4 15 0	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	..	—	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	—	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	14 14½	14 14½	4 2 9	—	14½	14
£30,000	10	7/0	Do. 7 per Cent. Preference	15 16½	15½ 16½	4 4 10	—	16½	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	107 110	108 111	4 1 10	—	110	108
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway	42 42	40 42	2 19 6	May and November	41	40
7,650	10	5%	Do. 5% Perpetual Preference	14⅜ 15½	14⅜ 15½	3 5 7	..	14⅜	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture xd	132 134	134 134	2 19 9	May and November	..	..
37,500	£10	2½%	Liverpool Overhead Railway	11⅞ 12	11⅝ 11⅞	1 17 11	—	—	—
10,000	10	5%	Do. 5% Preference	15½ 15⅝	15½ 15⅝	3 5 0	—	..	..
145,000	Stock	4%	Do. 4% Debenture	112 114	112 114	3 10 2	January and July	—	—

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption

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NOTES.

FROM the report of the proceedings at the reception of the deputation of representatives of the Colonies by Mr. CHAMBERLAIN on Tuesday, it will be seen that the Minister for the Colonies is favourable to the appointment of a Joint Commission to consider and report upon the question of a Pacific cable. Owing to the extreme depth of water in places, the great length to which some of the sections must extend, the various possible routes, the probability of the maintenance being exceedingly costly, and the necessity for large subsidies from the Imperial Government and the Colonies interested, it is desirable that the whole matter should be carefully and judicially considered, and the opinions of authorities on cable matters heard. It is satisfactory, therefore, to find that there is prospect that the Government will decide to take action in the direction indicated. Mr. CHAMBERLAIN is reported to have said that there was evidence that the amount of traffic over such a line would be satisfactory, but no one believes that this enterprise, unless subsidised, could be carried on without large deficits, and the laying of the line is entirely dependent upon the amount of Government aid forthcoming. With direct steamship and cable connection doubtless a considerable trade will spring up between Canada and Australasia, but obviously it will take years to grow. So far as this country is concerned—apart from its colonies—the principal argument for the line in question is the strategic one; as the average time occupied by messages between London and Sydney is only two hours, and the rate of 4s. 11d. per word is a moderate one for the distance (16,000 miles). However, Canada and the Australasian colonies—and especially the former—will not rest satisfied until they get a direct cable. Whether the connection will effect all they seem to expect from it is, to say the least, doubtful.

AT a special meeting of the Brighton Town Council on Saturday last the Brighton and Rottingdean Seashore Electric Tramroad Company confessed to having made fundamental alterations in its original plans, and withdrew all imputations of obstruction on the part of the Corporation. Having thus purged itself, the Company was graciously permitted to erect "13 tubular poles 80 yards apart" along the Brighton foreshore on agreeing to enter into a bond for £1,000 to remove the rails, &c., if the working of the line is at any time abandoned.

THIS desirable consummation was not, of course, reached without a lengthy debate, the only item of interest being the figures given by the Company's engineer, Mr. ST. GEORGE MOORE, with regard to the estimated horse-power required to propel the 60-ton perambulatory pier. "At low tide, with an incline of 1 in 300 on a 40-chain curve against a 14-mile wind, 24 H.P. would," he said, "be necessary for a speed of six miles an hour; running with bogies in the water, 40 H.P. would be needed under similar conditions, and with the car submerged, 63 H.P." Well, we hope it will be so, and trust that this little line may prove as commercially successful as it is electrically and mechanically interesting.

THE Paper by Dr. ROESSLER, the first portion of which will be found in another column, should be of interest to those concerned, either practically or theoretically, with transformer working. The statement that the magnetising current of a transformer can be reduced 30 per cent. by the adoption of a peaked E.M.F. curve will be welcomed by alternate-current central station engineers blessed (?) with a too-pointed load-diagram. It is unfortunate that the condition for highest transformer efficiency should be the direct opposite of that for the best illuminating power of alternating arcs. Up to the present, however, arc lamps are in this country chiefly used for street lighting, and alternate-current arcs are for this purpose the exception, and not the rule. The question of insulation is of greater importance as an objection to the pointed E.M.F. wave, but so long as actual disruptive discharge is prevented the virtual leakage current would be the same for all curves having the same virtual potential difference. It is very probable, also, that there would be no need to increase the insulation to prevent disruption, for, as has been shown, transformers under ordinary conditions of working are subjected to potentials of many times their usual value when the primary circuit is made or broken. It is these abnormal potentials which determine the degree of insulation required for a transformer, and as they would not be increased, but somewhat diminished, with the pointed curve (since Dr. ROESSLER shows that the maximum magnetic induction is less for pointed curves), there would be no need of higher insulation. In these circumstances there seems no reason why we should not take full advantage of the beneficent properties of the peaked E.M.F. wave.

WE have always considered that there existed an element of scarcely justifiable empiricism in the commonly-used formula

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for the hysteresis loss in iron which makes the loss an exponential function of the magnetic induction. It was difficult to believe that any such connection between the two things really existed; and it was simply impossible to rationalise the formula on the basis of any modern theory of the magnetisation of iron. In a Paper which he read before the British Association at Ipswich, and which we reprint this week, Mr. F. G. Baily has given the results of, and drawn a definite conclusion from, a number of experiments which he has made on the relation between hysteresis and magnetisation in iron. Briefly stated, these experiments seem to show that energy is wasted by hysteresis during only that portion of the change in the magnetic induction which is accompanied, so to say, by molecular grinding. When the induction changes in a region beyond the limit of saturation, the absence of any molecular movement during the change accounts for an absence of hysteresis; and when the induction is carried between widely-separated positive and negative limits, it is only the induction between positive and negative saturations which involves hysteresis. It would seem, then, that inasmuch as hysteresis is a function of the magnetisation and not necessarily of the induction, we should, as Mr. Baily points out, express the hysteresis in terms of "the intensity of magnetisation, with at most a small correction in terms of the latter quantity (the magnetic induction)," and not directly in terms of the magnetic induction itself.

The services rendered by the gas engine to electric lighting have been extensive and manifold. This engine has not only been used alone, both in public and private plants, but a useful field has been found for it as an adjunct to steam stations. Usually the supplementary gas-engine plant is to be found along with the steam engines in the same station; but at Brussels this practice has been modified in an interesting manner, by putting the auxiliary gas plant in a separate sub-station situated at some distance from the main station. The site chosen is a large vault beneath the Belgian State Railway Offices; and here the India Rubber and Telegraph Works Company, of Silvertown, have recently installed two out of a total of five generating sets, which it is intended ultimately to provide. Each set comprises a 120 H.P. twin cylinder gas engine, working on the "Otto" cycle, direct-coupled through Raffard clutches to two dynamos, one at each end of the crank shaft. The set runs at 150 revolutions per minute, and at this speed the dynamo gives a normal output of 320 amperes at 125 volts. The sub-station is provided with a storage battery of Julien cells, having a normal capacity of 250 amperes at 250 volts for eight hours' discharge. One of the features of special interest in this sub-station is the direct-coupling of the gas engines. Such engines have long been adopted in various stations on the Continent; but until recently they had not made their appearance in this country. Indeed, we have heard it stated more than once that the flexible belt between a gas engine and a dynamo is necessary to steady running of the latter. No such necessity appears to have been recognised in the successful stations of the Continental Gas Association, nor at Brussels; and we were glad to hear, the other day, that the additional plant for the Belfast gas-power electric supply station is to consist of direct-coupled engines and dynamos.

When drawing up rules or giving advice in regard to electric lighting, an insurance company is not likely to err on the side of laxity; but it would seem that its officers may be unnecessarily over-cautious. In an article contributed to the *Paper Makers' Circular*, Mr. L. M. Mann, of the North British and Mercantile Insurance Company, discusses the use of various artificial sources of light in paper mills, and the fire risks attendant thereon. After recounting the obvious and numerous precautions which are necessary with gas jets, he says:—

"With regard, now, to the lighting by electricity, there are dangers in connection with the lamps which call for safeguards not less evident than those just mentioned. For example, the surface round the top of the bulb of an incandescent electric lamp in the dry department is apt to become thickly coated with fluff and dust. Such a deposit upon the heated surface of the glass is dangerous, and should be prevented from forming by placing the lamp in an outer glass globe arranged to exclude dust."

Mr. Mann does not tell us in what way such a deposit of dust might be dangerous, but as the article is on fire risks we suppose it is a danger from fire that is apprehended. We should be surprised to hear that even an incipient fire had really ever originated from such a cause. At the same time the use of an outer globe is not altogether inadvisable where the atmosphere is so laden with dust that an explosion might result, from the fracture of a lamp bulb bringing a portion of the still glowing filament into contact with the explosive mixture of dust and air.

A few weeks ago we had occasion to express our well-grounded doubt in regard to the alleged high speeds attained by electric trains on the Nantasket Beach railway, in the United States. The claims for speeds rising to 80 miles an hour advanced by the parties interested in that railway, were, in our opinion, and taking into account the local circumstances, utterly unjustifiable. We are led to revert to this matter because of similar claims which have recently been advanced in favour of a train running on the Lake Shore and Michigan Southern Railway. It has been stated that a steam locomotive, with six-coupled driver wheels, drew a train weighing 136 tons a distance of 510 miles at an average speed of 64 miles per hour, including all stops, many miles being covered at a speed exceeding 72 miles per hour, and a maximum exceeding 90 miles an hour occurring over one mile of the run. It is time that these startling claims, of which the two already mentioned are by no means the only instances, should be disproved or else should be based upon better evidence than is at present forthcoming; and we are gratified to see that our contemporary the *Engineer* has investigated the matter very thoroughly, and has upset the claims, in the case of the Lake Shore Railway, by a complete *reductio ad absurdum*.

Coventry.—The municipal electric lighting station of this town was opened on Saturday last, November 16th.

Cable Interruptions:—	Date of Interruption.
Cadiz-Teneriffe	Sept. 25, 1895.
Perim-Assab	Nov. 19, 1895.

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Sydney University Engineering School.—A Sydney engineer, named Mr. P. N. Russell, has given £50,000 for the endowment of an engineering school in the Sydney University.

The Frédureau Diffusing Globe.—The light-diffusing globes invented by M. Frédureau, to which frequent reference has been made in our columns, is now being introduced commercially into this country.

Royal Society.—Among the Papers down for reading yesterday at the Royal Society was one by Mr. G. J. Burch "On the Calibration of the Capillary Electrometer." An extra meeting for the reading of Papers will be held on November 28th.—— The anniversary meeting will be held on Saturday, November 30th, at 4 p.m.

Birmingham Municipal Technical School.—We have received a programme of the classes in theoretical and applied science for the ensuing session at the Birmingham Municipal Technical School. The classes in electrical engineering and physics are under the direct tuition of the principal, Dr. W. E. Sumpner, assisted by Mr. Coultas.

Obituary.—The death occurred, at his home, 337, West 22nd-street, New York, on October 25th last, of Mr. Holbrook Cushman, at the early age of 38 years. Mr. Cushman was well known amongst electricians in this country about 10 years ago, at which time he was head of the electrical department at Messrs. Mather and Platt, after which he returned to America and became an instructor in the physical department and head of the laboratory at Columbia College, New York. The cause of death was heart disease. Amongst other institutions, Mr. Cushman was a member of the American Institute of Electrical Engineers.

The Central London Railway.—The experimental boring beside the Bank of England, which was instituted in connection with the proposed central junction station for the electric railway, to ascertain the character of the sub-soil, has now been completed. Made earth was found down to a depth of something over 13ft. then came a layer of gravel, then one of clay, then ballast, and, at a depth of about 30ft. that good foundation and excellent material for working through, the London blue clay. Nothing of antiquarian interest was discovered in boring.

Electric Lighting in Germany.—At the first autumn meeting of the Berlin Elektrotechnischer Verein Herr von Stephan, in his Presidential address, gave some interesting figures as to the present state of electrical enterprise in Germany. There were in actual working on October 1st in the German Empire, with the exception of Bavaria and Wurtemberg, 7,419 installations. Of this number 7,108 served mainly for lighting purposes, with a total number of 1,380,000 glow lamps and 61,000 arc lamps. Further 90 installations were mainly used for electrolytic purposes and 453 for transmission of power. These figures, the President said, were not quite correct, as information in some instances was difficult to obtain, but, in his estimation, they were rather below than above the actual figures.

Royal Society Medals.—The Royal Society's medals have this year been adjudicated by the President and Council as follows:—The Copley Medal to Prof. Karl Weierstrass, For.Mem.R.S., for his investigations in pure mathematics; a Royal Medal to Prof. James Alfred Ewing, F.R.S., for his investigations on magnetic induction in iron and other metals; a Royal Medal to Dr. John Murray, for his services to biological science and oceanography in connection with the "Challenger" reports, and for his original contributions to the same; and the Davy Medal to Prof. William Ramsay, F.R.S., for his share in the discovery of argon, and for his discoveries regarding gaseous constituents of terrestrial minerals. The medals will, as usual, be presented at the anniversary meeting on St. Andrew's day (November 30th). The Society will dine together at the Whitehall Rooms on the evening of the same day.

Electric Car Accident.—A terrible accident occurred at Cleveland, Ohio, on November 17th, at eight o'clock in the evening. An electric car, conveying between 20 and 30 persons, plunged over a drawbridge in the central part of a viaduct and fell into the Cuyahoga river 100ft. below. The viaduct is 3,000ft. long, and when the car was approaching the middle, where the drawbridge is situated, the conductor went forward. Although the gates across the road were closed, he signalled the way clear. The motorman accordingly turned on the current, and the car dashed through the gates and fell into the water. Several persons, including the motorman, jumped off, but all those remaining in the car were drowned. Thirteen bodies have already been recovered. The motorman, Rogers, has been arrested. He stated that the conductor, who was drowned, gave the proper signal for the car to proceed.

Electrical Manufacturing Activity in Germany.—The report of the Allgemeine Elektricitäts-Gesellshaft of Berlin for 1894-95, just issued, contains some interesting figures as to the continued growth of this large concern. The number of employees has increased from 3,385 to 5,121, and consequently the output of the different departments has been considerably greater than in the preceding year. No less than 2,049 dynamos and electric motors were manufactured of a total capacity of 22,800 kilowatts, or about 30,000 H.P. At present the Company has in hand orders for 2,000 dynamos for a total capacity of 58,500 kilowatts, or nearly 80,000 H.P.; 26 of these machines are to be over 1,000 H.P. each. In the traction department the number of tramways on the "A.E.G." system, either in working or in the course of erection, has increased from 19 to 29, the total length of line from 120 to 237 miles, and motor cars from 350 to 680. The generating stations of these lines represent a total capacity of 11,230 H.P., as against 5,950 H.P. in the preceding year.

Finsbury Technical College.—From the recently-issued report we learn that the Finsbury Technical College is making good progress. Referring to the work done in the mechanical and electrical engineering departments, Dr. Silvanus Thompson, the principal, writes in his report:—

"The past students of the two engineering departments can also show a good record of subsequent successes. All over the country Finsbury students are to be found, as engineers or assistant engineers, in the electric lighting stations. At Oldham, Taunton, Tunbridge Wells, Belfast, &c., and at various stations in London, including the City and South London Electric Railway, they may be found occupying posts of responsibility. . . A scrutiny of the present occupations of the certificated students in the list appended to this report will show how large a proportion are pursuing careers of which their college course was designed to prepare. . . . Of the uncertificated past day students, and of the past students of the evening classes, no similar register exists; but as the vast proportion of evening students are already employed in the cognate industries at the time when they enter the classes, it is probable that a still larger proportion remain in the industries which the college classes are designed to aid. It cannot be expected, now that the electric lighting industries are so overstocked with young men, that during the next ten years there will be the same pressure toward classes for electric lighting as has existed during the past ten. But other fields are opening in the extended use of electric motive power, and in the applications of electricity to metallurgy and to manufacturing chemistry."

The Telephone in Yorkshire.—On Wednesday, at the General Post Office, a deputation from the West Riding of Yorkshire waited on the Postmaster-General to urge upon him the necessity for increased facilities in telephonic communication in Yorkshire. Mr. Arnold, M.P., said he wished to emphasise the fact that in the part of Yorkshire which they represented there was a very large manufacture of soft goods carried on. The material, in the process of its manufacture, had to go to different towns in the West Riding, so that between these different towns there ought to be absolute freedom of communication as an essential thing. To secure this end he would advocate an increase in the number of trunk wires and the uniting of the various towns which they represented in one telephonic area. The Postmaster-General, in his reply, said that he should only be misleading them if he held out hope of only being able to accede to the first request. The areas had all been specified and drawn up carefully, while the deputation asked that they should all be thrown into one. The authorities were anxious to do all they could in the direction of increasing the number of trunk wires, but even if everything was granted that was asked for, there were limits to the perfection that was attainable.

Proposed Amendment to the Electric Lighting Acts.—The Directors of the City of London Electric Lighting Company

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invited the delegates to the Board of Trade Conference to a meeting at Winchester House on Monday last, with the object of an interchange of views on a proposal to appoint a deputation to wait upon the Board of Trade to suggest certain amendments to the Electric Lighting Acts. The Local Authorities represented at the meeting included the Corporations of Worcester, Burnley, Glasgow, Coventry, Tunbridge Wells, Newport and Eccles, and the Vestries of Hammersmith, Hampstead and Acton. The companies representatives present, in addition to the City of London Company, were the Westminster, Metropolitan, Charing Cross and Strand, Chelsea, Bournemouth, Oxford, Eastbourne, Hove, Sheffield and Altrincham. The chief subject discussed was the clause in the Acts which enables an individual with only a small property rights in the neighbourhood of an electric supply station to obtain an injunction, resulting in the stoppage of the electric lighting works, to the great inconvenience of the public and the serious pecuniary loss of the supply company or local authority. Several speakers commented upon the unworkability and injustice of the clauses as they stand, and the suggestion that a deputation should wait upon the Board of Trade to place the views of the meeting on this and other subjects was approved.

The Proposed Pacific Cable.—Mr. Chamberlain received, on Tuesday, at the Colonial Office, a private deputation of Colonial representatives for the purpose of discussing the project of a Pacific cable. The deputation consisted of Sir Charles Tupper (Canada), Sir Saul Samuel (New South Wales), Mr. Duncan Gillies (Victoria), Mr. Thomas Playford (South Australia), Sir Robert G. W. Herbert (Tasmania), Mr. Walter Pease (Natal), Mr. C. S. Dicken (Queensland), Sir Westby Brook Perceval (New Zealand), and Mr. Spencer Brydges-Todd (Cape Colony). Mr. Chamberlain observed that such a meeting of the Council of the Empire, brought together for the purposes of common interest, and attended by representatives of the Cape and Natal, which were not concerned with the project in its present form, was an evidence of solidarity and sympathy. He expressed his opinion that the project showed a very fair prospect of remunerative return on the capital required, and his willingness to join in the formation of a joint Commission, which should report upon the subject. He suggested that a Commission should be formed, consisting of two representatives of Great Britain, two of Australasia, and two of Canada. After some discussion it was arranged that the Colonial representatives should be named by the Colonial Governments and appointed by the Imperial Government, and that the Commission should consider and report upon the subject in all its aspects. It was also arranged that the Agents-General and the High Commissioner of Canada would move their Governments to appoint representatives on this understanding.

Magnetic Charts.—At a recent meeting of the Académie des Sciences, M. de Bernardières, of the Bureau des Longitudes, made a communication on the subject of the new magnetic charts of the globe undertaken under the direction of the Bureau des Longitudes. M. de Bernardières remarked that the magnetic charts published at the present day by the English Admiralty and other authorities, rested mainly on observations taken by navigators, the scientific value of these observations being very different in different cases. With a view of affording a better basis for a magnetic chart of the globe, the Bureau des Longitudes recently decided to train a certain number of naval officers and travellers at the Mont Souris Observatory in the art of taking magnetic observations with the latest approved appliances. In this task the Bureau received warm support from the French Admiralty and Colonial Office. The result has been that seven expeditions, each consisting of a naval officer and an assistant, have been sent out with a view of taking simultaneous magnetic observations in different parts of the world. These expeditions have been distributed as follows: On the Atlantic Ocean observations will be taken on the west coast of Africa and the east coast of America; on the Pacific Ocean observations will be taken on the west coast of America and in Oceania; on the Indian Ocean observations will be taken on the Red Sea littoral and on south coast of Asia and in Madagascar; in the China Sea observations will be taken on the Chinese, Japanese and Indo-Chinese coasts; in the north observations will be taken in the North Sea and on the coast of Scandinavia, Denmark, Scotland and Iceland; in mid-Atlantic observations will be taken at Madeira, the Canary Islands, the Azores, Cape Verd and Senegambia. As soon as the Bureau des Longitudes possesses the necessary instruments, the eighth expedition will be sent to Newfoundland, and will afterwards take observations in the Mediterranean. In addition to these special expeditions the Department of Marine has arranged to instal special apparatus on ships circumnavigating the world, and have arranged for observations to be taken as accurately and as frequently as possible on ships only possessing ordinary navigating appliances. These expeditions are at work, and have already communicated preliminary results; their observations are to extend over a period of about two years. The expedition to Iceland, which left France at the beginning of last spring on the "Manche," has returned and brought back a rich harvest of measurements taken at Cherbourg, in Scotland, the Shetland Isles, Iceland, Norway (where they went up as far as Bossekop and Hammerfest), in Denmark, and in the course of crossing the North Sea. Two complete series of observations, each lasting a week, were carried out in a temporary observatory constructed at Rejkiawik. The comparison of these results, obtained with considerable accuracy, with the results obtained 60 years ago by the observers on the "Recherche," and since then by different magnetic expeditions in these regions, should prove of considerable interest.

Contemporary Electrical Science.—P. Lenard's further Paper on CATHODE RAYS in *Wiedemann's Annalen* formulates a new general property of matter in the thesis that, whatever the nature and state of aggregation of the absorbing material, the absorption is proportional to the mass; in other words, that the absorption of cathode rays by a definite thickness of material increases with its density. Hydrogen deviates most from this rule, in the proportion of about 5 : 3. Glass, silver, collodion, and sulphurous acid are also rather highly absorptive in proportion to their density, but paper, mica, and aluminium are less absorptive. "Lenard's law" is now in the same state as was Boyle's law of yore, and requires another Andrews or Van der Waal to put it right.——Messrs. Paalzow and Neesen deal with the PASSAGE OF ELECTRICITY THROUGH GAS, and attempt to measure the temperature of the discharge by means of the evaporation calorimeter. "Supposing all the particles to take equal parts in the discharge," the temperature obtained is 649,000°C.! This astonishing result is, however, only a secondary matter in an otherwise valuable Paper.——O. Lehmann's Paper on CONTINUOUS DISCHARGES IN GASES will be noticed more fully elsewhere. As for such discharges, there are none.——H. Luggin has an interesting little Paper on the effect produced by dividing an electrolytic cell into two portions by a thin metallic membrane. In opposition to Arons, he proves that they do not take any part in transmitting the current. The apparent resistance of half a square centimetre of a gold membrane goes into 1,000 ohms, and the natural conclusion is that the current is conducted by pores in the sheet, whose aggregate area need not exceed a few millionths of a square millimetre.——Paul Czermak discusses the use of very fine thermo-elements in meteorology. These have the advantage of taking up the temperature of the surrounding air with great readiness. The wires should be 0·1mm. thick and attached to stout copper tubes filled with water. A "relative actinometer" constructed on these lines will indicate hundredths of degrees, and will gauge the varying thickness of a fleecy cloud.——Holborn and Wien are continuing their high temperature work at the Reichsanstalt. They are working with a new kind of porcelain which is exceedingly refractory. A thermo-couple made of two different rhodium-platinum alloys is introduced into the oven under an inverted magnesia crucible, and gives the melting point of platinum as 178°C.——A. Oberbeck investigates the evolving effect of air currents of known velocity upon a platinum wire carrying a current. The temperature is measured by the change of resistance of the platinum. Conversely, an anemometer can be constructed on the same principle. Here is Prof. Langley's opportunity of proving his dictum that all winds proceed in puffs.

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ELECTROMAGNETIC THEORY.—LXXVIII.*

BY OLIVER HEAVISIDE.

(*Continued from page 36.*)

§ 308. If there is no impressed force, but the middle cable is initially charged arbitrarily instead, there is a similar curious limiting case when the terminal cable Z_0 and the middle cable are equivalent. The general solution (100), through (110), reduces to

$$V_1 = \sin s(y+l)\frac{\sin sx}{\sin sl}\frac{sQ}{S}, \qquad (172)$$

indicating the potential at x, on the right of y, due to Q initially at y. When on the left side, interchange x and y to get the formula. The Z_0 operator is $(R/s)\tan sl$, as in § 306.

Developing by the expansion theorem, according to the roots of $\sin sl = 0$, and denoting the result by U, we obtain

$$U = \frac{2Q}{Sl}\Sigma \sin sy \sin sx\, \epsilon^{pt}. \qquad (173)$$

Now this is exactly the same as if the cable were earthed at $x=0$ and l. See (22), § 267, for example.

But the latent auxiliary normal functions, which we know to exist in general, have not been considered. The conclusion from the above result is, therefore, that in the complete expansion of the initial state, the sum of all the extra terms is zero. Only when t is finite can they be quantitatively existent in the total. They may be infinite then, should the p in ϵ^{pt} be infinite for the extra terms; but that is of no consequence as regards the initial state.

To verify the above, we may proceed as in § 307. Let Z_0 be not equivalent to the middle cable in the first place. Then Z_0 is as in (157), and Z_1 is its negative. The general equation (110) is now

$$V_1 = -\frac{(c\sin + \tan s_0 l_0 \cos)sy\,(c\sin - \tan s_0 l_0 \cos)s(l-x)}{(c^2+\tan^2 s_0 l_0)\sin sl}\frac{sQ}{S} \qquad (174)$$

instead of (172) above.

Developing this by the expansion theorem, let U be the regular part, and W the extra part. Then we get

$$U = \frac{2Q}{Sl}\sum \frac{(c\sin + \tan s_0 l_0 \cos)sy\,.\,(c\sin + \tan s_0 l_0 \cos)sx}{c^2+\tan^2 s_0 l_0}\epsilon^{pt}, \qquad (175)$$

in which $\sin sl = 0$, or $sl = \pi$, 2π, &c. And, in addition,

$$W = \frac{Q}{S}\Sigma \frac{c\epsilon^{q(x+y-l)}\epsilon^{pt}}{(1-c^2)q_0 l_0 \operatorname{shin} ql}, \qquad (176)$$

the notation being as in § 307, equations (161) or (163) finding the values of q_0. The unit impulsive function is the sum of U and W, with $t=0$, and $Q/S = 1$. The U part subsides to equilibrium, whilst the W part increases with the time.

Simplify by taking $f=1$, making $RSl^2 = R_0 S_0 l_0^2$, and $ql = q_0 l_0$. The unit impulsive function becomes

$$u = \frac{2}{l}\Sigma \sin sy \sin sx + \Sigma \frac{c}{l(1-c^2)}\frac{\epsilon^{q(x+y)}}{\epsilon^{q_0 l_0}\operatorname{shin} q_0 l_0}. \qquad (177)$$

Here the first part expresses the unit function concentrated at the point $x=y$, with repetitions outside the limits concerned, which do not count. We conclude that the rest represents zero between the same limits. The verification is easy, because the simplification made by assuming $f=1$ allows of the reduction of the extra part to a recognisable form. The extra part of u, say u_2, is

$$u_2 = \frac{1}{l(1+c)}\Sigma \exp\left\{(\lambda + in\pi)\frac{x+y}{l}\right\}, \qquad (178)$$

where n has all integral values, positive, negative, and zero. Or, which is the same,

$$u_2 = \frac{\epsilon^{\lambda(x+y)/l}}{l(1+c)}\left\{1 + 2\Sigma_1^\infty \cos\frac{n\pi}{l}(x+y)\right\}. \qquad (179)$$

This, by § 271, represents a row of impulses (not of unit size) outside the limits in question. Within the limits, therefore, u_2 is zero, as required.

Let u become v when t is finite. Then

$$v_1 = \frac{2}{l}\Sigma_1^\infty \sin\frac{n\pi y}{l}\sin\frac{n\pi x}{l}\epsilon^{-Ht}, \qquad (180)$$

where H is $n^2\pi^2/RSl^2$, and the summation is with respect to n. And for the extras, we have

$$\epsilon^{q(x+y)}\epsilon^{pt} = \exp\left\{(\lambda + in\pi)\frac{x+y}{l} + \frac{t}{RSl^2}(\lambda^2 - n^2\pi^2 + 2in\pi\lambda)\right\}, \qquad (181)$$

which makes

$$v_2 = \frac{\epsilon^F}{l(1+c)}\left\{1 + 2\Sigma_1^\infty \cos n\pi G\,.\,\epsilon^{-Ht}\right\}, \qquad (182)$$

where H is as before, and, for brevity, additional letters F, G are introduced, given by

$$F = \frac{\lambda(x+y)}{l} + \frac{\lambda^2 t}{RSl^2}, \qquad G = \frac{x+y}{l} + \frac{2\lambda t}{RSl^2}. \qquad (183)$$

Whilst v_1 subsides to zero, v_2 augments. In the singular case of failure, real or apparent, which occurs when $c=1$, the extra part v_2 jumps from zero to infiniteness instantly.

§ 309. Returning now to real electrical conditions, one of the minor matters that remains to be considered is the influence of the terminal arrangements on the state of the cable, when they are initially energised. The existence of auxiliary functions, one for every independent kind of energisation, has been pointed out. Also how, by means of the conjugate property of complete normal systems, their size may be determined. But the example given in § 295, relating to a terminal condenser, and the later examples, were not sufficiently general to illustrate the matter fully. So now take some other arrangements.

Say the $x=l$ end of the cable is earthed. Then $Z_1 = 0$, and,

$$v_1 = -\sin s(l-x)\frac{(R\sin + Z_0 s\cos)sy}{(R\sin + Z_0 s\cos)sl}\frac{sQ}{S} \qquad (184)$$

is the potential at $x\,(>y)$ due to Q at y. Interchanging x and y makes the potential at $x\,(<y)$ due to Q at y. Differentiating the new expression with respect to x and dividing by $-R$ produces the expression for the current on the left side of y. Put $x=0$ in it. The result is

$$C_0 = \frac{\sin s(l-y)}{(R\sin + Z_0 s\cos)sl}\frac{s^2 Q}{S}. \qquad (185)$$

This is, therefore, the total current in Z_0 due to Q, reckoned from left to right.

We conclude, by reciprocity, that a current momentarily established in Z_0 will produce potential at y, determined by the same operator as is concerned in (186), when there is magnetic inertia in Z_0. This is easily corroborated. Put an impressed voltage e at $x=0$. The C due to it, on the spot, that is, in Z_0, is

$$C = \frac{e}{Z_0 + (R/s)\tan sl} = \frac{e}{Z} \text{ say}, \qquad (186)$$

because the denominator is the sum of the resistance operators to right and left of e. This expands, when e is steady, to

$$C = \Sigma \frac{e\epsilon^{pt}}{p\dfrac{dZ}{dp}}, \qquad (187)$$

ranging over the roots of $Z=0$.

But let e be impulsive, say $= pL_0C_0$, so that L_0C_0 is the momentum generated. Then

$$C = \frac{p}{Z}L_0C_0 = L_0C_0\Sigma\frac{\epsilon^{pt}}{dZ/dp}. \qquad (188)$$

Putting $t=0$ makes the initial state. So

$$C_0 = \Sigma\frac{L_0C_0}{dZ/dp} \qquad (189)$$

must be the expansion of C_0, regarded as initially given to be the current in Z_0.

Also, the potential at x due to e is got by putting L_0pC_0 for e in (59), and $Z_1 = 0$. This makes

$$V = \frac{p\sin s(l-x)}{(Zs/R)\cos sl}L_0C_0, \qquad (190)$$

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operationally, or

$$V=\Sigma\frac{L_0C_0R\sin s(l-x)}{\cos sl\,(dZ/dp)}\epsilon^{pt}, \qquad (191)$$

by the expansion theorem. From this, again, (189) may be derived. It will be convenient to consider Z_0 to be R_0+L_0p in the above, meaning a coil of resistance R_0 and inductance L_0. At the initial moment, therefore, (191) is the zero expansion required to suit the case of an energised coil, an expansion in a Fourier series representing zero within the limits, such that V shows what it becomes at time t later, as the coil discharges itself into the cable.

Next consider the same matter from another point of view, viz., that of independent normal systems. Put

$$v=\sin s(l-x), \qquad c=\frac{s}{R}\cos s(l-x). \qquad (192)$$

Since $v=0$ at $x=l$, these are the proper normal functions for V and C in the cable, provided s is suitably determined to satisfy $v/c=-Z_0$ at $x=0$. That is,

$$Z_0+\frac{R}{s}\tan sl=0=Z \qquad (193)$$

is the determinantal equation. Provided, then, we include every possible normal system subject to the last equations, we see that the initial state is fully specifiable by

$$V_0=\Sigma Av=\Sigma A\sin s(l-x), \qquad (194)$$

$$C_0=\Sigma Ac=\Sigma A\frac{s}{R}\cos sl, \qquad (195)$$

where A is a constant. Given V_0 and C_0, the conjugate property finds A. That property asserts that

$$S\int_0^l v_mv_n dx-L_0c_mc_n=0, \qquad (196)$$

where v_m, v_n are any two normal systems of potential, and c_m, c_n the currents to match at $x=0$, because there is magnetic energy in the coil, and electric in the cable. It follows that

$$A=\frac{S\int V_0v dx-L_0C_0c}{S\int v^2dx-L_0c^2} \qquad (197)$$

finds the coefficient A belonging to any system v, c when V_0 is given as a function of x, and C_0 has any value we like.

Attending only to the part dependent upon C_0, the result is

$$A=\frac{-L_0C_0\frac{s}{R}\cos sl}{S\left(\frac{l}{2}-\frac{\sin 2sl}{4s}\right)-L_0\left(\frac{s}{R}\cos sl\right)^2}, \qquad (198)$$

which, used in (194), completes the solution so far as C_0 is concerned, since the state at time t is deducible by the introduction of the time factor. It will be found that the solution thus got agrees with the former one, viz. (191), on expanding dZ/dp. Also, that (195) agrees with (189). As regards the conjugate property (196) which has been used, its proof is to be found in testing that it is true, when the proper expressions for v and c are used. This remark applies in all expansions in normal functions. I shall, however, give later a general proof of the property.

In the numerical execution of the above case, it may be as well to remark that there is sometimes a pair of imaginaries concerned in the determinantal equation, which might be overlooked, if we merely drew the curves

$$y_1=\tan sl, \quad y_2=(-s/R)Z_0, \qquad (199)$$

and determined the roots by their intersections.

§ 310. Now take a case in which both kinds of terminal energy are concerned. Say

$$Z_0=R_0+L_0p+\frac{1}{S_0p}, \quad Z_1=0, \qquad (200)$$

so that there are a coil and a condenser in sequence at $x=0$. The determinantal equation is

$$Z=0=\frac{R}{s}\tan sl+R_0+L_0p+\frac{1}{S_0p}, \qquad (201)$$

where $p=-s^2/RS$, as usual. Taking the normal functions as before, equation (192), the current at $x=0$ is the current in the coil. Therefore (195) is the expression for one of the terminal arbitraries—viz., the initial current in the coil. The other arbitrary is the charge (or the potential) of the condenser. Say that the condenser is next the earth, and that its potential is v_1 in a normal system and V_1 altogether. We have

$$v_1-v=(R_0+L_0p)c, \qquad (202)$$

where v and c belong to the terminal of the cable, and also

$$v_1=-\frac{c}{S_0p}, \qquad (203)$$

these being the equations of voltage for the coil and condenser respectively. So

$$v_1=\sin sl+(R_0+L_0p)\frac{s}{R}\cos sl \qquad (204)$$

is the normal function for v_1. This may, by (201), be simplified to

$$v_1=\frac{S}{S_0s}\cos sl. \qquad (205)$$

The initial state is therefore fully expressible by

$$V_0=\Sigma Av, \qquad C_0=\Sigma Ac, \qquad V_1=\Sigma Av_1, \qquad (206)$$

where A is a constant, the same constant for every three connected functions, but differing in the different complete systems. Given, then, V_0 as a function of x, and C_0 and V_1 arbitrarily, we evaluate any coefficient A by

$$A=\frac{S\int V_0v dx+S_0V_1v_1-L_0C_0c}{S\int v^2dx+S_0v_1^2-L_0c^2}, \qquad (207)$$

because the conjugate property is

$$0=S\int v_mv_n dx+S_0v_{1m}v_{1n}-L_0c_mc_n, \qquad (208)$$

the terminal energies being of different kinds. When $L_0=0$, the value of C_0 ceases to have any influence on the value of A, as we see by (207), although the expression

$$C_0=\Sigma Ac\,\epsilon^{pt} \qquad (209)$$

remains in force, for any finite value of the time.

§ 311. If the condenser and the coil are in parallel, the case is somewhat different. We now have

$$Z=0=\frac{R}{S}\tan sl+\left(S_0p+\frac{1}{R_0+L_0p}\right)^{-1}, \qquad (210)$$

because the resistance operator Z_0 is the reciprocal of the sum of the reciprocals of the resistance operators of the coil and condenser; or the conductance operator is the sum of the separate conductance operators.

The potential v at the terminal of the cable in a normal system is the potential v_1 of the condenser, so

$$V_1=\Sigma Av=\Sigma A\sin sl \qquad (211)$$

expresses one of the terminal arbitraries.

But only a part of the cable current enters the coil, so it is not the full current c that is concerned in the other arbitrary. We have

$$c_0=-\frac{v}{R_0+L_0p}, \qquad (212)$$

if c_0 is the proper function to associate with v. Therefore

$$C_0=-\Sigma\frac{A\sin sl}{R_0+L_0p} \qquad (213)$$

is the expression for the current in the coil initially.

But to determine A to suit the initial circumstances, we may still use the formula (207), taking care, however, to use the proper expressions of the present case for v, v_1 and c. The last has now become the c_0 in (212), whilst v_1 is to be the v in (211).

§ 312. If the terminal arrangement consists of two coils in sequence, there is but one auxiliary function, because the current is constrained to be the same in both coils. Suppose e is an impressed voltage, and there is mutual inductance m between the coils r_1, l_1 and r_2, l_2. The equation of voltage is

$$e=(r_1+l_1p)c_1+mpc_2+(r_2+l_2p)c_2+mpc_1, \qquad (214)$$

where c_1 and c_2 are the currents. Both being equal to c, say, this reduces to

$$e=(r_1+r_2)c+(l_1+l_2+2m)pc, \qquad (215)$$

the same as for a single coil. So there is nothing new here.

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But if the coils are in parallel, there are two arbitraries. For we shall now have

$$e=(r_1+l_1p)c_1+mpc_2, \quad (216)$$

$$e=(r_2+l_2p)c_2+mpc_1; \quad (217)$$

from which the resistance operator of the combinations and the separate ones have to be deduced. Solve for the currents thus:—

$$\frac{c_1}{e}=\frac{(r_2+l_2p)-mp}{(r_1+l_1p)(r_2+l_2p)-m^2p^2}, \quad \frac{c_2}{e}=\frac{(r_1+l_1p)-mp}{(r_1+l_1p)(r_2+l_2p)-m^2p^2}. \quad (218)$$

These are the conductance operators separately. Their sum is the conductance operator of the combination. Its reciprocal is the resistance operator. Therefore

$$Z_0=\frac{(r_1+l_1p)(r_2+l_2p)-m^2p^2}{r_1+r_2+(l_1+l_2-2m)p} \quad (219)$$

is the required Z_0, to be used in the determinantal equation. Also, the previous equations for c_1 and c_2 give the proper normal functions for them in terms of e, which becomes $-v$, the normal function for the potential at the cable end. Thus determined, the two arbitraries are ΣAc_1 and ΣAc_2, to be associated with ΣAv, expressing the potential in the cable.

In determining A by the conjugate property, m must not be forgotten. Twice the energy of c_1 and c_2 is

$$l_1c_1^2+l_2c_2^2+2mc_1c_2=F, \text{ say,} \quad (220)$$

or

$$(lc_1+mc_2)c_1+(lc_2+mc_1)c_2; \quad (221)$$

and the mutual energy of C_1, C_2 and c_1, c_2 is

$$(lc_1+mc_2)C_1+(lc_2+mc_1)C_2=G, \text{ say.} \quad (222)$$

Consequently, given V_0 along the cable, and also the values of C_0 and C_1 initially, the value of A is

$$A=\frac{S\int V_0v\,dx-G}{S\int v^2dx-F}, \quad (223)$$

which renders the solution of the problem complete, when the normal potential function v for the cable is properly determined to suit Z_0, as in (218). The principle underlying these determinations is quite a simple one, and may be applied to the most complicated cases.

(To be continued.)

COVENTRY AND DISTRICT ELECTRIC TRAMWAYS.

It is now more than two years since the cessation of the steam tramways in Coventry. Prior to the starting of those trams a name had already been won for itself by Coventry in the annals of tramway traction, for it was over identically the same route as the present six-mile electric line between that town and Bedworth that, so long ago as 1811, a stone tramway had been built, this now antiquated pattern of line then extending from Coventry to Nuneaton. The subsequent steam tramways need not concern us much, except that the present rails were formerly laid for that system, and that a very small portion of the old steam plant has been retained for use at the electric generating station. It is little, if any, wonder that the steam-driven cars should have gone out of existence; and it is greatly to be hoped, if not reasonably to be expected, that their failure arose from their inherent defects, and not from local conditions of traffic. Rarely, indeed, can a line of tramways come into existence that does not put itself into competition with, and find a serious competitor in, some existing method or methods of locomotion. Usually it is a line of 'buses, or a railway, or the poverty which makes people walk; but at Coventry it is little of these by comparison with the bicycle and the tricycle. In that district almost everyone, without distinction of age or sex, is a devotee of the wheel; and, after traversing the route and noting the conditions, we feel sure that it is the cycle which will be the most serious competitor with the electric line shortly to be put in operation between Coventry and the suburban semi-rural districts extending to Foleshill and Bedworth.

At the present time the whole of the generating house and the car sheds are equipped and in working order, the six miles of track are almost completely equipped with the trolley poles, conductors, &c., and four of the old cars have been converted into motor cars, four new motor cars have been built, while two of the old cars have been fitted up as trailers, for use on market days and in times of excessive traffic. The inspection by the Board of Trade is now impending, and the line will be opened for traffic immediately after the sanction of that authority has been obtained.

From the earliest stage it had been intended to adopt the overhead trolley system, and in May last it was definitely decided to have the Westinghouse system, the contract for the electrical and generating plant and equipment being given to the General Traction Company, of Westminster.

The style of construction adopted by these contractors very closely follows the American model, differing from it only where this is made necessary by the regulations of the Board of Trade; and a considerable portion of the plant has been made in the United States. The generating station, with adjoining car sheds, is situated at Foleshill, about mid-way between the termini of the line. It is a substantial brick structure, of airy proportions and well lighted, by means of skylights and windows in the daytime and by inverted arcs and numerous glow lamps at night. The ground plan of the various rooms is shown in Fig. 1, and this drawing also shows the position of the plant. The boiler house, the floor of which is 3ft. below the level of the engine-room floor, contains two Babcock-Wilcox boilers, each capable of developing steam for about 100 H.P. These boilers are mechanically stoked by two Babcock-Wilcox automatic coking stokers, which are driven by a small Sturtevant vertical steam engine in the machinery room. This engine also drives a countershaft, from which a number of machine tools obtain power. Feed water is derived from a neighbouring canal, and is pumped into the station by a Worthington and a Hatton steam pump, the latter having been used formerly for raising water for the steam locomotives.

Ascending a short flight of steps, we pass into the machinery room. The equipment of this room has been arranged with a view to minimise the costs of attendance and superintendence; and with the same object in view, each detail of the plant has been solidly and simply built, so as to be capable of being run by an ordinary mechanic. To this end, the machine tools for the repairs, the auxiliary machinery and the store room have all been brought into the machinery room, and are all exposed to the view of one man in charge. Further to simplify attendance, each of the two traction power generators (but not the smaller dynamo for lighting) is surmounted by six pilot lamps connected in series to the brushes of the machine. The purpose of these seems to be to minimise the need for looking at the voltmeters on the switchboard.

There are two sets of generators for the tramcar service, each of which is capable of taking the ordinary load. Each set comprises a single cylinder, horizontal, non-condensing steam engine, built by Messrs. Browett and Lindley, belt-coupled to a 4-pole Westinghouse railway generator. Fig. 2 shows the general construction of the steam engines, the most striking feature in which is the two heavy flywheels on opposite ends of the crankshaft. This unusually massive construction is designed to enable the engines to take the excessive and momentary rises in load, which are a peculiarity of traction station work; and they are rendered necessary by the fact of there being no electrical storage plant. Changes of load are, however, also taken by the steam, the engine being provided with a prompt automatic cut-off governor, which will give steam on occasion up to half-stroke. The normal and most economical load is at quarter-stroke cut-off, and at this each engine develops about 120 H.P. The cylinders are 13in. in diameter, and the stroke is 13in. The normal steam pressure is about 100lb. At half-stroke cut-off, about 150 H.P. will be developed by each engine. An exhaust-steam feed heater stands beside the engines, after passing through which the exhaust steam is discharged through a pipe outside the building. Fig. 3 shows the type of railway generator used. Each of the two machines of this type is built to develop 200

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amperes at 500 volts, when running at 625 revolutions. The machines are provided with ironclad armatures, and carbon brushes are used. In addition to these two generators, there is a 5-kilowatt Immisch 100-volt dynamo, driven by a Sturtevant vertical steam engine, for the inverted arcs in the machinery room and car sheds, and for the glow lamps which are not used as pilot lamps.

at the bottom, and a Weston station voltmeter, which now has been placed in the top row. The top row includes two gravity ammeters for the generators; in the second row are the automatic circuit-breakers and a gravity station ammeter; and below are the switches, regulators and recording voltmeters.

Eight motor cars and two trailers will constitute the rolling stock. The motor cars are carried upon Peckham cantilever

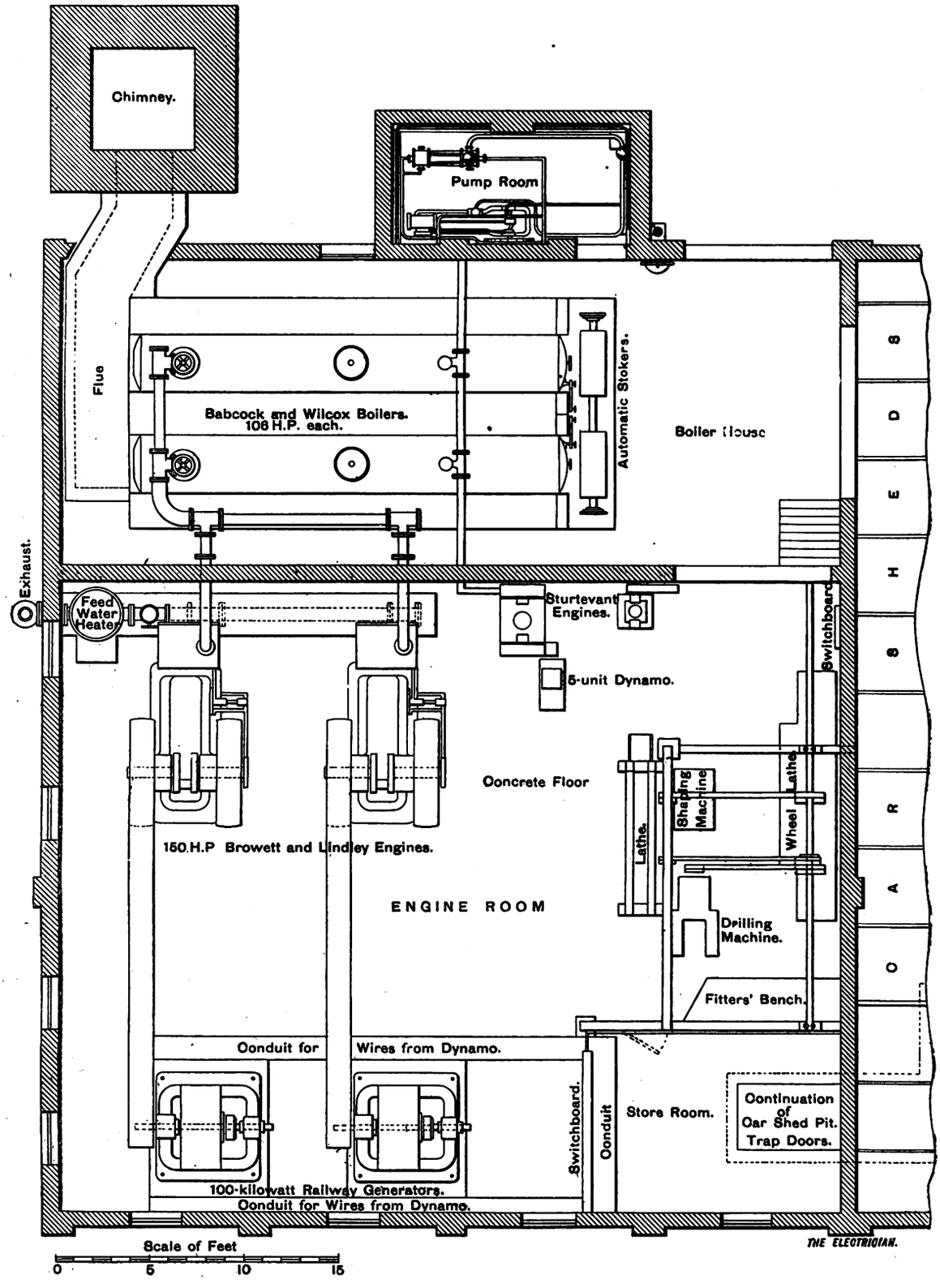

FIG. 1.—Plan of Coventry and District Electric Tramways Power Station.

The switchboard for the traction generators is built into one side of the iron-framed store room, and all the instruments are mounted on white marble slabs. Fig. 4 shows the switchboard equipment, with the exception of the two earth-current indicators, which will shortly be placed on the two vacant panels

trucks, of American manufacture, a view of one of which is shown in Fig. 5. Each truck is fitted with two 4-pole Westinghouse motors of the No. 12 type, each motor being built for a maximum load of 25 H.P. The 4-pole arrangement permits of the two brushes being placed near the top of the commu-

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tator (at 90deg. apart); and ready access to these is gained through a trap-door in the car floor, and by lifting a flap on the motor cover. The motors are geared by single reduction, oil-boxed, spur gear to the truck axles, the gear being of cut steel. A reduction ratio of 4·68 is obtained with the gear. A series-parallel controller is placed on the platform at each end of the car. In addition, the platform is equipped with a hand-ratchet brake, and with a foot-gong. Each car carries 11 glow lamps of 16 c.p. each, but 10 of which will be lit simultaneously. The lamps in use at any time will be coupled in sets of five in series across the trolley circuit. It has been found both in America and in this country that the plentiful illumination always to be found in trolley cars is a strong

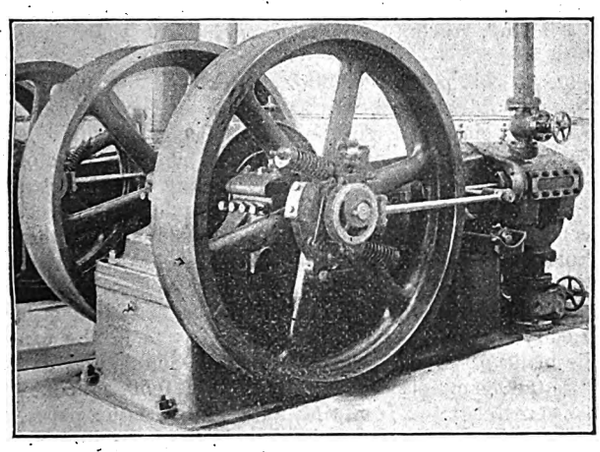

FIG. 2.—Coventry Electric Tramways. Browett-Lindley Engine.

inducement to ride in them; and in more than one place passengers are in the habit of changing from the 'bus to the trolley car at the starting-place of the latter. The Coventry cars carry four glow lamps for the deck passengers. The capacity of the new cars is 40 passengers; but the converted cars and the trailers will take 50 persons each.

The main portion of the route is of single track; but there are no less than 27 turn-outs, some of considerable length. The general character of the route may be described as undulating, with no very sharp curves, but with several steep

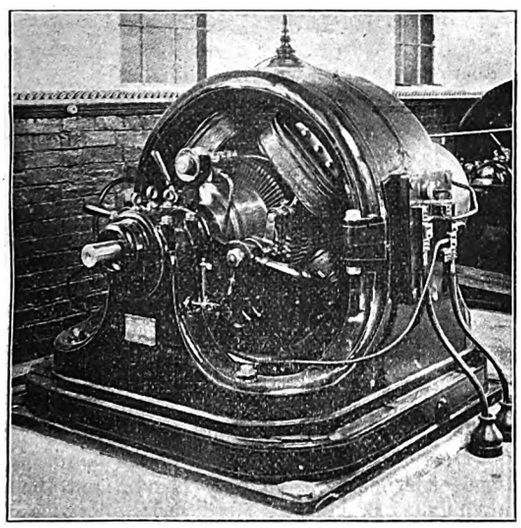

FIG. 3.—Coventry Electric Tramways. Westinghouse Dynamo.

gradients, the maximum gradient being 1 in 16. The old rails throughout have been retained, and have been bonded on the Chicago plan. There are no special cross-connections, as the bonds at the numerous turn-outs sufficiently answer the purpose. With so many turn-outs in no more than six miles of track, it has been decided to duplicate the trolley line almost throughout its length, instead of putting a frog at the in-turn and out-turn of each passing place. The object has been to save the time which would otherwise be wasted in passing the frogs, owing to the necessity for going slowly under such a device. The trolley wires are mainly held in position by means of span wires, from which they depend, and to which they are attached by "Ætna" insulator hangers. Along the country roads the span wires are fixed to steel poles, which are placed along both sides of the vehicular way at intervals of about 50ft. In the

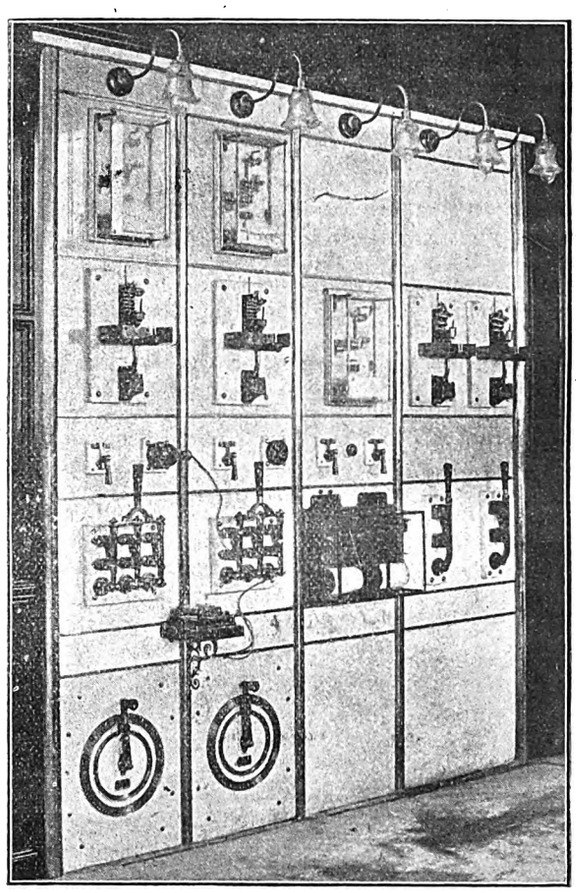

FIG. 4.—Coventry Electric Tramways. Switchboard.

narrower streets of the town these poles have been dispensed with, and the span wires are attached to insulated wall-plugs. Each of these plugs is provided with an india-rubber pad or cushion for silencing the noise of the trolleys. Over a comparatively short portion of the route, at the Coventry end, a single trolley wire, supported by single brackets on steel poles,

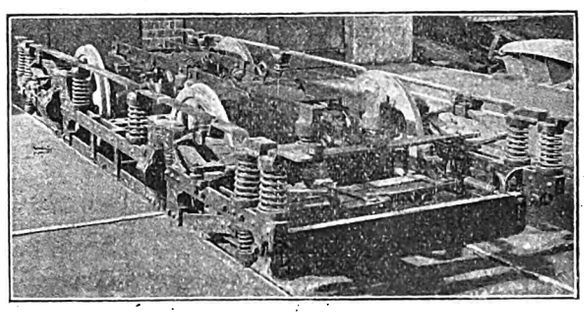

FIG. 5.—Coventry Electric Tramways. Motor Truck.

is used. The feeder for the sections of the line—these sections being in half-mile lengths—is, over the greater part of the route, carried on the tops of one line of poles, but in the narrower and busier streets of the town it is placed underground.

Our thanks are due to Mr. J. E. Winslow, the chief engineer to the General Traction Company, and to Mr. H. Lavington Fletcher, the resident engineer in charge of the construction work, for their kindness in placing information and photographs, &c., at our disposal.

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THE HYSTERESIS OF IRON IN AN ALTERNATING MAGNETIC FIELD.*

BY FRANCIS G. BAILY, M.A., A.M.I.E.E.

The hysteresis of iron, when exposed to an alternating field of magnetic force, shows at low induction a continuously increasing value, which has been stated by Mr. Steinmetz to be approximately proportional to the 1·6th power of the induction. The more accurate experiments of Prof. Ewing by his ballistic method show that this expression can be taken only as giving a general average over a part of the curve, and not as an accurate interpretation of the true function. But the ballistic method of testing iron arranged in the form of a continuously-wound ring, though very accurate, does not permit of the use of high magnetising forces, and falls far short of the saturation of the iron.

From a consideration of the theory of the cause of hysteresis, it seems probable that there will be no hysteresis in those changes of induction during which the iron is completely in the saturated condition, since the molecules are maintained rigidly in one position throughout. Therefore the hysteresis loss in a complete cycle, when slowly performed, will reach a maximum value at which it will remain constant for all values of the induction above that of saturation. Thus, in Fig. 1, if A is the point beyond which the iron is saturated, the area of the closed curve gives the maximum value of the hysteresis, and increase of the induction to B or beyond will not result in any change in the hysteresis. This point has not been proved experimentally, but there can be little ground for doubting it.

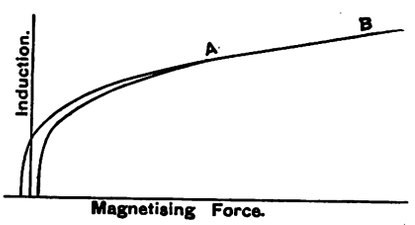

FIG. 1.—Hysteresis Curve with High Magnetising Force.

When the iron is placed in a rapidly alternating field, at a speed comparable with that of commercial alternating currents, the conditions are somewhat different. In such a magnetic field the induction will pass through alternately reversed maximum values, and as the magnetising forces are increased beyond the point of saturation the intensity of magnetisation will stay constant at its saturation value for a gradually increasing portion of each half-cycle. Hence the slope of the curve representing the change of magnetisation will become steeper at the two ends, the rate of change of magnetisation becoming greater.

At slow speeds the hysteresis, as stated above, is probably constant, but at high speeds it is possible that the increase in the rapidity of motion of the molecules may increase the energy of their vibrations as they swing into new combinations, and hence the hysteresis will be increased notwithstanding the saturation. The point depends on the effect of speed on hysteresis, which has not been very fully worked out. Experiments on soft-iron wires by Tanakadaté (*Phil. Mag.*, 1889), though not rigidly accurate, tend to show that up to 400 cycles per second the hysteresis per cycle is practically unchanged, and experiments of the author's, not yet published, confirm the result. The work of Steinmetz and of A. Siemens, in which a different result was obtained, does not seem reliable on this question, some of the results of the former experimenter being contradictory. If the problem is considered from a theoretical point of view, it seems probable that there will be very little, if any, change due to speed in hysteresis for a given value of the induction. Experiments with exceedingly rapid alternations show that iron molecules respond with great facility to rapid changes of field, and that the molecules exert a mutual action producing hysteresis. The time lag of magnetisation is therefore very small in the magnitude of its effect, although other experiments show that it is not small in the duration of its time of action. Moreover, the time of vibration of these molecular magnets must be enormously higher than a few hundreds per second, and hence nothing of the nature of synchronism can occur. Therefore the vibration caused by each cycle will be transmitted to neighbouring particles, or, in other words, disseminated as heat before the commencement of the next cycle, and changes in the speed of alternation, being of a different order of magnitude to the vibrations of the molecules, will be without sensible influence on them. On this view the same law of hysteresis should hold in a rapidly alternating field as in one of very slow change, and the curve of hysteresis and induction should show a flexure, reaching a maximum, and after that remaining constant.

To prove this point the following experiments were undertaken. In order to obtain a strong field the "isthmus" method was employed, the hysteresis being measured calorimetrically by the rise in temperature in a given time of the sample of iron under test in an alternating field of constant frequency. The apparatus consisted in a laminated iron electro-magnet built of soft charcoal iron sheets 0·25mm. in thickness, the pole-pieces being pyramid-shaped with flat ends, between which the sample was placed, as shown in Figs. 2, 3 and 4 The sample under test was very finely laminated in order to avoid eddy currents as far as possible. It was in the form of a cube made of 73 plates of thickness 0·085mm. and average breadth 0·808cm., giving a total area of 0·50 sq. cm. The plates were insulated from one another by tissue paper, the whole being soaked in shellac varnish, thus forming a solid cube. A single layer of silk tape covered the plates, and over this was wound a coil of 33 turns in a single layer. This was then covered with sheet cork $\frac{1}{16}$in. thick, and over this a second coil was wound of 22 turns. A second layer of cork was added, and the whole was coated with melted shellac. The two ends which had been left exposed were carefully faced, and a thin layer of cork was cemented on and coated with shellac. The section is shown in Fig. 5. The dimensions of the armature were as follows:—

Number of plates	= 73.
Thickness of plates	= 0·085mm.
Breadth of plates	= 0·808cm.
Area of iron	= 0·50 sq. cm.
Length of iron	= 0·9cm.
Size of wire in coils	= 0·12mm. diameter.
Number of turns in inner coil	= 33.
Area of inner coil	= 0·78 sq. cm.
Area of non-magnetic material	= 0·28 sq. cm.
Number of turns in outer coil	= 22.
Area of outer coil	= 1·61 sq. cm.

Difference of area of inner and outer coils = 0·83 sq. cm.

Between the inner layer of silk and the iron was placed a thermo-electric junction of a copper and German silver wire in contact with the iron.

The sample was placed in a small flat box, with ivory sides, against which the cork-protected ends of the sample abutted, and the box was then packed with cotton wool and placed between the poles of the electro-magnet. The armature was thus maintained always in the same condition, so that its capacity for heat remained the same throughout the experiments. The loss of heat from the sides of the sample was very small, as the experiment lasted only 1½min., and the rise in temperature did not exceed 25°C. Moreover, the cork lagging had a low specific heat and very low thermal conductivity, and the leading-in wires were extremely small. But it was found that at the ends, where the protective covering was thinner and was pressed against the pole-pieces, the transference of heat was too great to be neglected. In order to avoid this error the pole-pieces were maintained at the same temperature as the armature during the experiment by causing a stream of hot or cold paraffin oil to flow over the pole-pieces as required, the least difference of temperature being indicated by thermo-electric junctions in the pole-pieces connected to the one in the armature. By this means a very close agreement could be maintained, and any error caused was not always in the same

* Paper read before the British Association at Ipswich, Section A.

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direction. A stream of cold paraffin was used to cool the apparatus between successive tests. By the use of paraffin oil as a cooling agent no precautions were required to prevent the liquid reaching the exciting coil, which was in fact immersed in a bath of the oil. The armature was protected by its box from any contact with the liquid.

The rise in temperature was measured by connecting the thermo-electric circuit to a d'Arsonval galvanometer, which being on closed circuit was dead-beat, and gave accurate and instantaneous readings. The alternating current was taken from a dynamo, the speed of alternation being kept constant at 103 periods per second. The maximum E.M.F. was 800 volts and the maximum current was 8·5 amperes. In performing the test, the current was turned on for 1½ minutes, and the increase of deflection of the galvanometer was read at the end, the rise in temperature of the pole-pieces and armature being kept equal during this time, as described above.

The determination of the maximum value of the induction was made by means of the search coils on the armature. In the coil

$$\text{Mean E.M.F} = 4\,(B_i A_i + B_a A_a)\,m\,n,$$

where B_i is the maximum value of the induction in the iron, A_i is the area of the iron, and $B_a A_a$ the values for the air

Electro-Magnet for Alternating Currents.

FIG. 2.—Side elevation, ¼ full size.

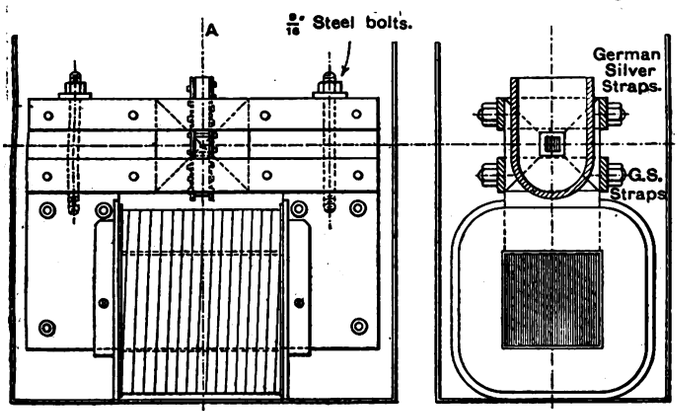

FIG. 4.—Plan of magnet.

FIG. 3.—Section through A.B.

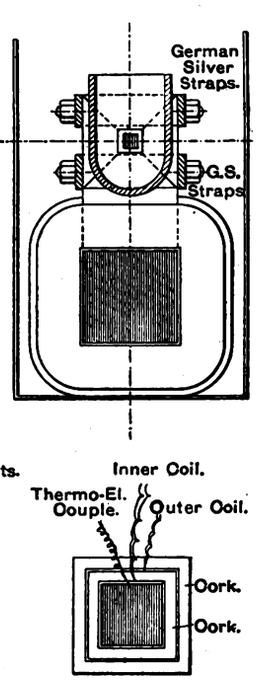

FIG. 5.—Section of armature. Full Size.

spaces, paper, &c. This is independent of the form of the curve dB/dt. Now in a circuit of large self-induction and small resistance, the counter E.M.F. follows almost exactly the impressed E.M.F., and the secondary E.M.F. induced in the search coils will also follow the same law. Hence their effects on a galvanometer will be the same and can be compared. By means of a soft iron-galvanometer, the current induced in the search coils through a known non-inductive resistance was compared to the current through a known non-inductive resistance from the terminals of one of the coils of the dynamo, the voltage of which was measured on a Cardew voltmeter. The E.M.F. curve of the dynamo was tested by the momentary contact method, and the ratio between the mean value of the E.M.F., and the square root of the mean square of the volts, as given by the voltmeter was calculated. It was found to be practically the same with different loads, so that the same constant could be used for all values of the current. The ratio was found to be 0·75, owing to the curve of the alternator being more peaked than the sinoidal form. In order to avoid any possible change in the galvanometer, each reading was calibrated immediately, by inserting resistances in the circuit from the alternator coil until the deflection was the same as that given by the search coil, the reading of the voltmeter being noted. By this method the E.M.F. induced in the search coil was compared directly with a known E.M.F. It is then easy to calculate the induction in the search coil.

If N is the total number of lines of force in the inner coil, N' is the total number of lines of force in the outer coil, R_1 R_1' are the resistances of the search-coil circuits, R_2 R_2' the resistances required to reduce the deflections of the dynamo coil to the values given by the search coils, V is the voltage of the alternator coil, m m' the windings of the search coils, and n the frequency, then

$$N = \frac{0{\cdot}75\,V\,10^8}{4\,n\,m\,R_2} R_1,$$

$$N' = \frac{0{\cdot}75\,V\,10^8}{4\,n\,m'\,R_2'} R_1';$$

and if A A′ are the areas of the coils, the magnetising force

$$H = \frac{N' - N}{A' - A},$$

and induction in iron

$$B = \frac{N - A_a H}{A_i},$$

where A_a A_i are the areas of air and iron in the inner coil. In the experiments R_1 and R_1' were always made qual.

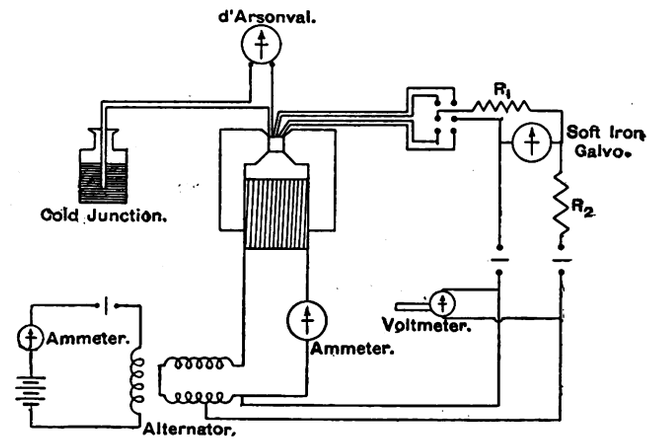

FIG. 6.—Diagram of Connections.

Owing to the change in the permeability of the iron the curves of dN/dt for the iron and the air will not be quite coincident, and this will introduce a small error in the estimation of the induction in the air. But as this only enters as a correction, the error in the value of the induction in the iron will be very small.

The galvanometer was a single-coil Thomson reflecting instrument of 10 ohms resistance and coefficient of self-induction $2{\cdot}24 \times 10^7$cm. The steel needle was replaced by a disc of soft iron placed at a small angle to the plane of the coil, so that the direction of motion was independent of the direction of the current. It carried the mirror, and was suspended by a fine platinum wire, which acted as the restoring force. A small aluminium vane, dipping in a bath of oil, damped the oscillations. With an additional 103 ohms in circuit, the impedance at 103 ∿ per second was 114 ohms. The galvanometer stood at a distance of 30ft. from the electro-magnet and 50ft. from the dynamo, so that it was quite free from all disturbances. All the leads from the armature to the galvanometer were very carefully stranded and insulated.

It may be of interest to mention that this galvanometer, though not of a form much in use, worked extremely well, giving very consistent readings when not touched, and being well adapted for the measurement of these small alternating currents. During each test readings were taken from each search coil, and calibrated from the dynamo coil.

In Fig. 6 is given a diagram of he connections with an enlarged diagram of the thermo-electri junctions in Fig. 7.

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Double-pole keys allowed of the insertion in the soft-iron galvanometer circuit of each of the two search coils and the alternator coil respectively. A three-way key (Fig. 7) made connection to the junctions in either pole-piece, and finally to the cold junction for the reading of the rise in temperature at the end of 1½ minutes.

After some preliminary trials to ascertain the reliability of the readings and to improve various details of the apparatus, a series of readings was taken with different values of the E.M.F. up to the maximum obtainable from the dynamo, each point being identified by two or more experiments. No attempt was made to obtain readings at low induction, since this part of the curve has been frequently examined by other methods. Moreover, it was found that at low induction the rise in temperature of the pole-pieces was much below that of the armature, and hence it was difficult to keep a balance of temperature, whereas at high induction the two parts heated up almost exactly together, rendering the equalisation very easy. The E.M.F. was varied by inserting a greater or smaller number of alternate coils in series, thus keeping the curve of the alternator E.M.F. unchanged in form.

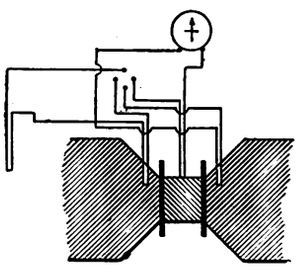

FIG. 7.—Thermo-Electric Junctions.

The differences in the values of R_2, R_2' and V in the same set of readings are caused by the fact that the winding of the magnetising coil was altered two or three times, and some of the repeated readings were made after the alterations. The calculated values of H and B were found to be in very close agreement.

The following table gives the readings and calculated results :—

—	R_1.	R_2.	R_2',	V.	Defl.	Mean values. N.	N'.	H.	B.	I.	Defl.
I.	114	9,900	13,400	116·0	5·0	7,700	8,200	600	15,400	1,180	6·0
	114	9,900	13,400	116·0	6·0						
	114	9,900	13,200	121·0	7·0						
II.	214	14,300	19,300	109·0	8·2	9,000	10,000	1,260	17,300	1,280	8·6
	214	14,000	19,000	108·0	9·0						
	214	14,300	19,300	109·0	8·5						
III.	214	12,300	16,500	105·0	9·5	10,100	11,400	1,300	1,900	1,410	9·8
	214	12,200	16,300	105·0	10·0						
	214	11,500	15,200	98·6	10·0						
IV.	214	9,400	12,300	86·0	11·5	10,800	12,400	1,850	20,600	1,490	11·3
	214	9,400	12,400	86·0	12·0						
	214	10,800	14,300	100·0	10·8						
	214	10,800	14,200	99·5	11·0						
V.	214	10,000	12,900	102·0	11·5	12,000	14.000	2,410	22,600	1,610	11·8
	214	10,000	12,900	101·5	12·0						
VI.	214	10,300	13,100	107·0	12·5	12,300	14,500	2,600	23,200	1,640	11·9
	214	10,400	13,300	109·0	11·5						
	214	10,700	14,000	111·0	13·0						
	214	10,700	13,800	111·5	12·0						
	214	10,700	13,700	111·0	11·5						
	214	10,800	13,800	112·0	11·0						

The results are plotted in Fig. 8, showing the relation between hysteresis and induction. In Fig. 9 is shown the relation between hysteresis and intensity of magnetisation, the latter being calculated from the expression $\mathsf{B} = \mathsf{H} + 4\pi\,\mathsf{I}$. It is probably not quite accurate, owing to the method of measuring H giving a somewhat excessive value for that quantity, but the general character of the curve is correct. The dotted portion of the curves are added from tests on another portion of the same sample of iron taken by the ballistic "return to maximum" method.

The results show clearly that there is a marked falling off in the rate of increase of the hysteresis as the saturation point is approached, the value at this point becoming practically constant. The calculated value of the intensity of magnetisation attained to is 1,640, a figure which is probably slightly below the real value. From Prof. Ewing's experiments the saturation value for soft iron is 1,660, so that the results are in good accordance.

The eddy currents have been neglected in the above curve, but a short calculation shows that they do not appreciably affect its shape. Taking J. J. Thomson's expression for eddy currents in thin plates in which the lines of force are in the plane of the plate, the power absorbed

$$= \frac{1{\cdot}67\,\mathsf{B}^2 n^2 t^2\, 10^{-16}}{\rho} \text{ watts},$$

where t is the thickness of the plate.

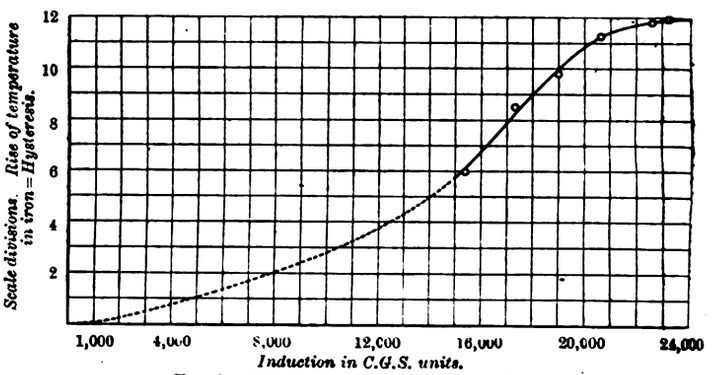

FIG. 8.—Hysteresis in Soft Charcoal Iron.
Alternating field, 103 ∿ per second.

The specific resistance of the sample was $1{\cdot}3 \times 10^{-5}$. Therefore the loss per cycle

$$= 1{\cdot}28\,\mathsf{B}^2\, n\, t^2\, 10^4 \text{ ergs},$$

where $\mathsf{B} = 23{,}200$, $n = 103$, $t = 0{\cdot}0085$cm.

$\mathsf{W} = 510$ ergs per cubic centimetre per cycle.

The maximum value of the hysteresis, calculated from the value obtained by the ballistic method, = 30,000 ergs approximately. Therefore the eddy-current loss at its maximum value is only 1·7 per cent. of the hysteresis loss, and is not greater than the unavoidable inaccuracies of the calorimeter method of measurement.

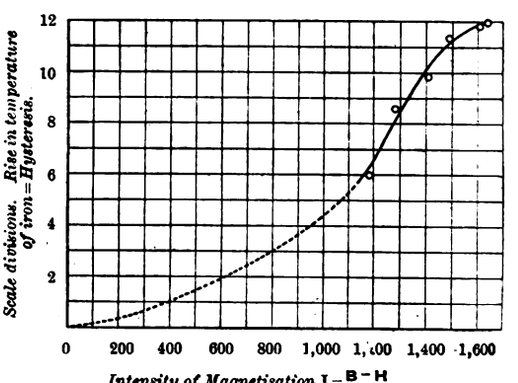

FIG. 9.—Hysteresis in Soft Charcoal Iron.
Alternating field, 103 ∿ per second.

With the dynamo power available, a further increase in the induction was not possible, but the author hopes to extend the experiment in order to obtain values of the hysteresis with induction beyond the saturation point, as it is possible that a small rise in the hysteresis may still occur.

The conclusion may, however, be drawn that the hysteresis in iron arrives substantially at a maximum when the iron becomes saturated, and that the function expressing the hysteresis in terms of the magnetic condition of the iron should depend not on induction, but on the intensity of magnetisation, with at most a small correction in terms of the former. The result accords well with Ewing's theory of magnetism, the third stage being very clearly marked. A reference to his Paper

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(*Proc.* Roy. Soc., and *The Electrician*, April 13, 1894) shows, however, that even at comparatively low induction Ewing had identified three distinct parts in the curve, the middle one from $B = 2,000$ to 8,000 having the smallest rate of increase, while from 8,000 to 14,000 the rate of increase of hysteresis is slightly greater. If this is the case an additional stage must be added from 15,000 to 23,000, in which the rate of increase becomes rapidly smaller, the point of flexure being, as is seen, at about the value $B = 15,000$. It is probable that the latter is the true third stage corresponding to the condition of the iron above the knee of the induction curve, and that the two stages from $B = 2,000 - 14,000$ really are a single stage corresponding to the condition of high permeability.

The above experiments were carried out in the electrotechnical laboratory at University College, Liverpool. The best thanks of the author are due to one of his students, Mr. D. S. Mitchel, and to his assistant, Mr. E. H. Morgan, for their valuable help in the work, and also to Messrs. Knight and Crowther for their kindness in specially rolling the very thin iron plates used.

LOCAL ANNEALING OF HARD-FACED ARMOUR PLATES.*

BY HERMANN LEMP, JUN.

Everyone is now more or less familiar with the Thomson electric welding process, which in past years has been introduced in almost every metal industry in one shape or another. This process created a new field in the technical application of currents of large volume and small E.M.F., a field which, while it was primarily intended for welding, naturally suggested a number of other applications to so fertile an inventor as Prof. Thomson; and so it happened that early in its fundamental inception the use of large currents was contemplated to be utilised for heating plain metal bars or parts of sheet billets, &c., for forging purposes, to rivet, upset, to temper or withdraw the temper, or to be worked upon in any well-known manner while being kept heated by the current.

It has been the good fortune of the writer lately to work out one of these novel applications, and since the literature concerning this branch of electrotechnics is somewhat limited, he has thought it advisable to bring an account of the same before the Institute.

One of the latest advances in the making of protective armour for battle-ships, or even forts, has been the introduction of what is known as the Harvey process. For those not conversant with the latter, I will briefly state that it consists in taking an ordinary low carbon steel plate and introducing an additional percentage of carbon into the surface metal, thus changing the crust to the depth of about an inch, into a steel resembling tool steel. A plate thus treated, is lastly water-hardened, similarly to an ordinary tool, and by experience has shown to offer, under equal conditions, more resistance to the impact of a projectile than any other armour known. And therefore we will take this as an illustration of hard-faced armour. The extreme hardness of the surface of a Harvey plate, while exceedingly valuable in preventing projectiles from piercing it, has a disadvantage when it is required to be pierced by a drill and tap. Such holes may be required either for fastening ladders, swivels, or other appliances to the hull of the vessel, or to fasten T-flanges supporting the deck to barbettes or turrets.

The methods heretofore used to produce these holes were principally two:—

1. To protect the surface of the plate in patches or strips, to prevent carburation, wherever holes were expected to be drilled.

2. To make accurate drawings and patterns of each plate beforehand, to which all holes are drilled before plate is hardened.

Plan No. 1 was practised in the United States until it had to be abandoned. In practice it was found that numerous alterations in construction, errors in either draughting room or mills, made it necessary to pierce holes where no provisions for annealing were made. It also happened quite frequently that the method for prevention of carburation did not always work satisfactorily, and while white paint indicated well enough where soft metal was expected, very often hard metal was actually found. Hence it was patent from the first that some process was needed to rectify errors of this kind. Experiments were then made with oxy-hydrogen blowpipe, or the electric arc, to anneal such spots as were required to be drilled, and numerous mechanical devices for drilling, with drills of every design and method of tempering, were tried, until it seemed that the case was without a remedy.

* Abstract of Paper read before the American Institute of Electrical Engineers.

It was at this stage that the problem was referred to the Thomson Electric Welding Company of Lynn, and experiments were immediately undertaken to solve it. The process and apparatus necessary to carry it out, all resulting from the experiments undertaken, will be described presently.

The second method, which is used in England, has the advantage over the first, that there is no difficulty in carrying it out, provided there are no alterations made and no errors committed. The present method of construction seems to be to make beforehand a complete *model* of the vessel to be built; then make accurate drawings and full-size patterns of every plate, giving the exact location of every hole. These are then bored, tapped and countersunk to a depth of approximately $\frac{3}{8}$in. and of a much larger diameter, filled with clay, and then the plate as a whole is heated and hardened with water (*see* Fig. 1).

This method works apparently all right, although in spite of drawings and models, errors are made. There is no doubt, however, that it is a slow and very costly method of working, and would hardly ever be resorted to in the United States.

From the above it seems clear that there has existed a need for a process by means of which isolated spots, regardless of location, might be annealed so as to permit drilling and tapping.

If, by sending a current of large volume through any spot thus to be treated, the spot is brought to a temperature of approximately 1,000°F., there can be no doubt that the temper has been withdrawn. Experiments carried to that effect at once showed, however, that upon taking off the heating current the heat was so rapidly conducted away by the surrounding metal masses as to cause the heated spot to become chilled just as effectually as if it had been plunged into cold water. No method of outside protection of the heated spot would prevent this, and the *gradual* cooling of the spot had to be attained by different means—namely, a gradual and slow withdrawal of the heating current. The method of introducing the annealing current is best shown Fig. 2.

Two copper contacts, C C, are cooled by water circulating inside. The current enters the plate by one end, and leaves it by the other. Right under the contact the metal comes to a bright cherry heat (shown in black), while the portion intervening and partly surrounding the contacts acquires a temperature of just a visible red. Line H H indicate where the influence of the Harvey treatment stops.

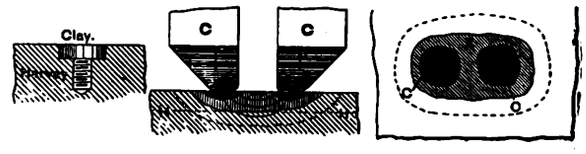

Fig. 1. Fig. 2. Fig. 3.

The shaded portions in Figs. 2 and 3 show the zone softened and ready to be machined, while the dotted line shows how far the heat radiation would cause the metal to turn blue. When cooled, the annealed portion shows a chocolate colour, while the place where the contacts have been resting is scaled and hard, and cannot be touched by a tool to a depth of about $\frac{1}{4}$in. These places can again be annealed later on, if required.

The apparatus necessary to carry out this process consists of the generator, the annealer proper (transformer) and the regulating apparatus.

The generator is commonly a separately excited alternator of variable potential, of a maximum of 300 volts and 100 amperes. The frequency, preferably, should be low, 50 cycles per second being used. When more than one annealer is to be run simultaneously from one generator, constant E.M.F. of the latter should be used, and each annealer regulated separately by a reactive coil. The annealer proper is a transformer similar to the well-known welding transformers. As the apparatus is to be operated outdoors, on board of vessels during construction, it is important that the same may be handled with immunity from electric shocks, even when operated in mist and rain.

To meet these conditions a copper-clad type of transformer is used, one in which the secondary is composed of two copper castings, each having a rectangular groove, which two halves, when bolted together, form a closed rectangular frame in which the primary is held enclosed. The hollow space intervening between primary and secondary is, moreover, filled with a heavy oil, which acts both as the insulator and conductor of heat from primary to secondary. The secondary, by completely surrounding the primary, affords an excellent mechanical protection, and prevents electric as well as magnetic leakage. The primary is a copper ribbon insulated with asbestos, and the ratio of conversion is 100 to 1. The transformer has two trunnions fastened to its sides, in a line a little above the centre of gravity, which trunnions swing in bearings, part of a yoke which straddles the whole. The yoke in its turn has a hook which may be secured to the latter at any place of the

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arch, thus allowing the transformer to be suspended, like a compass in gimbals, in any position desired.

It goes without saying that the copper castings which compose the secondary are cut through at one place in the circuit. On either side of the cut two short platforms form the base for copper contacts of various shapes and sizes, by means of which the currents are made to enter and leave the plate to be annealed. These copper contacts are of forged copper, hollowed out to receive water circulation for cooling purposes, and terminate in narrow tips rounded at the end.

The weight of the whole annealer, being approximately 1,000lb., is sufficient to give proper contact pressure for all work on a horizontal plate. When inclined surfaces, vertical or otherwise, are to be worked upon, the transformer is suspended so that its weight shall not interfere with the contact pressure, which is obtained for work by bracing the contacts directly with wooden wedges against any object near by. On the outside of a hull, it is proposed to use a pair of electro-magnets, which are made to hold themselves against the iron hull, and form a support for the annealer. Fig. 4 shows some of the various shapes of contacts that are used in various positions.

The remarkable thing is the great amount of current that is being carried by the copper contacts into the plate. The contact surface is seldom more than about ½in. square, and yet 10,000 amperes are made to flow through it continually. This is equivalent to 40,000 amperes per square inch, a density which is only possible on account of the thorough cooling by the water circulation.

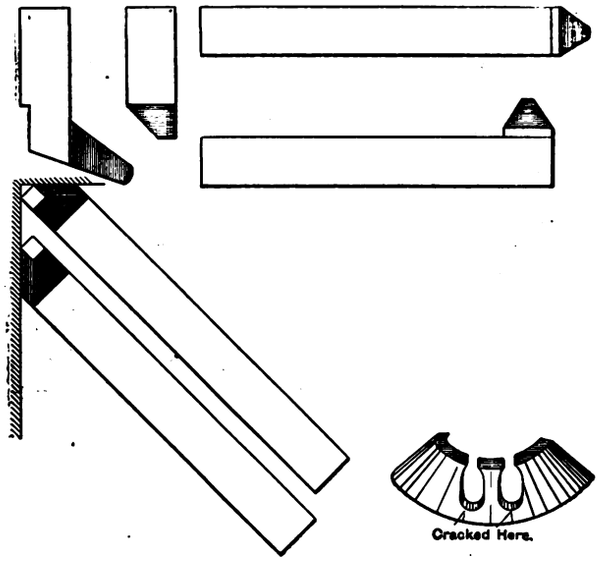

Fig. 4.

Fig. 5.

The regulating apparatus is in most cases simply a rheostat in series with the field of the generator. When more annealers than one are run simultaneously from one generator, as mentioned before, a reactive coil is interposed between the two, and this latter has been made automatic; that is to say, provided with a dash-pot, which permits the current to be reduced uniformly and at any given rate it is set for.

This reactive coil is composed of a solenoid coil of cable, well insulated, having a movable laminated iron core, which is raised out of the coil by means of a leather strap and winch. The core is composed of thin iron strips, placed side by side around a circle, and projecting radially from the same, and being held on top and bottom by a slate disc, in a manner similar to the securing of the copper segments of a commutator. No insulation of the core is necessary, and good ventilation is obtained. The core once raised out of the coil tends to return by gravity and the attraction of the solenoid, but is checked in its descent by a pair of dash-pots, one on each side of the coil. These latter communicate with each other, top and bottom, and have one of the pistons provided with a valve which opens when the core is raised, and closes when the core descends. The dash-pot cylinders are filled with a light mineral oil, which does not freeze nor clog under any ordinary conditions of temperature. An adjustable by-pass valve allows the oil to flow from the tube to the top side opposite. By opening or closing this valve more or less, any rate of descent and, consequently, diminution of current, can be uniformly obtained, without requiring any skill on the part of the operator.

The annealing operation is carried out as follows: The transformer is placed in position, the contacts touching the plate either side of the place marked to be annealed, and the primary current brought up by means of a rheostat to from 75 amperes to 90 amperes for about two minutes, according to the size of spot to be annealed, which will bring the metal to a dull red heat, a temperature at which a pine stick catches fire when held in contact with the plate. If no reactive coil is used, the current is now diminished by turning the rheostat one point every minute. If the reactive coil is used, the core is now raised by winch, the coil put in circuit by opening a short-circuiting switch, and then is allowed to descend on its own account. The operation generally takes *seven minutes*, all told. No difficulty has been experienced from the beginning. The annealing of individual spots was, however, only the stepping-stone to a more important work of a similar nature, work which was about to be given up, owing to what was considered insurmountable difficulties.

In the construction of a modern man-of-war, there are many armour plates which act as shields to the guns, and have to be perforated to allow the gun muzzle to pass through and to be either raised or lowered. Some of these shields are circular or oval, with narrow edges around the ports, in the case of Harveyed plate. To perforate these shields after carburation, and before being water-hardened, was the only possible way, since previous experiments had shown that prevention of carburation could not be relied on, and no process was known to anneal the plane locally after hardening. The hardening of a plate once perforated showed itself to be, however, almost impossible; in fact, a matter of chance. In most cases the plate cracked in two, as shown in Fig. 5, or the whole plate became distorted in such a way that it could not be used. As individual spots for holes could be annealed, there could be no doubt that a series of annealed spots could be likewise obtained by the electric process, following a line along which a cutting tool was expected to be run. The first attempt, therefore, and made in England, was to anneal a number of spots in proximity to each other in such a way that the annealed zones should overlap each other.

As described above, it is very important that the temperature of any individual part should be gradually and slowly withdrawn; and while for individual spots the only possible way was to do this by gradually diminishing the current, it was obvious that when a line was to be annealed, instead of annealing a number of spots side by side, the same effect of withdrawing the heat gradually

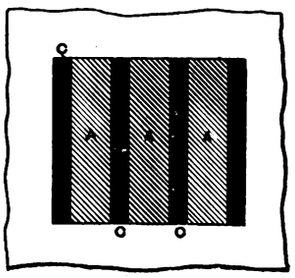

Fig. 6.

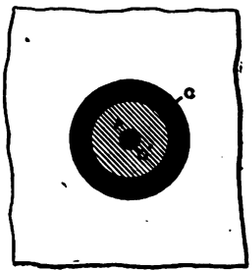

Fig. 7.

from one portion could be obtained by moving the apparatus itself relatively to the plate to be treated. The rate of this movement, of course, depended upon the rate at which the temperature should be allowed to fall in any particular spot to prevent chilling. The apparatus was therefore arranged to be moved along a line to be annealed, the motion being obtained by an ordinary screw and nut held in a bracket, the nut being turned at a predetermined rate controlled by a watch. It was found that a speed of about ¼in. per minute was sufficiently slow to ensure thorough annealing.

The copper contacts were of the simplest kind, as described above, bedding themselves partially in the surface, and when being dragged along by the screw and nut, raised in front of themselves a burr or chip similar to a planing tool. After a whole day's continuous use the copper contacts were found intact, while a number of chips from the steel surface were lying about. We thus had the peculiar phenomenon of a hard steel chip cut with a copper tool.

Upon the completion of the work, it was found that a strip about 2¼in. wide throughout the length over which the machine had been moved, could be operated upon by drills or a shaper, in a manner as easily as if it had never been hardened before.

In the work just described the apparatus was moved about, but in regular practice it would be better to construct a machine consisting of a large bed, on which the plate to be treated may be fastened and moved in any direction automatically at a predetermined speed, while the annealer proper is suspended in a given position above the plate. The annealing operation occupies but a small percentage of the time required for the cutting.

It is unnecessary to state that when the apparatus is used for continuous annealing the primary current is kept at a nearly con-

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stant value, the diminishing of heat at any individual spot being obtained solely by the moving of the apparatus from it.

As mentioned before, the places where the contacts are passing over the plate, being brought to a higher temperature than any other, remain hard. Experience has demonstrated, however, that they may be re-annealed later on by treating the spots in the same way as any other hard spot on the plate. By this means we are therefore able to anneal any shaped portions, not merely lines. This is best seen in Fig. 6, in which a series of strips are annealed side by side (shown in shaded lines A). The hard-faced surface is then removed on such places by a planer and drill; the machine is then run a second time over the annealed strips, resting it this time on the bottom of the groove and on the softer metal, thus annealing the ridges C left between the annealed strips, on which ridges the contacts were running previously. When all these strips are annealed they may be removed by machine tools without any further difficulty. In a similar manner a large round place may be annealed, as shown by Fig. 7. The transformer is set on the plate, one contact resting on C′, the other at any other place in circle C; the apparatus is then slowly revolved around contact C′ as a centre, until the second contact has completed the circle C. The shaded portion A represents now the annealed surface, which is removed by a cutting tool. The contacts are then made to rest on either side of the centre C′, and the latter is annealed and removed in its turn.

The apparatus may also be used for the reversal of the annealing process; that is to say, for creating isolated hard spots in soft tool steel by sending a current through the spot to be hardened until it reaches a bright cherry heat, and then suddenly removing the current or machine.

Various other applications will suggest themselves in the operation of this process, already adopted by the United States Government. It may be used in the construction of burglar-proof safes, for dies and punches, for projectiles and other articles of a similar nature.

THE "BOOSTER" SYSTEM IN ELECTRIC RAILWAY WORK AT CHESTER, PA.*

What is believed to be the first actual installation of the so-called "booster" system for electric railway work was, some months ago, put into practical and successful operation on the lines of the Chester Traction Company, in Chester, Pa., under the supervision of J. Lester Woodbridge, of the Woodbridge and Turner Engineering Company, the licence to use this system having been purchased by the Traction Company from the owners of the patent covering this system.

Two lines were thus equipped, one extending to Darby, eight miles from the power house, and the other to Media, about seven miles from the power house. It became evident from past experience, that in order to handle the heavy Sunday and holiday traffic on these two lines through the summer in a satisfactory manner, about $20,000 must be expended for additional feed wire, unless some other arrangement were made to maintain the voltage. The Company were about to instal an additional generator of 400-kilowatt capacity, leaving idle two Short generators of 100 and 150 kilowatt capacity respectively. It was these two generators that were adapted and connected up as boosters for the two lines above mentioned, and they were so arranged that either can be used as a booster, or, by simply throwing over a switch on the switchboard, in case of emergency, either can be instantly connected up as a generator in multiple with the other machines, the corresponding feeder being at the same time restored to its original connection with the 'bus bar. Thus the total capacity of the station has not been reduced by the appropriation of these machines, and although their design is not just what it would have been, had they been specially built for the purpose, they are found to do their work satisfactorily, special connections and rheostats having been introduced into the field windings to make their action automatic.

For the information of those who are not thoroughly posted on the subject, it might not be amiss to state that the "booster" system consists in the introduction into a feeder, and in series therewith, of an additional electromotive force to compensate for the loss of voltage on said feeder. Usually this is accomplished by a generator whose voltage is made to vary with and adapt itself automatically to the varying loss on the feeder by causing its fields to be excited wholly or partially by the varying current on the feeder.

The installation in Chester proves conclusively, it is said, the advantage of the "booster" system in railway work, its adaptability to electric lighting having been already demonstrated in a number of instances; and whatever may be said regarding its economy for *continuous* use, as a substitute for feed wire, the net efficiency of the above-mentioned installation, which is operated only at times when the traffic is excessive, must be conceded at once. The additional coal consumption for operating the booster a few hours a week becomes a matter of minor importance when compared with the interest on the investment saved.

The practical results achieved in Chester in maintaining the voltage on distant portions of the line are very satisfactory. An approximately constant pressure of 500 volts is secured at the Darby terminus, regardless of load, when the "booster" is in operation, the loads on this section varying from zero to 450 amperes; without the "booster" a single car, climbing the Darby Hill, has been known to bring the voltage down to 275. At this low voltage it required a current of nearly 170 amperes to operate the car, and speed was very slow. With the "booster" in operation three cars have been brought up the hill simultaneously and at good speed.

* From the *Electrical Engineer* of New York.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

TO-DAY (FRIDAY), November 22nd.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. (1) "An Exhibition of Photographs of Spectra," by Dr. G. Johnstone Stoney. (2) "A Direct Reading Platinum Thermometer," by R. Appleyard. (3) "Historical Note on Resistance and its Change with Temperature," by R. Appleyard.

MONDAY, November 25th.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

8 p.m. Meeting at the Palatine Hotel, Hunt's Bank, Manchester. Paper to be read: "The Use of Dust Destructors as Steam Producers for Electricity Supply Stations," by E. Manville.

TUESDAY, November 26th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "The City and South London Railway: Subaqueous Tunnelling by Shield and Compressed Air," by James H. Greathead.

WEDNESDAY, November 27th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Locomotive Carriages for Common Roads," by H. H. Cunynghame.

THURSDAY, November 28th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Papers to be read: (1) "The Electric Wiring Question," by F. Bathurst; (2) "Concentric Wiring," by Sam Mavor.

SATURDAY, November 30th.

THE ELECTRO-HARMONIC SOCIETY.

8 p.m. Concert (Ladies' Night) at the St. James's Hall Restaurant (Banquet Room), Regent-street, W.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Electricity in an Austrian Paper Mill.—The Leijkam-Josefthal paper mill, which was destroyed last spring during an earthquake, has now been rebuilt, and extensive use has been made of electricity in the fitting up of the mill. The water power of a river some two miles distant has been employed, and a generating plant of 500 H.P. has been erected. This plant consists of two turbines of 250 H.P. each, driving on to a common countershaft, to the two ends of which two "drehstrom" generators of 250 H.P. each are coupled. These machines are of the Ganz type, and give an E.M.F. of 3,000 volts when running at 170 revolutions per minute. The current is taken to the mill by three overhead conductors, where it is transformed to 300 volts. The loss in the conductors is about 5½ per cent. At the mill a third generator of 250 H.P. of the same type has been provided, but working at only a potential of 300 volts. This machine will be used as a supplementary one. From a main switchboard the "drehstrom" is distributed to various motors which drive the mill shaftings and the special machinery. There are motors of a capacity ranging from 160 H.P. to 3 H.P. A continuous-current dynamo for lighting purposes is driven off the main shaft.

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THE BOARD OF TRADE CONFERENCE.

The Board of Trade Conference has come and gone—gone, we trust, for a quinquennium at least. Not that the meeting in the Westminster Town Hall has been anything but exceedingly pleasant and fruitful. We cannot, of course, expect even the doubly revised electric lighting Regulations to be as concise and as permanent as the decalogue; but in the course of the two-days Conference between law-makers and law-breakers considerable progress was made in the direction of greater brevity, and it would be distinctly advantageous to the electric lighting industry if at least equal progress were made in the matter of permanency. The air of late has been full of rules, regulations and round-table meetings, and a lengthened breathing space is highly desirable, even though the Board of Trade rules may as a consequence lag a little behind instead of leading, as heretofore, the march of improvement. Three distinct classes of objectors have revealed themselves. There is the objector who deems all Board of Trade regulations unnecessary, who argues that as it is to the interest of the supplier of electric energy to maintain the continuity and constancy of the supply and to secure the safety of the public, enlightened self-interest will lead him to do of his own free-will anything and everything that can be reasonably demanded. Then there are individuals who do not object to Board of Trade rules, but hold that they should be mere generalities and obvious truisms; details, they contend, are better left to those who know. Lastly, there are some who realise that, under our present dispensation, regulations—

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detailed regulations—are bound to be made, and, therefore, the best thing the electrical engineer can do is to take full advantage of the broad-minded policy inaugurated by Sir COURTENAY BOYLE, and to work up the Departmental edicts into a practical shape. Naturally, this latter genus predominated at the Westminster Town Hall on Tuesday and Wednesday.

As it may be some little time before the new Regulations are issued in their final form, it may not be without use to briefly review the principal results of the gathering. The ball was opened by a prolonged attack on the Board of Trade definition of "low-pressure"; naturally enough, everyone wanted the limit raised. In the end Sir COURTENAY BOYLE promised to consider the feasibility of a higher limit both for continuous and for alternate currents, and to be advised by a small committee of experts. Regulation 4, which lays it down that "no high-pressure electric line shall be used for the transmission of more than 200,000 watts . . ." was the next one attacked. The Chairman intimated that he was disposed to accept a 300,000-watt limit, but was doubtful as to the safety of a 500,000-watt maximum. Around Regulation 9, dealing with the testing and insulation resistance of new mains, the battle raged at great length; and the outcome was that the Board of Trade agreed to forego any demand for a definite insulation, and to merely require that "every electric main shall be tested for insulation after having been placed in position, the testing pressure being at least 200 volts, . . ."; service wires under a certain length being altogether exempted. The sting was then taken out of a large number of rules by their being made prospective. Regulation 13 was debated for some time, and finally Sir COURTENAY BOYLE agreed that central-station dynamos should only be submitted before coming into use to a pressure 50 per cent. greater than their normal maximum, in lieu of 100 per cent., as originally laid down. After a long discussion, the Chairman agreed to consider the question whether the Board of Trade could not relax Rule 23, requiring every high-pressure aerial line to be suspended from a bearer wire by means of insulating ligaments. Regulation 27, which ordains that all electric conduits, pipes and casings shall be so constructed as "to prevent any *influx* of gas from the adjacent soil," gave rise to a very valuable debate, in which Mr. PREECE, Prof. KENNEDY, Mr. CROMPTON and Mr. FRANK BAILEY took an active part. Ultimately, Sir COURTENAY BOYLE intimated that he was willing to accept the clause drawn up by the Institution of Electrical Engineers, in which by the substitution of "accumulation" for "influx" everyone is made happy.

On resuming its sitting on Wednesday morning the Conference set to work with renewed energy to mould the handiwork of the Board of Trade officials according to its own ideas, and succeeded to an astonishing degree in so doing. Rule 32 was much mutilated; Rule 33 was struck out, and Rule 8 of the old Regulations substituted. Rule 35 was transformed almost beyond recognition. In its original shape it ran as follows: "All street boxes which contain any vacant space shall be so constructed as to prevent any influx of gas or water. . . ." As amended it will run: "In the construction of street boxes used as transforming chambers efficient means shall be taken to prevent any influx or accumulation of gas or water. . . ." New Regulations 37 and 38 were struck out and old Regulations 15 and 16 substituted. Much time was spent in an endeavour to radically amend Rule 41, dealing with the position and protection of the consumer's main fuse; the result was a clarification of the wording and the authorisation of sealed as well as of locked receptacles for the cut-outs. New Rule 43 gave place to old Rule 18, mainly at the instance of Mr. H. M. SAYERS, and transformers in small houses will not have to be protected with all the elaborate care bestowed on an American millionaire's mausoleum. Rules 44-46, relating to consumers' wiring, were the subject of what threatened at one time to be an endless and desultory discussion. It was edifying to observe the extreme eagerness of those who, up till then, had been engaged in the game of whittling down rules applying to themselves, to impose all manner of stringent Board of Trade Rules and Regulations upon wiring contractors, and the extreme reluctance of this rule-making Department to take over this particular job had also its amusing aspect. The net outcome of the war of words is that in future no wiring is to be *permanently* connected if it be found that the insulation resistance is less than k/n megohms, k being a constant to be settled by our good friends at the Board of Trade, n being the "number of points for taking off current." But for the interposition of Mr. A. BROMLEY HOLMES, of the Liverpool Electric Supply Company, who mentioned motors, k would have been 75, as suggested by the Institution of Electrical Engineers. This addition is intended as an antidote to the very low figure of 5,000 ohms to which the insulation has to fall before the supplier of electricity *must* cut off the delinquent householder. Rule 48, relating to arc lights, resulted in the minimum permissible height of 10ft. being strictly limited to street arcs used for public lighting. After this concession, and a few more of minor importance, the meeting terminated amidst a chorus of mutual congratulation.

It only remains to be said that Sir COURTENAY BOYLE, as is customary with him, presided over the Conference with tact and urbanity, and that Prof. KENNEDY, Prof. AYRTON, Mr. CROMPTON, Mr. HAMMOND, Mr. H. M. SAYERS, Mr. HOLMES, and Mr. GAY did yeoman service in rendering these Regulations reasonable and workable; they did not content themselves, as many did, with making barren objections, they made valuable and fruitful suggestions.

REVIEWS.

Electrical Measurements. A Laboratory Manual. By HENRY S CARHART and GEORGE W. PATTERSON. (Boston: Allyn and Bacon.)

For students and others possessing an elementary knowledge of physics and mathematics, and wishing to gain a clear insight into the principles and practice of modern electrical measurement, this manual should prove decidedly welcome. It is marked throughout by conciseness, lucidity, and method. The orderly progress of the text is not interrupted by those practical hints which lend such a specious air of practicality to so many books of the kind. The proper place for practical hints is the laboratory itself; the proper person to give them is the individual actually supervising the test. Laboratory manuals dealing with such elaborate work as electrical measurement has now become should be strictly confined to elucidating methods and principles. It may be objected to this doctrine, that it tends to preclude the home student from acquiring a practical grasp of modern electrical measurement; but the elaborate and expensive electrical apparatus considered necessary in these days renders modern electrical measurement beyond the reach of anyone outside a well-equipped laboratory. Another marked feature of this volume is its extreme modernity and the frequent apposite references to more specialised works. The typography and diagrams are of the best.

Scientific and Technical Papers of Werner von Siemens. Vol. II. Translated from the Second German Edition. (London: JOHN MURRAY.)

How easy it is to sum up the life's work, even of the busiest and longest-lived men, in a few lines; and in many cases even when the written records of a life of assiduous labour are

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gathered together by admiring friends or by an appreciative society, how small the bulk and how difficult is it for those who are not fully acquainted with the intrinsic value of the work done to resist a feeling of disappointment that so many years of toil should not have resulted in a greater mental output. Quite other is the feeling aroused by the contemplation of the two bulky tomes containing the collected Papers and patents of Werner von Siemens; the difficulty here is to properly digest the fare set before us. The second volume is devoted to the practical and commercial side of Werner von Siemens' work, and it exhibits very clearly the tenacious way in which Siemens ever kept pace with the steady march of electrical progress. From 1847 to 1867 we read of nothing but matters telegraphic; cable insulation, keys, relays, "constant galvanic" batteries. On January 17, 1867, came that remarkable note to the Royal Academy of Sciences of Berlin "On the Conversion of Mechanical Energy into Electric Currents without the Use of Permanent Magnets," in which the dynamo-machine, as we know it now, was first revealed; an energetic indication of his claim to priority in this discovery being made by Siemens before the same Society 13 years afterwards. Thenceforth telegraph Papers and patents are mingled with others relating to dynamos. On January 21, 1878, came a long-disquisition "On Telephony," in which the history of the subject up to that date is summarised, with many vaticinations with regard to the future. Amongst other proposals there is one for overcoming static induction effects whenever single telephone conductors are made up into multiple-cored cables by wrapping the single-insulated conductors with a thin layer of tinfoil. From 1880 onwards telegraphy is abandoned entirely, and the remaining pages of the volume are occupied by communications dealing with electric railways and electric meters. The Appendix contains two Papers on the necessity for a patent law for the German Empire, in the second of which the veteran inventor makes a vigorous appeal to his countrymen to raise their standard of commercial morality, and two Papers relating to the founding of the now world-famous "Reichsanstalt."

The pages of this work form a splendid record of practical many-sided inventive effort.

Life and Labour of the People in London. Vol. VI. Population Classified by Trades (*continued*). Edited by CHARLES BOOTH. (London: Macmillan and Co.)

We freely admit that anything is better than a mass of ill-digested, ill-arranged, unreliable statistics; nevertheless, we must candidly confess to a sense of disappointment at the small space allotted in this volume to the Electrical Trade in London and to the meagre information therein contained, and this whilst ready to make allowances on account of the youth of the industry and the vagueness of its boundaries. Less than 20 pages are occupied by curves, tables and comments, and these are rendered valueless for all practical purposes owing to the fact that surgical, scientific and electrical instrument makers are mixed up with cable-manufacturing hands, wiremen, &c. This poverty is all the more striking by reason of the proximity of the admirable section dealing with the printing trade. Electrical employees in London are easily divisible into some such classification as this:—Telegraph and telephone wiremen, house wiremen (bell and electric light), central-station hands, employees in heavy electrical engineering shops, in cable factories, glow-lamp factories, electrical-fittings factories and instrument-making firms. Tables and statistics with regard to the wages, hours, numbers and social condition of these various types of "electricians" would meet a decided want. As it is, the data gleaned are few in numbers and dubious in character. According to Mr. Booth the Electrical Trade in London numbers 4,930, of whom 3,887 are males over 20. The Electrical Trades Union, founded in 1889, has in London a membership of only 285, though it possesses a total membership of 1,700. The Amalgamated Society of Telegraph and Telephone Workers, notwithstanding the length of its title, has a very short roll of 150 members. We cannot think that this section of Mr. Charles Booth's important compilation will prove of much use to electro-statisticians.

THE BEHAVIOUR OF TRANSFORMERS UNDER THE INFLUENCE OF ALTERNATING CURRENTS OF DIFFERENT WAVE FORMS.*

BY DR. G. ROESSLER.

The general definition of an alternating current as an electrical current the strength of which periodically varies gives us only a partial conception. For the exact definition of any known alternating current we require either a statement of the mathematical law which is followed by the periodic variations of the current or a graphical representation of the same. By Fourier's theorem the general formula which describes any periodic function consists of a number of sine functions, the knowledge of which determines any alternating current in which the variation departs from a simple sine law; hence it is usual in all alternating-current problems to assume a simple sine variation of the current. This procedure is only justifiable if, by experiment, and by theoretical considerations, it is ascertained that the departure of the current from sine variation does not greatly influence its practical properties. How far this influence extends is as yet an unanswered question.

In the practical application of alternating currents we have to do with lamps, transformers and motors. With regard to lamps, it is obvious that, with glow lamps, owing to their conditions of working, the luminous intensity is independent of the form of the current wave if the $\sqrt{\text{mean-square}}$ of the current is constant. In the case of arc lamps, the influence of the form of the current wave on the luminous intensity requires special investigation. I had the honour of bringing before last year's meeting† a series of measurements which endeavoured to solve this problem. Their result was that the candle-power of alternating arcs depends greatly on the form of the potential and current curves, and in such a manner that a greater luminous intensity results from a given current, the longer the current maintains its maximum value—*i.e.*, the flatter the wave is.

Concerning the influence of the time variation of the alternating current on the behaviour of transformers and motors, our knowledge is very limited. An inquiry which the *Electrical World* of New York made on the occasion of a scientific controversy with the London *Electrician* last summer, although resulting in agreement on some points, brought forth the most contradictory answers. While, in the former journal, the position was taken that it was advisable in the building of an alternator to endeavour to obtain a sine variation of the E.M.F., the second journal considered that desideratum valueless, and "possibly" detrimental.

In face of these differences of opinion upon so important a point in alternate current working, it seemed to me right that I should bring before you a series of investigations which I have made with a transformer belonging to the electro-technical laboratory of the Berlin Technical High School. The period of investigation extends over the last year and a-half. Since an empirical result is only of value when based on a theoretical foundation, the description of the investigations, and the tabulation of their results, is followed by a theoretical explanation, which extends the results of the measurements to a general theory of the transformer under the influence of currents of different wave forms.

Description of the Alternators and Transformer.

As the source of current for the excitation of the transformer, two alternators of the electro-technical laboratory were used alternately, which machines were specially suitable for this investigation, since one of them gave an extraordinarily pointed potential curve, whereas the curve of the second was nearly sinusoidal. The first (Fig. 1) is a four-pole 5·5 unit machine, by Ganz and Co., with rotating magnets; the second is an older small 480-watt machine, by Wechsler and Co, with four magnets on each side of a ring armature having four coils (Figs. 2A and 2B). A complete description of the electrical arrangements of the two machines is given in last year's Paper, on the illuminating power of alternating-current arc lamps. To ensure uniform conditions of working with both machines it was necessary to use an old 480-watt transformer, on account of the small output of the smaller of the laboratory machines. It is probable, though the absolute efficiency of this old and small transformer cannot be taken as representative of that of the transformers of the present day, its relative behaviour, with the two alternators, may be taken as typical of all transformers, with either closed or open magnetic circuit.

The following is a description of the transformer: The iron circuit consists of 78 E-shaped wrought-iron plates, of the dimensions given in Fig. 3, and about 0·5mm. thick. The plates lie

* "Das Verhalten von Transformatoren unter den Einflusse von Wechselströmen verschiedenen periodischen Verlaufs." A Paper read at the third annual meeting of the Verband Deutscher Electrotechniker, Munich, July 6, 1895.

† See *The Electrician*, Vol. XXXIII., pp. 523, 539, August 31st and September 7, 1894.

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alternately in the positions ⊔⊔ and ⊓⊓, and are insulated with silk paper. They are held together by a wooden frame, whereby the magnetic circuit is confined entirely to the iron plates. The total weight of the plates is 8·168 kilogrammes. The specific

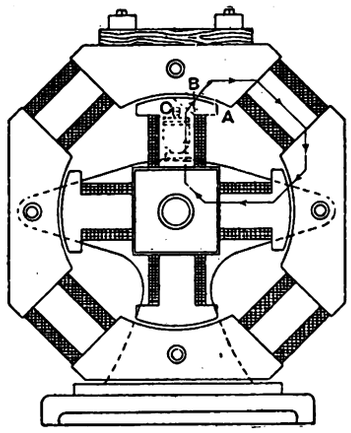

FIG. 1.—Ganz Machine.

gravity of the iron, obtained by weighing a sample in air and water, was 7·81 cubic cm., and the total volume 1,046 cubic cm. The two copper windings are arranged side by side, as in Fig. 4.

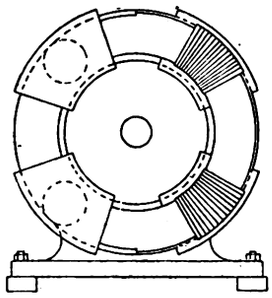

FIG. 2A.—Wechsler Machine.

The primary consists of 132 turns of 2·7mm. wire, the secondary of 265 turns of 1·8mm. wire. The primary resistance = 0·179 ohms cold, 0·214 ohms hot. The secondary resistance = 0·775 ohms cold,

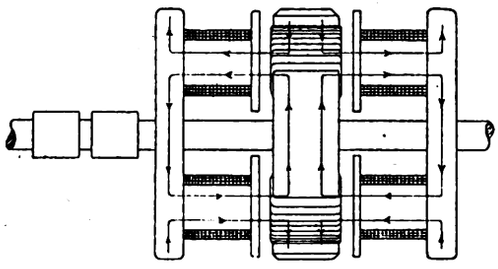

FIG. 2B.—Wechsler Machine.

0·943 ohms hot. The hot resistances were taken after four hours running of the transformer at full load. The working cross-section of iron, from the above data, was 20·19 sq. cm.

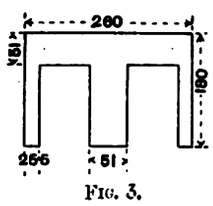

FIG. 3.

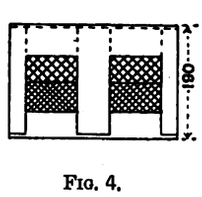

FIG. 4.

Measuring Instruments and their Calibration.

For the determination of the primary and secondary potentials a Cardew voltmeter was used. The primary current was measured by a Kelvin balance, and the secondary current by a Siemens-Halske electro-dynamometer (up to 5 amperes). The primary power was measured by a wattmeter made by the Helios Company, whilst the secondary load, being absorbed by glow lamps, was obtained by the product of the secondary current and potential.

In the calibration of these instruments for this investigation it was, for many reasons, desirable to ascertain whether the form of the waves affected the wattmeter readings. In the Cardew voltmeter and the current-measuring instruments there is, by the nature of their action, no dependence on the form of the wave. In the former, at each instant, the heating effect is proportional to the square of the potential; and in the others the force at any instant is proportional to the square of the current; the reading, therefore, for fixed coil position, always depends on the mean square. The instruments can also be easily provided with scales, upon which the $\sqrt{\text{mean-square}}$ is engraved. These $\sqrt{\text{mean-square}}$ readings are henceforth referred to in this Paper as R.M.S. (*Quadratische Mittelwerthe*). Each scale can then be obtained by standardising the instrument with known continuous currents, and can then be used for alternating currents of every kind. The wattmeter, in the form devised by Ganz, which is intended for the measurement of the mean value of the varying power, only gives this value correctly when the self-induction in the shunt circuit is negligible. If this is not the case the power, measured with alternating currents, will differ from that given by the scale for direct currents. The magnitude of the error is conditioned, by the self-induction of the wattmeter shunt, by the phase difference between the potential and current, which produce the required power, and by the form of the current curve. Prof. H. F. Weber, of Zurich, who first embodied the magnitude of these errors in a general formula, has found that in investigations on transformers by the Ganz wattmeter, the correction factor is less than $\frac{5}{10000}$, even when the current-curve differs greatly from the sine form, and the lag between current and potential is very great. The wattmeter of the Helios Company, used in these measurements, is almost identical with the Ganz instrument, so that Prof. Weber's calculations apply without alteration. Nevertheless, it was considered advisable to have experimental confirmation, on account of the capacity of the non-inductive shunt resistance, and other unknown factors. This was obtained in the following way:—

The alternating current was passed through a bank of glow lamps, and the potential measured by the two Cardew voltmeters, which had been calibrated for direct currents, and the current by the current balance. The latter was standardised against the standard of the Reichsanstalt, and had so small an error as to be negligible. The Siemens dynamometer was connected in series for calibration. The wattmeter was so connected that it measured the total power in the glow lamps and its own shunt. As the resistance is practically inductionless, the power is equal to the product of the potential and current given by the Cardew voltmeter and balance. The constant of the wattmeter is thus deducible. The results for the dynamometer and wattmeter are as follows:—

Table I.

Ganz machine.		Wechsler machine.	
Wattmeter.	Dynamometer.	Wattmeter.	Dynamometer.
c_1 = 0·001433	c_1 = 0·009080	c_1 = 0·001425	c_1 = 0·008997
0·001441	0·009054	0·001437	0·009000
0·001443	0·009080	0·001441	0·009002
0·001444	0·009055	0·001434	0·009018
0·001452	0·009023	0·001430	...
0·001447	0·009180	...	...
...	0·009C04	...	...
Mean c_1 = 0·001445	Mean c_1 = 0·00905	Mean c_1 = 0·001436	Mean c_1 = 0·009004
c_2 = 0·004530	c_2 = 0·02587	c_2 = 0·004482	0·02583
0·004528	0·02568	0·004514	0·02595
0·004525	0·02594	0·004521	0·02588
0·004555	0·02600	0·C04522	0 02600
0·C04541	0·02597	...	0·02592
Mean c_2 = 0·004536	Mean c_2 = 0·02590	Mean c_2 = 0·004510	Mean c_2 = 0·025?2

The suffixes 1 and 2 are for two connections of the fixed windings of the dynamometer and wattmeter. Each of these has a thick and thin coil. In the first readings the thick and thin coils were connected in series; in the second, only the thick coil was used. The difference observed between the constants are small: 0·62 and 0·57 per cent. for the wattmeter and 0·51 and 0·077 per cent. for the dynamometer. The fact that variations occur in the dynamometer shows that the wattmeter variations cannot be accounted for by the self-induction of the shunt. This conclusion is supported by a reading of the wattmeter, with continuous current, which gave c_2 = 0·004566, a greater value than the alternating measurements gave; whilst, on the other hand, the latter should have given the greater value, if the self-induction of the shunt was considered. The explanation of the small differences observed partly lies in unavoidable errors of reading, and partly in small irregularities of running of the machines, in consequence of which the individual values of the constant have a maximum difference of 1 per cent.

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among themselves. So far as a difference of the constant exists, it has its explanation, not in the self-induction of the shunt, but in other causes, such as the capacity of the fixed coils of the current-measuring instruments and the wattmeter. By using the above empirically determined constants, in which these causes are allowed for, we may expect to get the true result.

The Measurements.

The two sets of measurements on the transformer were taken one after the other on the same day. The investigation with the Ganz machine was conducted in the morning, that with the Wechsler machine in the afternoon. The arrangement (Fig. 5) was such that, after the first set of measurements, only one main lead had to be altered, the remaining connections being unchanged. In order to reproduce the speed exactly in the two four-pole machines, the same

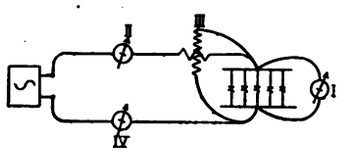

FIG. 5.—I. Cardew Voltmeter. II. Current Balance. III. Wattmeter. IV. Dynamometer.

tachometer was used in both investigations, its connecting link being attached to either machine. The Ganz machine was driven by an 8 H.P. Deutzer gas engine, which at the same time drove an "A.E.G." shunt machine which charged cells, and thus kept the gas engine well loaded. The speed was thus very constant, and by altering the excitation, or lead, of the "A.E.G." machine could be very finely regulated. The small Wechsler machine was upon the same transmission, being driven by the "A.E.G." machine as motor from the cells. The regulation gave a constant primary potential of 60 volts, and a tachometer reading of 1,250 revolutions per minute. The latter was checked by a revolution counter of Schaffer and Budenberg, connected with clockwork. The mean of six observa-

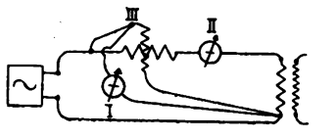

FIG. 6A.—I. Cardew Voltmeter. II. Current Balance. III. Wattmeter.

tions gave a value of 1,217 revolutions per minute; this gives, with a four-pole machine, a periodicity of about 41. The departure from this value during all the transformer measurements was always under 1 per cent.

In the connection of the wattmeter, it is necessary to remember that the instrument not only measures the power supplied to the transformer, but, if connected as in Fig. 6A, the wattmeter shunt has a higher potential difference than that of the primary circuit of the transformer; and, if connected as in Fig. 6B, a larger current flows through the fixed winding than that through the primary of the transformer. In the first case, a correction must be made for the potential difference between the shunt terminal and the trans-

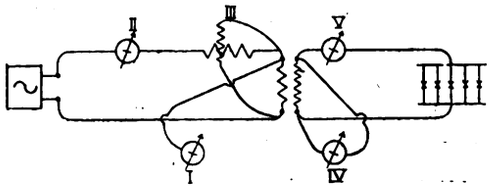

FIG. 6B.—I. Cardew Voltmeter. II. Current Balance. III. Wattmeter. IV. Cardew Voltmeter. V. Dynamometer.

former. If one of these potential differences is neglected, the other cannot be determined with sufficient accuracy, the difference depending, not only on the resistance, but also on the self-induction of the current balance and fixed wattmeter coil. These E.M.F.'s of self-induction cannot be determined very accurately by calculation, since their value depends also on the form of the current curve, and exact knowledge of the power in the transformer is impossible. If the wattmeter, balance and Cardew voltmeter are connected as in Fig. 6B, the power and primary current of the transformer is known from the readings of these instruments, and is independent of the forms of the potential and current curves.

Let t be the time, J the current as measured by the ampere balance, i the total shunt current, J_1 the primary current of the transformer, and $E p_1$ the primary potential; then, at each instant, $J_1 = J - i$.

If the inductionless resistance of the Cardew voltmeter, and wattmeter shunt, in parallel, be w, $i = \frac{E p_1}{w}$,

$$\therefore J_1 = J - \frac{E p_1}{w},$$

and
$$\frac{1}{T}\int_0^T E p_1 J_1 \, dt = \frac{1}{T}\int_0^T E p_1 J \, dt - \frac{1}{T}\int_0^T \frac{E p_1^2}{w} dt \quad . \quad . \quad (1).$$

Inserting for T in this equation the periodic time we have

$\frac{1}{T}\int_0^T E p_1 J_1 \, dt$ is the primary power of the transformer;

$\frac{1}{T}\int_0^T E p_1 J \, dt$ the power measured by the wattmeter;

$\frac{1}{T}\int_0^T \frac{E p_1^2}{w} dt$ the power lost in the shunt.

The latter is known from w, and the square of the potential difference measured by the Cardew voltmeter, which is $\frac{1}{T}\int_0^T E p_1^2 dt$.

The general equation (1), for all alternating currents, thus enables us to determine the mean power supplied to the transformer by the measured quantities. For the calculation of the primary current we have the equation

$$J_1^2 = J^2 - 2 J i + i^2$$
$$= J^2 - 2\frac{J E p_1}{w} + \left(\frac{E p_1}{w}\right)^2.$$

Hence,

$$\frac{1}{T}\int_0^T J_1^2 \, dt = \frac{1}{T}\int_0^T J^2 dt - \frac{2}{w}\frac{1}{T}\int_0^T E p_1 J \, dt + \frac{1}{w^2}\frac{1}{T}\int_0^T E p_1^2 dt.$$

In this equation

$\frac{1}{T}\int_0^T J_1^2 \, dt$ is the effective or R.M.S. of the primary current;

$\frac{1}{T}\int_0^T J^2 \, dt$ the current measured by the balance;

$\frac{1}{T}\int_0^T E p_1 J \, dt$ the power measured by the wattmeter;

$\frac{1}{T}\int_0^T E p_1^2 \, dt$ the square of the potential measured by the voltmeter.

If we denote henceforth by J, J_1 and $E p_1$ the R.M.S. of the current strength and potential difference, and by A_1 the power measured by the wattmeter, then the primary current J_1, and the primary power A_1, are given by the equations

$$A_1 = A - \frac{E p_1^2}{w}$$

$$J_1^2 = J^2 + \frac{E p_1^2}{w^2} - 2\frac{A}{w}.$$

It is to be observed that the latter equation, with the broadest interpretation, would give the primary current simply as the difference of the measured current J and the shunt current $\frac{E p_1}{w}$, if the transformer had no self-induction, then $A = E p_1 J_1$ and

$$J_1^2 = J^2 + \frac{E p_1^2}{w^2} - 2\frac{E p_1 J_1}{w} = \left(J - \frac{E p_1}{w}\right)^2.$$

This method can, with small transformers, and especially with those having open magnetic circuits, give rise to great errors.

On open circuit, in the present investigation, we have, for example, $J = 1{\cdot}598$, $A = 51{\cdot}27$, $E p = 60\ 54$, and $w = 227$.

If we calculate J_1 by the formula

$$J_1 = J - \frac{E p_1}{w},$$

we have $J_1 = 1{\cdot}598 - 0{\cdot}266 = 1{\cdot}332$ amperes.

In reality, however, $J_1^2 = J^2 + \frac{E p_1^2}{w^2} - 2\frac{A}{w}$

$$= 2{\cdot}552 + 0{\cdot}07076 - 0{\cdot}4512 \quad \therefore \quad M J_1 = 1{\cdot}474 \text{ amperes.}$$

The difference between the results amounts to about 9·6 per cent. The value obtained from the first method is always too small.

In the secondary circuit, as in the former case, the loading was effected by glow lamps; the calculation of the current J_2 from the reading J of the dynamometer, and the reading $E p_2$ on the Cardew voltmeter, is given by the simple equation $J_2 = J + \frac{E p_2}{w}$. The resistance of the shunt, which in the secondary circuit is simply the Cardew voltmeter, is in the present case 390 w.

(To be continued.)

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THE BOARD OF TRADE REVISED ELECTRIC LIGHTING REGULATIONS.

CONFERENCE AT THE WESTMINSTER TOWN HALL.

A Conference of Corporations and companies concerned in the Regulations made by the Board of Trade under the Electric Lighting Acts was opened on Tuesday in the Town Hall, Westminster. Sir Courtenay Boyle, K.C.B., of the Board of Trade, who was accompanied by Mr. Hopwood, C.B., C.M.G., Sir T. Blomefield, Bart., of the Board of Trade, Mr. W. H. Preece, C.B., chief electrician to the Post Office, and Major Cardew, R.E., presided.

In opening the proceedings, Sir COURTENAY BOYLE stated that the Board, finding it necessary to revise the Regulations made by them under the provisions of the Acts of 1882 and 1888, had thought it convenient as well as courteous to give to all who had raised objections an opportunity of stating those objections verbally, thereby assuring that the Board of Trade's final decision might not be come to until after carefully hearing all that could be said on the various matters dealt with in the Regulations. Although the entire responsibility rested on the Board of Trade, who could not divest themselves of that statutory responsibility, he could assure those present that the Board would carefully weigh all the arguments and representations that might be placed before them.

The TOWN CLERK of MANCHESTER observed that it was felt by all municipal bodies which, like that of Manchester, had spent large sums on works that might be affected by the result of this Conference, that it would be of great importance that they should have an opportunity of seeing and making observations on any altered Regulations that might be decided upon before they were finally enforced.

Sir C. BOYLE promised to consider the point, though he hoped the Board would be able to arrive at a final conclusion as a result of the Conference.

The Conference then proceeded to consider the proposed revised Regulations in detail, and the criticisms submitted by undertakers and public bodies. The first controversy arose on the proposed new definition of "low pressure."

Sir C. BOYLE said they had better come to the question of whether the proposed maximum of 300 volts should be raised.

Mr. HAMMOND remarked that it was known to everyone in the room that great improvements had been made in the distribution of electricity, and that reliable electric lamps had been introduced working at from 200 to 250 volts. It was most desirable that this improvement should be facilitated. They hoped that in time they would be allowed to go up to 600 volts. He maintained that that would be a perfectly fair limit from the point of view of safety, but if it was thought too great they ought to have at least 500 volts. The Board of Trade had already sanctioned that limit for traction purposes, and the danger was less in matters of lighting. He had himself had shocks at 600 volts several times, and such shocks did not injure a man in ordinary health.

Dr. JOHN HOPKINSON pointed out that the case of Manchester required consideration, for in that town 400 volts pressure was occasionally required. The Manchester Corporation had laid out £175,000 up to the end of last March, and since then, for purposes of extension, they had obtained sanction for the expenditure of a further £100,000. This had been done on the undoubted feeling of security that the work would be allowed to go on as the system was originally laid out unless serious damage were found to result from it or serious risk. What were the facts? In Manchester they had no trouble whatever with their electric mains—they had set no buildings on fire, they had hurt no one, and they had given thorough and complete satisfaction to a large number of consumers. If there had been danger from shock surely they would have found it out, seeing that they had 937 consumers wired, with many more coming on. A large number of these had been on for a considerable time, and no one had ever complained of having received a shock that had caused inconvenience. Of course, as many of them knew, a shock could be got, and a smart one, at 400 volts.

Sir C. BOYLE said he did not wish to press the point home, but it was clear that Manchester had been infringing the Regulations.

Dr. HOPKINSON said it was a pity to waste time in considering that matter. He would deal with it if it were desired, but he did not wish to waste the time of the meeting. There was the fact, however, that in Manchester they had been working with a pressure of something like 420 volts; the thing had worked well, and, financially, had been a great success. He believed there was no town in the kingdom which had a better record than Manchester, and which had made a larger percentage and profit. They had proved that they could give the public the benefit of the electric light economically, and they desired that they should be allowed to work at the pressure they had been working at. It would be exceedingly hard on Manchester if they were to be interfered with in doing what they had done in the past, and done with marked success.

Sir C. BOYLE: If you are going to develop that argument I shall have to enter upon the question of whether you have or have not been infringing the Regulations.

Dr. HOPKINSON said this was not a question to be dealt with here. The Board of Trade would have its remedy if the Manchester Corporation had been doing wrong. They would be perfectly prepared to deal with the matter if it were raised elsewhere. It would be hard if the Regulations were to be so altered as to press more heavily on Manchester than they did at present; and, further, if they were so altered with regard to future works which had to be worked from the same centre of supply as that now used. The experience of Manchester fully justified the Board of Trade in sanctioning pressure up to 500 volts.

Mr. Alderman HIGGINBOTTOM, referring to the Manchester case, said he could not agree that they had gone beyond the Board of Trade Regulations. They had a low-pressure system of 400 volts sanctioned by the Board of Trade on two occasions—once when the Order was granted, in 1890, and again, in a letter from Sir C. Boyle himself, in 1892, in which it was said that the Board of Trade approved of the system of which the description was annexed—and that description was given as a low-pressure direct-supply continuous-current system at constant pressure of 400 volts. By leaving out the letter "a" and the words in the original Order they would convert the Manchester system from a low-pressure into a high-tension system, and the consequence would be that they would have to re-lay the whole of their mains, of which they had more than 89 miles laid up to the present time. That was a very serious thing to them, and if it was contemplated to make the new regulation retrospective, as was rather suggested, it became a matter of enormous importance. Only last March the whole of their plant capacity was taken up, and they had to go to the Local Government Board for borrowing powers. The Local Government Board granted them £100,000, and a large part of that had been spent. It would be all gone before next June. Their contention was that this new regulation should not be made to include the case of Manchester, which was a special system, namely, a five-wire system, and one which had proved so successful in every way that they had not been called to account by the Board of Trade or by their consumers. He thought in the new Regulations the Board of Trade ought to keep to the voltage that had been sanctioned by the Board of Trade and the Local Government Board. To make the Regulations retrospective would be a serious thing to the Manchester Corporation, and would mean a great increase in cost to the consumer, who now could purchase the electric light at a price that no other municipal body had hitherto produced it at. The Manchester Corporation asked that the regulation should be amended in accordance with the observations they had made on the agenda.

Prof. AYRTON thought a certain amount of difficulty had arisen from its not being made clear whether the pressure referred to any two wires leaving the central station, or to two wires going into a particular house. It seemed to him that there would be a great danger in the number of volts specified depending on what interpretation was to be given to the Order. The regulation said: "The expression 'pressure' means the difference of electrical potential between any two conductors through which a supply of energy is given." Did it mean any two conductors which left the central station, wherever those conductors might go to, or did it mean any two conductors in a house?

Major CARDEW said the question as to what was to be considered high pressure depended upon many other considerations besides the possibility of danger to human life. He did not say that in selecting 300 volts, continuous, they had not arrived at a limit which very fairly did discriminate between the pressure which might under certain conditions be dangerous to life and the pressure which could be taken by anybody with impunity. The Regulations provided that low-pressure conductors need not be continuously insulated in the streets, and that was one very material point to bear in mind in considering what should be the limit. They knew that whatever dangers arose—such as damage to pipes, explosions, fires—would be increased by an increase of pressure. Supplies such as that of Manchester were not free from danger. Though nothing might have happened at Manchester itself, taking those supplies generally, there had been regrettable accidents in connection with them. For instance, there was the accident to the St. Pancras mains, which must be fresh in the mind of everyone. Then there was a similar system at Southampton, where they had lately had an explosion caused by the same means which it was found had been at work at St. Pancras. There had been explosions on the St. James's and Pall Mall system and under the Preston Electric Lighting Company and elsewhere, but it would be invidious to hold up particular companies to reprobation. With these systems of bare conducting mains there had been accidents, and he held that if they increased the pressure at which they allowed these uninsulated, uncovered mains to be laid, they must to some extent increase the risk. Mr. Crompton had pointed to the fact that in some instances, for traction purposes, thay had allowed the use of 500 volts, and he had stated it as his opinion that what was allowed for traction might be quite equally well allowed into houses. He (Major Cardew) must differ from that. Five hundred volts had only been allowed in the case of overhead wires under very severe restrictions. Those wires were necessarily put up in a permanent and strong way, and were not likely to become into contact with by anyone; but, on the other hand, when they had wires going into houses and open to people without any electrical knowledge at all touching them, they must provide that those wires should be perfectly safe. They were put into children's nurseries, and no one knew what might happen there. Apart from any injury and alarm caused by electric shock, there was the fire risk in houses as well. They had had a strong opinion on the matter from Mr. Musgrave Heaphy. Other speakers had pointed to the great advantage to be derived from the use of 200-volt lamps. All the speakers had been dealing with the question from the point of view of supply. They had had no one come forward on behalf of the consumers to say that they had no fear of it, and he did not think they would find an educated consumer who knew much about electricity who would say there would be much advantage in the use of such lamps from his point of view. All the advantages to be derived from the use of high-pressure lamps were on one side, though it must not be forgotten that the use of them cheapened the supply, and that therefore to that extent they were of benefit to the consumer. To suddenly double the pressure there must be some risk of fire—risk of the arcing of switches and of increased leakage at the fittings. He did not think it would be right to suddenly raise the pressure throughout a whole district in that way. Something would be wanted to guarantee that the pressure in houses should not exceed 300 volts' limit. Taking the question of danger to life, the only instance, he was happy to say, which bore materially on the point in the United Kingdom had been the lamentable accident at Port

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rush. There, they knew, the pressure could not have exceeded more than 300 volts by anything more than a slight fraction—possibly it might have been 320. There they had an unfortunate man thrown upon a charged rail making a good contact. Probably because the shock deprived him of the power of moving, he remained in contact longer than anyone would willingly remain in contact with such a current. The doctors who saw him thought that if the electric shock had not been added to the mechanical shock he would not have been killed. Besides this case they had had evidence of the death of horses and cattle on the line. It could not be said that with 300 volts the shock could be taken with absolute impunity under all conditions. It was impossible to draw an exact line, and to say "At this point there is danger—below it there is none." If they hastily raised the limit, which had worked well hitherto, in a short time they would be again pressed to raise it. He thought the proposal to slightly raise the limit laid down for low pressure, as regarded alternating current, so as to give them 200 volts, was worth considering; but as regarded continuous current he need hardly point out that under the existing Regulations 200-volt or 250-volt lamps could be used with the consent of the consumer. The regulation would prevent the use of such lamps except with the assent of the consumer, and that, under present conditions, was desirable. If any consumer liked to be supplied with 250 volts pressure he could get it now under the continuous-current system.

Sir C. BOYLE said he had no hesitation in stating that he intended to advise the Board of Trade to raise the 150 volts in the case of alternating pressure to a higher figure—to 220 volts or some other figure.

Mr. SIEMENS said with regard to the St. Pancras accident that if they had had only 50 or even 30 volts between the mains the same thing would have happened. The Portrush case could not be compared to the London case, where the bare wires were out of the reach of everyone but workmen. What was dangerous and what was not really depended upon the individual.

Sir C. BOYLE said he thought they had discussed this regulation long enough. He could not to-day announce what advice he should give the Board of Trade, but he honestly said that the suggestions made would be carefully borne in mind. His personal opinion was that the figure 300 in the case of continuous pressure might be slightly raised. Also, it would be his duty to advise the Board of Trade that, after all, when they were deciding what should be high pressure and low pressure, they were only deciding that in cases of high pressure certain additional precautions should be taken. There was no prohibition of the high-pressure system, but only insistance on additional precautions in connection with it.

On *Regulation* 2, Sir C. BOYLE, in reply to the representative of the Southport Corporation, said that a consumer who for experimental purposes converted low pressure into high pressure would do it at his own risk.

Regulation 4 was as follows: "No high-pressure electric line shall be used for the transmission of more than 200,000 watts, or in the case of an aerial line 50,000 watts, except with the consent in writing of the Board of Trade; and efficient means shall be provided to prevent this limit being at any time exceeded."

To this exception was taken on the ground that 200,000 watts was too low. The Institution of Electrical Engineers suggested that the figure should be 500,000.

Sir C. BOYLE said he was disposed to accept the alteration from 200,000 to a higher figure.

Mr. CROMPTON said that by means of an automatic cut-off it was as easy to deal with 500,000 watts as 200,000. The matter should be allowed to be worked out on commercial lines, as it did not affect the public. It would be unwise to unduly fetter engineering designs, and that he was sure Sir C. Boyle would be the last to wish to do.

Major CARDEW said that in the case of a breakdown, which was the danger foreshadowed by the regulation, the energy might be converted into heat at the point where the cable had broken down. If that amount of heat were discharged at one point in the street, though it might be underground, something must happen. They were not going to generate all that heat and have nothing result from it. This was the way in which the Cannon-street and Sloane-square explosions occurred. The sudden generation of heat was enough to cause a serious explosion without an accumulation of gas.

Sir C. BOYLE said he should advise the Board of Trade to raise the 200,000 watts, but he should have to consider whether he could go so far as Mr. Crompton and propose the substitution of 500,000 watts. He thought that would be going too far. The consent of the Board of Trade in writing to an excess of the watts was always obtainable.

Regulation 5.—"Every high-pressure electric line, conductor, or other apparatus shall be protected by a suitable automatic quick-acting cut-off."

Dr. HOPKINSON said that under the old Regulations at Manchester they had been required to put in fuses, but they had never ventured to do so for the reason that they feared to run a greater risk of extinguishing the light than any other risk. In Manchester they had had no trouble from the absence of fuses. No doubt they had not followed the Board of Trade Regulations, and he submitted that it would be better to omit this regulation requiring all mains to be protected by fuses.

Sir C. BOYLE said the regulation only applied to high pressure.

Regulation 6.—"In every case where any transforming apparatus is used to convert a high-pressure supply into a low-pressure supply, some suitable automatic and quick-acting means shall be provided to protect the low-pressure system from any accidental contact with or leakage from the high-pressure system, either within or without the transforming apparatus."

Sir C. BOYLE, in reply to a question whether the automatic means here referred to were really needed when earth-shielded tranformers and earthed metallic shielding between high-tension and low-tension conductors were everywhere employed, said he should think they would be.

Regulation 7.—"The maximum working current in any conductor shall not be sufficient to raise the temperature of the conductor or any part thereof to such an extent as to materially alter the physical condition or specific resistance of the insulating covering, if any, or in any case to raise such temperature to a greater extent than 30° F.; and efficient automatic means shall be provided which will render it impossible for this maximum working current to exceed such limit to the extent of 50 per cent., even for short intervals of time; and special care shall be taken that the cross-sectional area and conductivity at joints are sufficient to avoid local heating, and that the joints are protected against corrosion."

Sir C. BOYLE said this was an old regulation. There had been no difficulty in working it up to the present.

Dr. HOPKINSON, on behalf of the Manchester Corporation, urged that the regulation should be omitted. In the large majority of low-tension stations it was not carried into effect. Cut-outs were not used, and those who were best qualified to speak on the subject said they were better without them. A law which was constantly transgressed, and transgressed with impunity, would be better revoked. He proposed to omit "and an efficient automatic means shall be provided which shall render it impossible for this maximum working current to exceed such limit to the extent of 50 per cent., even for short intervals of time."

Sir C. BOYLE said he was advised that he could omit those words; therefore he would do so.

Regulation 8 was agreed to.

Regulation 9.—"Every electric line shall be tested for insulation after having been placed in position, the testing pressure being at least 200 volts, and the undertakers shall duly record the results of the tests of each line or section of a line. No electric line shall be brought into use in which this test indicates an insulation resistance less than at the rate of 100,000 ohms per mile for every volt of pressure of the supply, unless it is connected with earth with the consent of the Board of Trade, in which case the insulation resistance of such electric line shall not be less than 10 megohms."

The Conference then proceeded to consider Clause 10 of the regulations dealing with the insulation test to be applied to every complete circuit used for the supply of energy, including all machinery, apparatus, and devices forming part of, or in connection with, such circuit. A large number of criticisms upon this rule had been sent in in writing. The representative of the Bournemouth and District Electric Supply Company submitted suggestions to the effect that on low-tension mains tests at much longer intervals than a week would be sufficient, and that to maintain the insulation at the standard mentioned might involve much interference with consumers' installations, over which undertakers had no effective power, especially if the low figure of 5,000 ohms was retained.—Sir C. Boyle and other speakers pointed out that under the existing regulations it was quite possible to maintain the insulation required, because in any case where private consumers were responsible for excessive leakage the undertakers could absolutely refuse to continue a supply to any customer whose wires were not in a proper condition. On the other hand, it was pointed out by Mr. Crompton that it would be unreasonable to require a weekly test. Major Cardew pointed out that the test could be carried out without in any way interfering with the supply of electricity. His idea was that close observation should always be kept as to faults of leakage.—Mr. Crompton pointed out that they could not ascertain whether a leakage was in their own circuit or in the house circuit without detaching the house service from their own, and private consumers had a great objection to officials of the supply companies having an almost indiscriminate right of entrance to their houses to make the examinations.—Prof. Kennedy said that the Westminster Company tested their leakage every morning, and they found no difficulty in doing it. When they found that there was a large leakage going they used their best efforts to ascertain where it was.

Mr. PREECE said that, as one who had had some considerable experience in the practical maintenance of the electrical systems, he would like to point out that there was no more important clause in these draft Regulations than that which was now under discussion. There was not a single electrical enterprise that he knew of that had not been maintained in efficient order by the practical carrying out of such regulations as that now proposed. It was impossible for consumers, or undertakers or the Board of Trade to ensure that the law was properly carried out unless some such regulation as this was introduced. It had been suggested by Gen. Webber that the wording of the clause was not wide enough, and that it did not include lamps and apparatus in houses. To his (Mr. Preece's) mind, however, it was quite clear that the words "complete circuit" included everything, and unless undertakers had a certain command over the part of the circuit in the consumer's house they could not have control over the whole of the system. All of them who had any practical experience knew that the chief source of trouble lay in the way in which cheap work in connection with installations was put into houses, and, subsequently, as far as maintenance was concerned, neglected. They had all had experience of having consumers' houses disconnected in order to call in firms to put the wires into proper order. It had been urged that once a week was too frequent a test. In regard to that he thought it right to say that there was not in the country a much larger system of electric application to be kept in order than that of the telegraphs and the post-office service of the Government. Their practice was every morning without exception to test every circuit. They found no difficulty in doing that. It was done with the greatest ease, and by that means they obtained the earliest information of faults and secured the proper maintenance of the service. He could not conceive any well-conducted electric lighting company in this country having any difficulty in carrying out a proper test once a week. Therefore, as a practical man, he urged the Board of Trade very strongly to maintain the draft clause in its present form. The test was not a very serious one, and in exceptional cases the Board of Trade might make an exception to the rule.

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Major CARDEW said he thought they must look to the supply companies to maintain the supply throughout, and it was quite in the power of the companies to cut off the supply where they found excessive leakage after addressing a remonstrance to the consumers.

Sir C. BOYLE: It is not necessary for me to announce any decision to-day. The observations that have been made will be carefully reported to the Board of Trade, and their decision will be announced in the usual way.

Clauses 11 and 12, relating to the quality, amount and thickness of the insulation of leads and apparatus, were discussed together.

Sir C. BOYLE, referring to Clause 12, said he was prepared to advise the Board of Trade that it should be made prospective, but only on condition that if any evil effects were discovered from the absence of the regulation in existing cases the company must expect to have the regulation made applicable to it retrospectively.

On Clause 13, which provided that "no electric line, machine, device, or apparatus intended to form part of, or be connected with, a high-pressure circuit shall be brought into use unless the insulation thereof has withstood the continuous application during one hour of twice the pressure to which it is intended to be subjected in use, and that the undertakers shall duly record the results of such test,"

Prof. KENNEDY thought that the word machine should be left out of the regulation.

Sir C. BOYLE: But you want some test even of an alternator.

Prof. KENNEDY: Yes; I would suggest 25 per cent. above its nominal pressure.

Mr. HAMMOND: I would suggest 50 per cent. I think the apparatus should bear in the public interest, the highest tests.

Mr. CROMPTON doubted whether any test of these apparatus on their own premises did much to secure the safety of the public. It rather savoured of grandmotherly legislation.

Sir C. BOYLE: I can only say that there is constant pressure being put upon the Board of Trade to be a great deal more grandmotherly than they are at present.

After further discussion,

Sir C. BOYLE said the probability was that the decision of the Board of Trade would be to make the test twice the normal pressure in the case of an electric line and 50 per cent. in the case of a machine, device, or apparatus.

On Clause 15, which provided that "where any accident by fire or explosion, or any accident causing or likely to have caused personal injury, occurs at any part of any electric line or work to which these Regulations apply, the undertakers shall give immediate notice thereof to the Board of Trade," the Town Clerk of Manchester asked that it should be so altered as not to apply to trivial accidents, but only to those of a really serious character.

Sir C. BOYLE: How do you define a serious accident?

Eventually it was agreed, subject to the final decision of the Board of Trade, to alter the draft regulation so that it should read as follows: "Where any accident causing, or likely to cause, personal injury occurs at any part of any electric line or work, the undertakers shall give immediate notice thereof to the Board of Trade."

Regulations 16, 17, 18 and 19, dealing with aerial lines, were agreed to in substance as proposed.

Clause 23 enacted: "Every high-pressure aerial line shall be efficiently suspended by means of insulating ligaments to suspending wires, so that the weight of the line does not produce any sensible stress in the direction of its length. All suspending wires, if of iron or steel, shall be galvanised."

Mr. CROMPTON urged that when aerial cables were used at all, except in neighbourhoods where the population was sparse, it was best to make them of copper and self-suspending.

Major CARDEW: What distances between the poles?

Mr. CROMPTON: From 50 to 100 yards.

Sir C. BOYLE: What happens in that case if the cable breaks?

Mr. CROMPTON: It falls down just as at present.

Sir C. BOYLE: And anyone beneath it would be in a bad way?

Mr. CROMPTON: Yes, but these cables have fallen down, and the tags, which are the most vulnerable part of the construction, have never prevented such accidents. It is always the suspending wire that breaks.

After further discussion, Sir C. BOYLE said that Mr. Crompton's argument on the matter would be carefully considered.

Several minor points having been discussed, the Conference next proceeded to discuss the Regulation (No. 37) that "all conduits, pipes, or casings used as receptacles for electric lines shall be constructed of durable material, and of ample strength to prevent damage from heavy traffic, and, where they are laid in streets in which gas mains are also laid, shall be so constructed as to prevent any influx of gas from the adjacent soil."

Mr. HAMMOND and others urged that the rule was unfair to those engaged in the supply of electric lighting.

Mr. PREECE said that from 44 years' experience of fighting between gas and the pipes they had succeeded in the Post Office at least in getting what they wanted. In London alone there were 8,000 boxes, and in the United Kingdom 16,000 boxes in connection with the Post Office, and it was a very rare thing for the year to pass without several explosions taking place. He would like very much to point out, in reference to what Mr. Hammond had said, when he advocated leaving the bottom of the boxes open, that that was what the Post Office did not do, and were prevented from doing. They were obliged to fill them up to prevent the influx of gas. They had done everything that reasonable beings could do to prevent the influx of gas into the boxes, but it did get in nevertheless, and through people throwing down matches or through sparks arising from other sources there would, when there was an accumulation of gas, be an explosion. It was difficult to prevent it. He supported the suggestion put forward by Mr. Crompton on behalf of the Institution of Electrical Engineers, in which the word "accumulation" was substituted for "influx."

Sir C. BOYLE said the desire of the Board of Trade officials was to compel the electric lighting companies to keep the gas out of their boxes, and to compel the gas companies to keep their gas from getting into the electric companies' boxes. He knew, however, that it was difficult, if not absolutely impossible, to enforce that obligation in either case. Therefore, the clause as it stood on the paper must fall to the ground. He would propose a clause to the Board of Trade based on the recommendation brought by Mr. Crompton and supported by Mr. Preece.

Mr. CROMPTON expressed his gratitude for the concession made by Sir C. Boyle.

WEDNESDAY, NOVEMBER 20TH.

The Conference on Wednesday resumed the consideration of the proposed Electric Lighting Regulations. Sir Courtenay Boyle, K.C.B., again presided. The attendance of delegates was not quite so large as on the previous day.

Sir COURTENAY BOYLE said: I have carefully considered the very important representations made to me yesterday on the question of the definition of low pressure. The importance of that definition was made very clear to my mind by the arguments which were used yesterday. The points raised were highly technical and highly scientific, and I have come to the conclusion that it would not be possible for me to give definite or final advice to the Board of Trade as to their decision on the points that were submitted yesterday. I think probably it would be for the convenience of those interested in the matter if a decision was reserved for a short time, and if the Board of Trade were to appoint a small committee—say not exceeding, perhaps, three expert advisers—to carefully consider the scientific aspect of the question, and finally to make representations to the Board of Trade.

General WEBBER, and several others of those present, expressed their approval of the course proposed.

Sir C. BOYLE: Then I shall recommend that course to the Board of Trade.

On the proposed Regulation 29, which provides that "all metal conduits, pipes, or casings containing any electric line shall be efficiently connected with earth, and shall be so jointed and connected across all street boxes and other openings as to make good electrical connection throughout their whole length,"

Mr. CROMPTON said that the Institution of Electrical Engineers desired that the regulation should apply only in cases of high pressure.

Major CARDEW pointed out that it seemed to him that the point now being raised was dealt with in the next regulation.

Mr. CROMPTON, having referred to Clause 30, said he found that that was so, and his argument therefore fell to the ground.

On Clause 30, that "where isolated lengths of metal conduit, pipe, or casing are used for the protection of any electric line at road crossings or similar positions, there shall be interposed between such electric line and the conduit, pipe, or casing such additional insulating material as will prevent the possibility of any electrical charging thereof," the representative of the Manchester Corporation suggested that it would be very hard upon them if the regulation were passed in its present form, as they had a large number of cased lines, which had cost a great deal of money, and to alter which in compliance with this regulations would involve a great deal of expense.

Sir C. BOYLE: I think we may make this regulation a little more general, and simply require that sufficient precautions be taken to prevent the possibility of electric charging.

Clause 31 provided as follows:—"Where the conductors of electric lines placed in any conduit are not continuously covered with insulating material, they shall be securely fixed in position, and no unfixed material of a conducting nature shall be contained in the conduit. Adequate precautions shall also be taken to ensure that no accumulation of water shall take place in any part of the conduit, and to prevent any access of moisture to the conductors or the insulators; and the latter shall be so disposed that they can be readily inspected."

Mr. BAYNES, of St. Pancras, said that many of their mains were laid at a depth which would make it impossible to carry out the inspection in the way suggested by Prof. Kennedy. They had something like £40,000 worth of mains sunk, and it would be a most serious matter for them to have to alter them.

Sir C. BOYLE: Nobody ought to be more alive to the danger of allowing inflammable incrustation of insulators than the authorities of St. Pancras.

Mr. BAYNES: We have examined some of them recently, and found no incrustation, and there has been only one case of explosion.

Major CARDEW: We certainly found in one case that there had been a deposit on intermediate insulators; but I admit that it is not frequent.

Sir C. BOYLE, after further discussion, said they must have some precaution such as that embodied in this regulation; but he thought it would suffice if they made it prospective. Of course, it was desirable that undertakers should start at once to work up to that level of excellence as far as they could.

In answer to a question, Major CARDEW said it was intended by the new Regulations that there should be some external protection to the casing of an electric cable, to prevent people outside being brought into accidental contact with it. In the case, for instance, of high-pressure leads being brought inside a post, the idea was that the lead should be enclosed in a metallic casing. Steel armour would constitute a sufficient casing.

Prof. KENNEDY: It is important to know whether lines going by lamp-posts are included.

Major CARDEW: The lamp-post itself would form the outer casing of an armoured cable, but, of course, it must be connected with the earth.

Sir C. BOYLE remarked that the provision in question would be retrospective.

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The Conference next proceeded to consider Regulations Nos. 33 and 34, which were as follows :—

(33) "Every high-pressure electric line transmitting more than 50,000 watts, or used for the supply of energy to transformers placed in street boxes, shall, except within the generating station, be entirely enclosed in strong metal casing efficiently connected with earth, and such casing shall not contain any low-pressure electric line."

(34) "High-pressure electric lines not intended to transmit more than 50,000 watts, may be enclosed either as provided in the preceding regulation, or in glazed stoneware casings properly laid and jointed in cement at a depth of not less than 2ft. below the surface of the ground and sufficiently protected against breakage."

Mr. CROMPTON proposed to substitute for the two draft clauses just mentioned the following, which he believed would accomplish all that the Board desired, and would be more workable :—"Every high-pressure electric line transmitting more than 50,000 watts shall, except within the generating station or sub-station, be entirely enclosed in strong metal casing efficiently connected with earth, or in stoneware or other suitable casing, and such casing shall not contain any low-pressure electric line unless this line is a concentric cable with the outer conductor earthed."

Sir C. BOYLE, after considerable discussion, remarked that it had been suggested to him that instead of adopting these two new regulations, they should go back to the old regulation known as No. 8.

Mr. CROMPTON: The proposal to go back to the old regulation meets our case.

Sir C. BOYLE: I prefer it.

Major CARDEW said that the only question in his mind was as to whether the limit of depth should not be 2ft. instead of 18in.

Sir C. BOYLE said he would follow what was the evident and general feeling—that they should drop out the two new clauses, and revert to No. 8 of the old Regulations.

The next Regulation (No. 35) considered was the following: "All street boxes which contain any vacant space shall be so constructed as to prevent any influx of gas or water either from the adjacent soil or by means of any pipes, and ample provision shall be made by ventilation or otherwise for the immediate escape of any gas which may by accident have obtained access to the box, and for the prevention of danger from sparking."

Sir C. BOYLE explained that this had only been put down as a basis of discussion. In regard to street boxes used for transforming chambers, he must have some further precautions, such as were agreed to at the Conference held some months ago. He did not want the regulation particularly in regard to ordinary street boxes, but it was a question whether it should not apply to very large street boxes, even if not used as transforming chambers.

Mr. GUNYON, for the London County Council, suggested that there should be a special clause in regard to transforming chambers and other large street boxes—say those of 1 cubic yard capacity. That would leave the smaller box on a different footing.

Mr. Crompton, Mr. Hammond, Prof. Kennedy and others thought that Mr. Gunyon's suggestion would be generally accepted—namely, that the regulation should apply only to boxes of not less than 1 cubic yard capacity.

Mr. HOLMES (on behalf of Liverpool) urged that if there was to be a limit of capacity, it should be 2 cubic yards instead of one. They had put these large boxes under the streets over ten years without any difficulty having arisen.

Sir C. BOYLE: We are not proposing in any way to limit the size of street boxes. We only want to provide that where they are large they shall be provided with sufficient ventilation. I think it will be generally acceptable that Clause 35 should apply only to street boxes containing transformers. We will consider Mr. Gunyon's suggestion, that a regulation should be made for the ventilation of other street boxes, which are of 1 cubic yard capacity.

The new Regulations 36 and 37 were agreed to, after some modifications.

A long discussion arose on Clause 38, which runs as follows :—

"All converting stations, or points in a system of distribution to which a high pressure supply is given from generating stations, and from which a low pressure supply is given to consumers, shall be established in suitable places, which are in the sole occupation and charge of the undertakers."

The general feeling appeared to be that the supplying undertakers ought to have the sole right of access to chambers, and Sir C. Boyle pointed out that the difficulty of occupation could be got over by the undertakers renting a room occupied by the chambers in the same way that they might rent a cellar in a person's house. Eventually, after hearing Prof. Ayrton and others on the subject, Sir C. Boyle admitted that there was great force in the objection which had been offered to this particular regulation, and thought that it would be better to drop it, and go back to the old regulation, No. 16.

Several other rules were then discussed and agreed to with certain amendments, and Sir C. Boyle consented to a proviso that undertakers should not be obliged to connect up to houses unless there was an insulation resistance of at least k/n megohms, k to be subsequently settled, n being "the number of points for taking of current," although on the other hand they *must* cut off connection if the insulation resistance fell below 5,000 ohms.

The regulations relating to arc lighting were next proceeded with, and Sir C. Boyle stated, in answer to a question, that they related only to the undertakers.

Clause 47 was passed without amendment. On Clause 48, that "arc lamps used in any street shall be so fixed as not to be in any part at a less height than 10ft. from the ground,"

Mr. HOLMES (Liverpool) said he had no objection if the regulation referred only to public lamps for street lighting, but he would point out that, by Liverpool Corporation regulations, consumers' arc lamps could now be fixed at 8ft. from the ground, and to raise them 2ft. would render them useless for their intended purpose—viz., lighting shop windows.

Sir C. BOYLE said that the regulation would be modified so as to read that *arc lamps used for public lighting* shall be fixed at 10ft. from the ground, and that lamps used for private lighting shall be fixed at 8ft. and screened.

Mr. BAYNES asked whether the Board of Trade would not also concede that public arc-lighting lamps should be allowed to be fixed at 8ft.

Sir C. BOYLE: No. I have given way on the private lamps. I must stick to 10ft. for public lighting lamps.

In Regulation 49, dealing with arc-lamp switches, Sir Courtenay Boyle, on the representation of a delegate, agreed to leave out, in Sub-section C, the words "by an inexperienced person."

On Clause 50, dealing with penalties, the TOWN CLERK of HULL said he was afraid the clause, as it stood, would result in throwing upon electric lighting undertakers responsibilities which primarily belonged to other companies or bodies. He did not think the Board of Trade in forming these regulations intended to confer an advantage upon a gas company at the expense of an electric lighting company. Assuming that an accident occurred, the person injured might not have regard to those who were primarily responsible, but come down upon the electric lighting undertaker. The undertakers did not object to a penalty for breach of the bye-laws; but they objected to regulations framed for the protection of the public being used for the purpose of shifting the responsibility for accidents from the shoulders of those who were primarily the cause to those of the electric undertakers, who were only liable in a secondary degree. The person injured ought to rely on the common law remedy against those who were primarily responsible. He would suggest that these words should be added: "And nothing in this regulation shall impose upon the undertakers any liability to make compensation in respect of any damage or injury which may be caused by reason of such default."

Sir C. BOYLE said his counsel advised him that the regulation did not shift any responsibility. There was, however, some difficulty in the matter in the mind of his counsel, and he would only now say he would deal with it in the best way he could.

The regulations as to supply were speedily disposed of. The proposed notice of a week to commence a supply was reduced to 48 hours on the suggestion of Mr. Hammond. In the clause for the maintenance of a constant supply, the proviso was amended so that the permission to temporarily discontinue the supply might be given not only for the purposes of testing "or for any other purpose connected with the efficient working of the undertaking," and "at such intervals as may be thought expedient."

On the provision that "the variation of pressure at any consumer's terminals shall not under any conditions of the supply which the consumer is entitled to receive, *nor at any time*, exceed 4 per cent. from the declared constant pressure, *whether such variation be due to the resistance of the service lines or apparatus belonging to the undertakers, or to any action or effect produced by such apparatus, for which the consumer cannot be shown be responsible, or, partly to any variation of pressure in the distributing mains from which the supply is taken*,"

Sir C. BOYLE consented to omit the words italicised by us.

This concluded the business of the Conference.

Sir C. BOYLE said it was his pleasing duty to thank very heartily the various representatives who had attended the Conference, in the name of the Board of Trade, for the manner in which they had raised their objections and the courtesy with which they had pressed them.

On the motion of Alderman GIBSON, Manchester, seconded by Alderman MYLES, Bolton, a cordial vote of thanks was passed to Sir Courtenay Boyle.

The Conference then separated.

DINNER TO MR. W. T. ANSELL.

A dinner was given at the Holborn Restaurant, London, on the evening of the 14th inst. to Mr. W. T. Ansell, the traffic superintendent of the Eastern Telegraph Company, to celebrate his jubilee in the telegraph service. The chair was occupied by Mr. J. Denison Pender, the Managing Director of the Eastern Telegraph Company, on whose immediate right sat the guest of the evening, and the company included Sir Henry F. Mance, Major A. Wood, Prof. D. E. Hughes, Mr. C. E. Spagnoletti, Mr. W. H. Preece, F. J. Griffiths, W. H. Burman, H. C. Forde, H. A. Taylor, A. Le Neve-Foster, J. Gavey, F. Higgins, J. Hookey, W. W. Howell, J. Jenkin, F. Lucas, D. Sinclair, W. O. Smith, J. W. Wilkins, H. D. Wilkinson, F. Webb, Captain Hampton, N. Jauralde, and F. Deering, as well as a large number of Mr. Ansell's colleagues and personal friends in the telegraph service. The committee who had charge of the arrangements carried them out with complete success, and had the satisfaction of receiving a well-deserved vote of thanks.

The usual loyal toasts having been duly honoured,

The CHAIRMAN proposed the toast of "Telegraphy." It was not, he remarked, the toast of the evening, but it was one of very great importance. He would not go into the details of the progress of telegraphy, as there were so many gentlemen present who had followed, step by step, the advancement of this great enterprise, which now made so notable a mark in the world. The satisfaction of America and of Canada when they were able to speak with the old country some years ago with one cable was extreme, and the same means of communication had since been extended to all parts of the world, and not only by one cable, but by many. He was connected with some of the companies which at the

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present time maintained the communication between Canada, America and Australia through Great Britain, but he did not wish in any way on that account to throw cold water on that other great project, the Pacific cable. He thought, however, he was justified in saying that before this enterprise was undertaken those who had been identified by their past with the telegraph world, whether by land or sea, should be listened to, and listened to attentively (hear, hear). It was easy to lay a cable at the bottom of the sea, or to put anything into the ocean; but when a cable was put into the ocean they wanted to be able to get hold of it again. The sounding wire had not yet fathomed the depths in some parts of the Pacific where it was proposed to lay the cable. He therefore thought the gravest consideration ought to be given to the proposal before it was undertaken. The contractors' business was to lay a cable and then hand it over to the Company concerned to work it, but he thought that if the contractors were asked to name their price for maintaining the Pacific cable, the amount required would show what the undertaking really meant. Cable men must not and did not forget the value of the land lines, which he believed were 2,500,000 miles in extent, and which took up the cable work and distributed it for the submarine companies. They also collected the cable companies' work, and handed it over to them in all parts of the world. Were it not for the network of these great land lines he feared the cable companies would not hold the high position they now occupied. They had both followed the flag wherever trade had sprung up. The public might say with truth that the cable companies received subsidies from the Governments. They did not, however, get subsidies to begin with, and it must be remembered that the cable companies had shareholders to face and to pay dividends to. It was not exactly the same thing with the Government lines, but he was bound to thank—and he wished to take that opportunity of doing so—those who held positions under the Government, and with whom the cable companies had daily dealings, for the courtesy and assistance which they always received from them (hear, hear). The great enterprise of telegraphy was due to science and capital. Science could not do without capital, and capital in this case could not do without science. He regretted that he was not a scientist, and he must admit that capital occasionally lagged, which was never the case with science. Science would on one day do that which would revolutionise the working of their cables, and even their land lines, but it would on the next day begin again with the view of improving what was regarded as perfect. He believed that if science and capital would, as in the past, set aside any little jealousies which might arise between them, there were even greater things before them than those which had been already realised (hear, hear). He was proud that the name he bore had been associated with the beginning and the development of this great industry. He felt that he could not pay a higher tribute to those who had led the way in the enterprise than by urging the younger men not only to do their duty, as those before them had done, but to endeavour to do even better; and by means of science and their own energy try to keep Great Britain in the pre-eminent position which she had always held, scientifically and commercially, throughout the world. It was by such work, by such energy, that Mr. Ansell occupied the proud and honoured position in which they saw him that night (loud cheers).

Sir H. F. MANCE traced the progress of submarine telegraphy from its earliest days, telling more than one amusing incident in connection with the defects in the lines and the mistakes which consequently arose. When he looked back over his past life he thought that his experience might possibly be considered unique, for he had assisted in the making of the cable, submerging it, working it for many years afterwards, then having to repair it, and eventually having to lay a new cable in its place. He mentioned various names identified with the progress of the enterprise, and remarked that it was the great commercial genius of Sir John Pender to which was attributable so much of the success of submarine telegraphy, while their honoured guest of that evening might be permitted to stand among them as the representative of the submarine telegraphs throughout all parts of the world. At all stations the name of Ansell was familiar as household words (cheers).

Prof. HUGHES, F.R.S., replied for scientific telegraphy, observing that instruments and discoveries had often been made in advance of their time. Thus the duplex was invented in Germany, England, and the United States many years before the condition of the lines would permit of its use. Bain early showed them how to transmit and receive over 1,000 words a minute, but the inherent qualities of their lines did not allow of this speed even at the present time. Ever since his first connection with practical telegraphy in 1856 nothing had surprised him more than the gradual and sure improvement of the lines throughout Europe and America. He believed this constant progress was due in a great part to the use of more scientific methods and exact measurements. Scientific telegraphy had ever been on the alert to combat any phenomena which would act in a deleterious manner against the rapid transmission of signals. He would not weary them by enumerating the phenomena that scientific telegraphy had to observe. Electricians and engineers had worked faithfully, and had made wonderful progress during the last 50 years, and he was convinced that science would not rest until our lines and instruments were as near perfection as possible. Mr. Ansell commenced his career in the age of steam, but he now found himself in the age of electricity. His name and services were well known throughout the civilised world to all connected with scientific telegraphy, and he was sure that they all wished him strength and health to continue his career (hear, hear, and cheers).

Mr. C. E. SPAGNOLETTI also responded to the toast, referring more particularly to the progress of the land lines and to the high perfection of working to which they had now been brought. He had lately been connected with an instrument which appeared to want a little more attention —the phonopore. It had not been favourably received, and some might laugh at it, but it had done excellent work, and he felt assured that if it were only placed in the hands of good people to work with opportunities of trying experiments, all difficulties in connection with it would be overcome. It would be an excellent instrument in case of emergency. There was no doubt in his mind that Englishmen would still continue to carry out all the improvements which were brought forward periodically for perfecting the lines. He wished long life to his old friend and old chief, Mr. Ansell, from whom he had learned a great deal.

Mr. W. H. PREECE, C.B., afterwards proposed "The Guest of the Evening." It was, he said, exactly 44 years since he (Mr. Preece) made acquaintance with a fine, bold, splendid Roman hand, whose memoranda and notes used to be deciphered without any difficulty by him in the small office in the West Strand. From a note which he received on the previous day he had been pleased to see that there was not a trace of faltering in that fine Roman hand (cheers). Mr. Ansell commenced his career before he (Mr. Preece) did, but for 44 years their careers had run side by side. In 1845 Mr. Ansell commenced with that *alma mater* of all telegraphists, the old Electric Company, incorporated in 1846, and from 1846 to 1856 he remained in a position of trust and responsibility, acting as one of those pioneers who succeeded in establishing telegraphy in this country on a sound financial basis (hear, hear). The Chairman had remarked that science and capital must always be found in this enterprise. That had been so. He could speak from experience of it. In the south of England he was the scientific fellow, and Mr. Ansell was the capital fellow (hear, hear and laughter). Mr. Ansell remained the same capital fellow, but he himself lost his science on a memorable evening 39 years ago, when he was informed that the time between Southampton and Berlin had gone back nearly two hours (laughter). His career as a lecturer had thus been cut short. He never knew the culprit, who, however, had acknowledged himself that night [referring to an incident recounted by Sir H. Mance]. He was one of those who believed that the finest incentive to progress was opposition, as illustrated by the great struggle they had had in this country to push on telegraphy, telephony, and the electric light. Unfortunately, in the time of progress, Mr. Ansell's health broke down, and he retired for a short time to the Greek Archipelago, and took charge of the cables in the Levant; but that only led, with a slight interrupton, to his subsequent entry into the service of the Eastern Telegraph Company —that great octopus, whose feeders were found all over the world (hear, hear and cheers). He was sure they would all join with him in wishing long life and prosperity to Mr. Ansell. With all his faults—they were very few—they loved him still. He had a kind heart, he was a cheering companion, and if there was anyone in discomfort or distress, and wanting assistance, he had only to go to Old Bill Ansell, and with that impetuosity which they had no doubt all seen, he would help a friend out of the greatest difficulty (cheers).

The toast was drunk with enthusiasm amid continuous cheering, followed by the singing of "He's a jolly food fellow."

Mr. W. T. ANSELL, who was again warmly received, in reply assured them that, although the expression was hackneyed, that was the proudest moment of his life. He did not know how to express his feelings in acknowledging the unprecedented honour which they had done him, and he had not been aware until that moment how many valued friends he had gained in all parts of the world. Perhaps he might say without egotism that it was a fitting end to a career such as his (Voices, "No, no," and "You have not done yet.") At the time to which his old friend, Mr. Preece, had referred, the incorporation of the old Electric Company in 1846, there were 84 of them on the muster roll—he had a printed list of them Of those 84 men, who were the pioneers of telegraphy of the world, five were still living, but he himself was the only one who was in harness. There was one old friend of his present who was his senior in telegraphy, although he had left the career of telegraphy since 1850—he referred to Mr. Wilkins (cheers). It was a source of great gratification to him to find Mr. Wilkins among them that evening, because although, as he had said, Mr. Wilkins abandoned telegraphy to resume his profession, it was to that gentleman and his principals that they were indebted for the first steps which were taken in what had subsequently been, and still was, the most important and the greatest boon to the world that this or any century had seen (hear, hear). Mr. Preece had sketched his (Mr. Ansell's) early career in connection with the land line telegraphs. The first 25 years of that career were spent almost entirely, excepting the short time he was in the Levant, in connection with land telegraphy. It was his fate to be pushed to the front, and he was in the van of nearly every line that was erected in England. In the same way it had been his fate in the last 25 years of his life to be connected with submarine telegraphy and to find himself in the van of progress. He had mentioned his friend Mr. Wilkins, and as regarded himself they knew that his connection with telegraphy began in November, 1845. There was, however, still one gentleman prominently before the public, he was happy to say, who ran him very closely in active harness—he alluded to his honoured Chairman, Sir John Pender (cheers), who in 1847 first associated himself with telegraphy in connection with the British Electric Company, and to whom the world was indebted for the greatest civilising boon that had yet been seen. Fifty years ago, before the days of ocean steamers and of the Suez Canal, it took six months for a merchant in London to get a reply to his letters and to know that his orders for a shipment had been executed. Of course, everything was dear. The merchant's capital was locked up for months, and, naturally, the consumer suffered. They now found that what formerly took six months only took six hours (cheers). He was proud to say that he was still serving the man to whose indomitable pluck, perseverance, and prescience the world was indebted for what no man yet could properly appreciate. But for Sir John Pender they would never have had submarine telegraphy in the advanced position it now occupied. Although he was deeply grateful to them for the honour that had been done him, he must still be allowed to give honour to whom the greatest honour was due (cheers). He was proud

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of the assurance of his friend on his right (Mr. Preece) that his efforts to benefit his fellows had been appreciated, and he desired to thank them again from the bottom of his heart for their kindness, and for the unprecedented honour which they had conferred upon him (loud cheers).

The CHAIRMAN afterwards presented Mr. Ansell with a handsome gold watch and chain, and a clock and ornaments *en suite*, together with a beautiful diamond brooch for Mrs. Ansell. They all congratulated Mr. Ansell on having arrived at 50 years' service, and on being in a hale and hearty condition to undertake, he hoped, many years' further work. Mr. Preece had referred to having worked in harmony side by side with Mr. Ansell for so many years, and, speaking on the part of the companies with which he (the Chairman) had the honour of being associated, he wished to say that it was their desire to work in harmony with others wherever it was in their power to do so. The testimonial which he had presented to Mr. Ansell was a token of appreciation and goodwill from all parts of the world. He had a bundle of telegrams in his possession; he was not going to detain them by reading them, but he might say that they came from every part of the world for Mr. Ansell.

Mr. ANSELL again feelingly acknowledged the kindness which had been displayed towards him.

Mr. DRAPER afterwards proposed "The Chairman." Mr. Pender, he said, had always identified himself with the interests of the staff both at home and abroad, and it was due to his good feeling, his energy, and his imperturbable good humour that he was enabled to carry on his very complicated work for the companies with which he was associated. In the name of the Committee, and in his own name, he desired to thank Mr. Pender for the cordial relations that existed between them and him, and the Directors for the confidence which they reposed in their officers.

The toast having been cordially drunk,

The CHAIRMAN acknowledged it in appropriate terms, and incidentally observed that he was always not only willing but pleased to associate in anything which could bring the different sections of the telegraph service in this country together, that they might act as one man and maintain their position against any opposition that might attack them in any part of the world (cheers).

Major WOOD proposed "The Committee" who had carried out the arrangements for the celebration. He desired to endorse all that had been said that night. He could assure the Chairman, on his own part and on the part of those whom he represented, that they were really most anxious that the telegraph interests should work unitedly in every possible way.

Mr. T. A. BULLOCK, in responding for the toast, remarked that the Committee had, as they could see, done everything possible to make the gathering a success, and referred to Mr. A. R. Hardie and Mr. W. Hibberdine, as having done a large share of the hard work of the Committee.

The company shortly afterwards dispersed.

LONDON COUNTY COUNCIL.

At the weekly meeting of the London County Council on Tuesday it was agreed, on the recommendation of the Building Act Committee, that consent should be given to the erection of electric lighting buildings on the south side of Bowling Green-walk, Hoxton, on the application of the Vestry of Shoreditch, subject to the usual conditions imposed by the Council as to the works being commenced within six months, &c.

National Telephone Company.

It was reported by the Bridges Committee that the National Telephone Company had applied for permission to lay a cable along Waterloo Bridge. The Company proposed fixing a 2½in. cable upon the last cornice of the bridge and within a segmental galvanised iron casing, 9in. in width at the base by 5½in. in height. The casing was to be flanged at the base and to be attached to the cornice bymeans of Lewis's bolts let into the granite. As so large a casing would probably interfere with the architectural lines of the structure, the Committee were of opinion that the Company should be restricted to the use of a 3in. tube, as at Hammersmith Bridge. With regard to the attachments, those should be made by narrow iron straps attached at intervals to the base of the plinth of the bridge, with the object of providing a means of drainage beneath the pipes. As to the rent to be paid by the Company, the Committee suggested that an annual rent of £10 should be charged, which was the same as that charged for the cable across Hammersmith Bridge. They recommended: "That the National Telephone Company be allowed to lay a cable across Waterloo Bridge on the terms and conditions before mentioned, to be embodied in an agreement to be prepared by the solicitor, and subject to the work being carried out to the approval of the engineer of the Council."

Mr. ROBERTS said that that was a matter which he hoped the Chairman of the Committee would take back. It was a proposal to lay a 3in. cable. The original proposal was a monstrous suggestion to fix a 9in. by 6in. pipe. That was not a question of saving the ratepayers' money. Waterloo Bridge was, he might say, the best bridge they hadin London, and there was already one tube there for the Council's own purposes. Should they allow the Company to save money by the laying of that tube and spoiling the bridge architecturally? Why should not the National Telephone Company put the tube in the road, for there would be very little space required? He thought it was somewhat strange that the Company did not approach them when the roadway was being made; but of course it was a question to the National Telephone Company as to how they could best carry out their work; but it was no part of the work of the Council to allow them to spoil one of the best bridges in London.

Mr. EMDEN said that whilst they wanted to keep the bridge from being disfigured he did not think they should encourage the placing of the wires under the roadway. Nothing could be worse for the general public than having the middle of the public road pulled up. He did not think the placing of that small tube on the cornice of the bridge would disfigure it in the eyes of anyone unless they looked specially for it. If the matter went back there might be some other bridge on which it might be carried over.

Mr. PEARCE (Chairman of the Committee) said that in view of what was evidently the feeling of the Council, he would take the recommendation back.

The proposal to take the report back was then agreed to.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November 1, 1895.*

Electrical Speculation in Philadelphia.—The Quaker City has not been noted as a speculative centre, but recent events would seem to indicate that its character in this respect is undergoing a change. Some months ago a storage battery company was organised there with a capital of $13,500,000, and a few weeks ago the stock reached 70, but has since fallen to below 50. Mr. W. W. Gibbs, the promoter of the United Gas Improvement Company, of the Heisler system of electric lighting and of the Welsbach light, is at the head of the enterprise first referred to—the Electric Storage Battery Company. Speculation in all of the above stocks (except the Heisler, which system has apparently been abandoned) has been so rife that the name of the "American Kaffirs" has been applied to them. Still more recently, the same promoter organised a syndicate which has obtained control of the Edison Illuminating Company of Philadelphia, and it is announced that the profits under the new management will be largely increased from the sale of exhaust steam, for which purpose an extensive system of piping is to be laid throughout the business districts. The capital stock of the Edison Company was $2,000,000, and that of the new concern is $10,000 000.

November 8, 1895.

A New Conduit Electric Railway.—The Metropolitan Street Railway Company of Washington (D.C.) has nearly completed equipping about four miles of double track with a modified Budapest conduit system, after the designs of its chief engineer, Mr. A. N. Connett. The insulators, instead of being horizontal as at Budapest, are vertical, and consist of a corrugated porcelain cylinder in a metal cup, which latter is secured by a set screw in the top of the conduit. The conductor consists of a 6in. T bar, to the vertical face of which chilled shoes secured to a plow similar to a cable grip will be held by a light spring pressure. A voltage of 500 will be used, instead of 300 as at Budapest. A manhole alongside of each insulator will make these easily accessible for examination and repair. The feeders are carried in terra-cotta ducts between the tracks.

Storage Batteries.—The phenomenal success of the Electrical Storage Battery Company of Philadelphia in its stock operations has caused storage battery companies to flock to the front. The above Company last week purchased the Pumpelly-Sorley battery of Chicago, paying, it is said, a price that was very advantageous to those interested in the Chicago Company. The Reed Electric Company of Philadelphia was incorporated a few days ago, and will manufacture a Planté cell invented by Mr. C. J. Reed, the well-known electro-chemist. The specific points in the Reed cell are its light weight and the extremely small amount of time required for charging, it being said that the cell can be fully charged in 40 minutes; it is also claimed that the cell will stand a very high rate of discharge on account of its extremely large surface and depth of active material. Among other companies entering the field are the Haschke Storage Battery Company of Chicago, and the Hatch Storage

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Battery Company of Philadelphia, but no details have as yet been printed concerning the construction of their cells. In connection with storage batteries, we may say that the Madison-avenue street car line of New York city has during the present week placed two storage batteries cars on its line, using chloride cells.

CORRESPONDENCE.

STREET LIGHTING BY ARC LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have glanced through Mr. Hesketh's translation of M. Blondel's very interesting articles, being already familiar with the original. There are several points which I should like to discuss, but I will confine myself for the present to only one or two.

The curve (Fig. 8) on page 848, correctly reproduced from the original, appears to me to be wrong. It should not run up to a sharp point; and supposing that it is fairly correct between the one lux and eight, it ought to curve over and stop at about 12. Figs. 5 and 6 appear to me to be inaccurate also. I cannot understand how so sharp a peak as that given in Fig. 15 is possible. It is true that it represents an artificial and not a natural distribution, and means that the light was strongly concentrated at a point below the lamp. But the polar curve in Fig. 13 gives no indication of any such vertical concentration. The natural curve is given correctly in Fig. 4 and in Fig. 17. The expression "curve of horizontal illumination," a true enough translation from the French, is an unfortunate one. The author means illumination of (or upon) a horizontal plane, but those who have not studied the subject, or who only run rapidly through the articles, might think that the illumination due to horizontal rays is intended. This is an instance of ellipsis which is already too common in scientific writings. People use "potential" instead of "difference of potential" merely to save time, or because they are lazy. I have been guilty of using "candle-foot" instead of "candle at a foot," but will do so no more. The undue compression of *ars longa* into *vita brevis* can only be accomplished by scamping.

The calculated isolux, or as I have called them, contour, or isophotal curves, which the author has borrowed from M. Maréchal's book, are very pretty, but one or two actually observed plans would have been much more interesting. Plans of this kind, from actual measurements in Queen Victoria-street and in Whitehall, were given in my Paper read before the Institution of Civil Engineers in 1892. That Paper covered a good deal of the ground traversed afterwards by M. Maréchal and M. Blondel, and when the latter alludes to "Mr. Trotter's article, which is by no means a mere repetition of mine," I can only suppose that he has been rather carelessly translated. My Paper was read on May 10, 1892, and M. Blondel's articles only appeared this year. He probably means repetition neither in the sense of imitation nor of subsequence, but of coincidence. He did not see a copy of my Paper until his own had been written. I regard the coincidence of our independent work as a very valuable confirmation of the results at which we have arrived.

One mistranslation of a more serious character catches my eye, and appears in the first paragraph on page 89, the word *foyer* being translated "lamps" in some places and "lanterns" in others. It is generally safe to translate this comprehensive word (in this connection) as "source of light," and one is tempted to shorten this into "light" or "lamp." But to translate it as "lantern" entirely misrepresents the author's meaning. The translation runs: "At first sight everything seems to resolve itself in favour of large lanterns." The use of large globes for small lamps is a well-known tradesman's trick. For exhibition purposes a 6-ampere arc in a 20in. globe seems to the more or less intelligent public as good as a 10-ampere arc in a 14in. globe. The useful illumination, of course, is not so great, but who cares for useful illumination except MM. Blondel, Maréchal, Wedding, Wybauw, Palaz, Weissenbruch, and a few other photometrists?—Yours, &c.,

A. P. TROTTER.

[With regard to the translation of M. Blondel's French we cannot do better than quote the original, which is as follows:—"Les lecteurs que ce sujet interesse auront donc grand profit à lire entièrement le mémoire de M. Trotter *qui ne fait pas double emploi avec le mien.*" The italics are our own, and these words were translated accurately as above. As to the word *foyer* being sometimes translated "lantern" and sometimes "lamp," Mr. Trotter is quite right in pointing out the incorrectness of the former term, which was in nearly every instance avoided.—ED. *E.*]

GRAPHICAL METHOD OF CALCULATING MAGNETIC FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The method mentioned by Mr. Everett in his letter in last week's issue was the first way of doing this that suggested itself to me when I wanted to make the planimeter do the required integration. On considering it, however, I saw that in practice it would be an inaccurate method, involving as it does the measurement of angles as well as lengths. It is well known to practical men that lengths can be measured much more accurately than angles, so I discarded this method in favour of one involving only the measurement of lengths. He, by the way, takes no precautions about his dimensions, so gives it a specious simplicity. I think that if he will look at my Paper again and remember that in a practical formula it is of the utmost importance to keep the dimensions correct, he will see that I have not made it needlessly complicated. The measurement of angles, also, comes into his other method, making it less accurate than the method I gave.

I am amused at the persistent quoting of Ampère's formula

$$F = i\int \frac{d\theta}{r}$$

by Mr. Everett in his letters to you; in time some people may be led to believe that he was the first discoverer of it.—Yours, &c.,

ALEXANDER RUSSELL.

Faraday House, Charing Cross-road, W.C.,
November 15, 1895.

HIGH VOLTAGE SUPPLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the discussion on the subject of raising the E.M.F. of continuous-current supply stations (Hull, St. Pancras, &c.), I beg to suggest the following method, which I am advocating in similar cases. Allow a substantial discount to all consumers taking a supply at the higher voltage, raising the price to others if necessary. This may be applied to all alike or to old consumers only, new ones being supplied only at the higher voltage. In the case of a large consumer having more than one meter the change may be made gradually, leaving one circuit on the low tension till the old lamps are used up as far as possible. A small allowance may be made for old lamps, to be used up in the station, where there will be no advantage in using the higher pressure (except for experiment) until the change is complete, and even then any pressure may be taken from the batteries. When, by this method, the bulk of the consumers have been induced to make the change, it may be enforced on the remainder with comparatively little friction. It is of some importance to arrive at the easiest method of making a change which will put continuous-current stations more on a level with alternating as regards capital outlay, and enable them to supply power economically for tramways from the same plant as for lighting purposes.—Yours, &c.

126, Prenton-road, Birkenhead, ARTHUR J. HILLS.
November 19, 1895.

THE PRESIDENCY OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There can be little question that the majority of Members and Associates of the Institution of Electrical Engineers have cordially endorsed the opinion set forth in last week's electrical Press; but it has since become apparent that

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the Council intend to persist in the nomination of Sir David Salomons to a position which he and they must fully know should only be occupied by a man of great distinction in electrical science and engineering. All of us appreciate how much the Institution of Electrical Engineers owes to the Institution of Civil Engineers, and the intercourse between the societies must be mutually useful. It is to be hoped that in the coming election the Electrical Engineers will take a leaf from the book of the parent society and follow their policy in such a matter as this, for it would be humiliation indeed if, in the same year as the Civil Engineers have appointed the most distinguished engineer in England (if not outside of it) to be their chief, the Council of the Electrical Engineers succeed in electing to a similar position a most worthy and benevolent dilettante. It will be pitiful, too, if the Council succeed in putting pride in its own procedure above the interests of the Institution. It has already become quite apparent that, however ingenious and influential may be the support of the Council's nominee, the justification of its choice is feeble enough. The Council must further know that its action will be opposed by a large part of the youth and energy of the profession, who have a strong ally in time, and who most firmly believe in the principle for which they are contending. It might conceivably be the great privilege of some of those young engineers to write the biographies of the distinguished gentlemen who now control the destinies of the Institution, and it would be sad to have to chronicle the notable dis-service the promoters of Sir David's candidature are rendering to their own constituents. This movement has been carried on so far with a great desire to avoid personalities and to leave unimpaired the dignity of the Institution. This spirit will be continued through the contest which has been challenged if it is clearly remembered that the opponents of Sir David have no other motive than the preservation of the high scientific renown which previous presidents have won for an Institution which has already become a factor of no inconsiderable importance in the industrial development of the Empire.—Yours, &c.,

ALFRED E. MAVOR.

32, Victoria-street, S.W.

LEGAL INTELLIGENCE.

Hunter and Jack v. Kuisopp.

The plaintiffs, who are electrical engineers at Glasgow, were successful in the Sheriffs' Court at Linlithgow, in an action against the defendant, a draper of Bathgate, who was sued for the sum of £36. 4s. 7d., the balance of contract price for an electric light installation amounting to £166. 6s. 8d. The defendant contended that plaintiffs asked permission to fit up on the outside of his premises two arc lamps for the inauguration of the installation. The lamps did not turn out satisfactory, and in January last one of the brackets from which the lamps were suspended broke, and in its fall smashed one of the defendant's shop windows and injured three persons, to whom the defendant had had to pay £30 as compensation. He attributed the accident to carelessness in fitting up the lamps and the bracket being insufficient to bear the strain of the lamp. Defendant urged that plaintiffs were bound to repay him the £30 paid as compensation.

The Sheriff decided that plaintiffs, having completed the work, are entitled to payment of the sum sued for. The lamps, he says, which were at first fitted up were changed for two lamps of a different pattern; and one was removed and placed in a higher position by the defendant without the sanction of the plaintiffs.

Poole and White (Limited) (in Liquidation) v. South.

In the City of London Court, before Mr. Commissioner Kerr, this action was brought to recover £37. 7s. 10d., for fittings and other electrical appliances supplied to the defendant, Mr. Harry South. The defendant did not dispute the delivery of the goods, but set up an agreement with the plaintiffs to take electrical goods in contra account. Mr. South, the defendant, said that he had done business with the plaintiffs for a great many years. In September, 1894, their representative, a Mr. Larkin, agreed that he should receive electrical goods from the plaintiffs as a set-off against his account, as the plaintiff Company was then in liquidation. That was the second liquidation, and as he could not get money for the goods which he had previously supplied he took goods instead. As a matter of fact there was a balance due to him. For the plaintiffs it was urged that Larkins had no authority to make the arrangement set up by the defendant, as the Company was at that time in the hands of a man named Kelly, who had been made receiver and manager by the debenture holders. There was no agreement in writing.

Mr. Commissioner KERR said there was no necessity for that. If there was to be a flat contradiction he would send the case for trial before a jury. Ultimately the case was referred to the Assistant Registrar for consideration and report.

Imperial Telephone Company (Limited) v. Electric Novelty Syndicate (Limited).

This action was heard in the City of London Court, and was for the recovery of the sum of £3. 13s. for goods sold and delivered to the defendants. Mr. Gilbert, who appeared for the defendants, said that his clients were in negotiation with the plaintiff Company for the purchase of their patent. At the suggestion of Mr. Watson (who was in fact the plaintiff Company) a telephone was put up in the defendants' office for experimental purposes, but the defendants declined to purchase the instrument, and had asked the plaintiffs to take it away. Evidence was given that the defendants had purchased the instrument, but the case was adjourned for the attendance of Watson.

Harrison v. Estelle.

In the Westminster (London) County Court, last week, the plaintiff, an electrical engineer, sued the defendant to recover 15 guineas, balance of account, in respect of work done. Work had been done to the extent of over £100. There had been payments on account, but there was still due the amount now claimed. The defendant appeared to be under the impression that she was not liable to pay for certain alterations and extras which had been carried out to her instructions, which, she contended, were rendered necessary owing to the plaintiff's own mistakes. The judge decided that the defendant was right so far as some of the items were concerned, and should therefore give judgment for the plaintiff for nine guineas and costs on that sum.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1895 (thirteenth) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is READY. In addition to the old well-known features of the book, which are brought up to date, a quantity of new and useful matter has been added, rendering the book more than ever indispensable to the Electrical, Engineering, and Allied Trades. Price 7s. 6d., post free 8s. 3d., abroad 9s.

The Edition for 1896 is in active preparation, and orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. The usual circulars, &c., are now being sent out.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES can be obtained of the Booksellers or direct from the Publishing Offices:—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

A LARGE-SHEET TABLE, giving full particulars of the Electricity Supply Stations throughout the Kingdom, can now be supplied mounted on stout board, with cord for hanging. Price: Varnished, 3s. 6d.; Unvarnished, 3s. —each post free. A Map showing positions of Supply Stations throughout the country is mounted on the back of the Table, and a Coloured Map of Metropolitan Electric Lighting Areas and a large sheet of Electricity Supply Statistics are also mounted on some copies, the price of which complete, post free, is 5s.

A SHEET TABLE showing Total Capital Outlay and Receipts and Expenditure for the year 1894 of the Statutory Electric Supply Undertakings of the Metropolis is now ready, printed on thick paper. price 6d.

A SHEET TABLE giving similar particulars in relation to Provincial Statutory Electric Supply Undertakings is now ready, printed on thick paper, price 6d.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

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TENDERS INVITED.—The Corporation of Durban require tenders for cast-iron service boxes, cast-iron junction boxes, cast-iron manhole frames and covers, and ornamental cast-iron arc-lamp pillars. Conditions, &c., from the Consulting Engineer, Mr. W. H. Radford, Pelham-chambers, Nottingham, and tenders must be sent in to Messrs. Webster, Steel and Co., 5, East India-avenue, London, E.C., by the 27th instant.

——— The Swansea Corporation invite tenders for (1) the supply and erection of destructor and electricity supply station buildings; (2) for the erection of a chimney shaft, 150ft. high, with all necessary foundations and accessories; and (3) for the supply and erection of a dust destructor, including eight destructor furnaces and four water-tube boilers, with all necessary flues, dampers and accessories. Tenders, addressed to the Town Clerk (Mr. Jno. Thomas), The Guildhall, Swansea, must be in by 4 p.m. December 6th.

——— The Magdeburg Direction of the Prussian State Railways invites tenders for the supply of 25¾ tons of galvanised iron wire and 1,500 porcelain insulators. Tenders to the Königliche Eisenbahn Direction, Knochenhaueruferstrasse I, Magdeburg, by 26th inst.

——— The Secretary of State for India is inviting tenders for the supply of electric light plant, railway stores, &c. Tenders to Mr. J. Parker, India Office, Whitehall, S.W., by December 10th.

——— The Markets Committee of the Manchester Town Council invite tenders for the supply of two dynamos for the Foreign Animals Wharf, Mode Wheel. Tenders by December 2nd to the Town Clerk.

——— Tenders are invited for the electric lighting of New Cardiff Technical School. Tenders to the Secretary, University College, Cardiff.

TENDERS ACCEPTED.—The following tenders were received by the authorities of the Cancer Hospital, Brompton, London, for electric light wiring and fittings at the hospital:—

Name of Firm.	Wiring.			Cutting away & making good.			Fittings, exclusive of lamps.			Totals.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Drake & Gorham (*accepted*)	309	0	0	25	0	0	86	19	0	420	19	0
Crompton and Co.	668	0	0	45	0	0	107	8	0	820	8	0
Rashleigh Phipps and Co.	523	0	0	20	0	0	115	5	6	658	5	6
H. M. Leaf	310	0	0	25	0	0	99	11	6	454	11	6
Sotheby and Co.	293	10	0	25	10	0	77	14	0	397	14	0

Mr. Morgan Williams, Assoc.M.Inst.C.E., is consulting engineer for the installation.

——— The Harrogate Town Council, at their last sitting, accepted the amended tender of Messrs. Paterson and Cooper for the wiring of the public baths for the electric light. The tender of Mr. C. O. Dawson for erecting electric bells was also accepted.

——— The Saltash Town Council have decided to accept the tender of Mr. T. Martin for lighting the town by electricity from January 4th next. The cost is to be £2. 10s. per light.

——— At the last meeting of the Cheltenham Town Council it was decided to accept Messrs. Siemens Bros. and Co.'s tender for a switchboard at £165 and regulating resistance for £12. 10s.

SALES BY AUCTION.—Our advertisement columns contain particulars of the sale by auction, by Messrs. Wheatley Kirk, Price and Goulty, on Thursday, December 5th, of the entire contents of the works premises at Broadway, Walham Green, S.W., in the occupation of Messrs. Russell and Co., who are giving up business. Catalogues can be obtained from the auctioneers, and from Messrs. Russell and Co., 11, Queen Victoria-street, E.C.

——— The Reading Electric Supply Company having completed their new electricity station, Messrs. Wheatley Kirk, Price and Goulty give preliminary notice of the piecemeal sale by public auction, at an early date, of the entire contents of the Company's old station, the Island, Reading, comprising engines, boilers, combined lighting sets, dynamos, &c. Further information is given in our advertisement columns.

CHANGE OF ADDRESS.—We are invited by the publisher of *Electricity* to insert the following:—

"DEAR SIR: If not too much against your own interests I shall esteem it a great favour if you will mention in your columns that, owing to the constant increase in the sale of this paper and the technical works published by me, I have had to move to more commodious offices on the first floor of No. 11, Ludgate-hill, London, E.C."

APPOINTMENT VACANT.—The Lighting Committee of the Wolverhampton Corporation require a clerk and canvasser in the office of the borough electrical engineer. Salary £100 per annum. Applications to Mr. F. Harman Lewis, Borough Electrical Engineer, Town Hall, Wolverhampton, by Saturday, December 7th next. Further particulars appear in our advertisement columns.

DISSOLUTIONS OF PARTNERSHIP.—The partnership business of electrical engineers hitherto carried on by Messrs. E. Hodgson, A. Blackburn and J. Walker, under the style of Blackburn, Walker and Co., at Toft's Mill, Cleckheaton, Yorks., has been dissolved. The business will be carried on under the same title by Messrs. A. Blackburn and J. Walker.

LIQUIDATIONS.—Mr. E. Wilding, liquidator in the matter of Poole and White (Limited), forwards us a summary of the liquidator's accounts from March to September, 1895, which shows that the estate is becoming smaller by degrees and beautifully less. The balance brought forward in March was £520. 19s. 11d., the balance carried forward in September £165. 2s. 6d., £350 of the difference being swallowed up in remuneration to the liquidator. There is nothing on the face of the summary to show what has been done for this very considerable sum, except the disbursement of a few pounds in "sundry expenses."

——— In the failure of W. J. Kelly (the representative of the debenture-holders in Poole and White, Limited) a return has been made which shows receipts £5, payments £7. 12s., assets *nil*. Mr. E. Leadam Hough, the Official Receiver in this matter, intends to apply "within 21 days" for his release. This may be taken as an official intimation that there is nothing in the estate for the liquidator or the creditors.

——— At the County Court, Worcester, on Wednesday, before Sir R. Harington, the examination of the Directors and officers of the New British Electrical Installation Contractors (Limited) took place, the examination being conducted by Mr. Luke Sharp, the Official Receiver. The secretary, Mr. J. W. Hill, stated that the Company was promoted by Messrs. Griffiths and Millington. He as secretary had no salary, and kept no books except the register of members and the share ledger. The prospectus of the Company, of which fifty or sixty thousand copies were circulated, "was made as attractive as possible to the public." One of the ideas was to put electric launches on the River Severn, but no launches were ordered. He admitted that a paragraph extolling the prospects of the Company was written by himself and appeared in the Worcester papers, in which the prospectus was extensively advertised. The promoters had lost over £3,000. Mr. J. Duce, who was General Manager and Secretary to the old Company, said that the whole of the contents of the prospectus was true, and that had capital been subscribed for the old Company it would have been a great success, but they could not get the money in. After the examination of Mr. Millington, the Chairman of the Company, who said that if everyone had worked as hard as he had done the result would have been different, the examination was adjourned till December 18th.

——— A meeting is to be held at 3, Hammet-street, Taunton, on December 20th next, at 3 p.m., to receive an account of the winding-up of the Taunton Electric Light Company (Limited).

——— At an extraordinary general meeting of the members of the Collier-Marr Telephone and Electrical Manufacturing Company (Limited) on the 13th inst., it was decided to wind up the Company voluntarily, and Mr. Wm. Frost, 77, King-street, Manchester, was appointed liquidator.

——— Creditors of the Printing Telegraph and Construction Company of the Agence Havas (Limited) (in liquidation) must send in particulars of their claims to Mr. W. H. King, 13 and 14, Basinghall-street, London, E.C., by December 31st next.

INTERNATIONAL ELECTRIC SUBWAY COMPANY (LIMITED) (*in Liquidation*).—A meeting of shareholders was recently held for the purpose of deciding what steps should be taken to renew the British and Continental patents owned by this Company. The shareholders decided to contribute no money for this purpose. The liquidator, Mr. C. W. Grimwade, 38, Coleman-street, E.C., therefore invites creditors to provide the necessary money for the upkeep of the patents. The amount required is £25. Should the creditors not be disposed to adopt the suggestion, the liquidator proposes to take the usual steps to close the liquidation of the Company.

HOOKHAM ELECTRICITY METERS.—Messrs. Chamberlain and Hookham are prepared to receive applications from first-class agents in the United States and foreign countries for the Hookham meter.

"PRITCHETT" ACCUMULATORS.—We have received a price list of these accumulators, which are of the Planté type. It is claimed that the construction of the plates renders them capable of being discharged at very heavy rates without buckling or loss of active material. The method of connecting the plates to the lug allows for any positive plate to be removed and a new one substituted without the section being taken out of the acid. The list of prices received is for batteries of from 1 to 21 plates. These cells are manufactured by Messrs. Pritchetts and Gold, of Soho-square, London, W., who will supply full particulars on request.

CATALOGUE.—Messrs. Crompton and Co. (Limited) have sent us a copy of their new price list of electrical heating and cooking apparatus, for which five diplomas and four gold medals have already

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been awarded to the firm. Judging by the variety and size of the apparatus, cooking and heating by electricity are making considerable progress; indeed, the cleanliness, convenience and general superiority of the electrical over every other methods have only to become widely known to be very generally adopted by the public.

ELECTRO-HARMONIC SOCIETY.—A "ladies' night" is announced for Saturday, the 30th inst., at the St. James's Hall Restaurant (Banquet Room), Regent-street, W., at 8 o'clock.

ASHTON-UNDER-LYNE.—At the last meeting of the Town Council it was decided to refer the electric lighting question to the General Purposes Committee.

AUSTRALIAN LAND LINES.—Telegraphic communication has been established between Perth (Western Australia) and Yalgoo, and is expected to materially assist in developing the mineral resources of that extensive district.

BANGOR (IRELAND).—A special meeting of the Town Commissioners will shortly be held for the purpose of considering the question of the advisability of applying for a Provisional Order.

BELFAST.—The head offices of the Belfast Banking Company have been fitted throughout for the electric light by Mr. J. H. Greenhill. Theinstallation consists of four 3,000 c.p. arcs and 72 incandescents. The work has given the greatest satisfaction to the Directors.

BLOEMFONTEIN.—The Town Council have just signed a contract with an electric lighting firm for the lighting of the town by electricity.

BRAY.—At the last meeting of the Town Commissioners it was decided that a clause be inserted in the Provisional Order now sought by the Commissioners to enable them to sell electricity for motive-power purposes.

BURTON-UPON-TRENT.—In an application to Parliament by the Corporation notice is given of application for powers to manufacture, sell and hire apparatus and fittings for the electric light. ——The Town Council have decided to apply for powers to extend their electric lighting area.

BURY ST. EDMUNDS.—The electric lighting plant recently put down by Messrs. Crampton and Co. for the lighting of Abbeygate-street is now in full working order, current being supplied to shops and offices in the locality at 7d. per unit. The first quarter's working has, it is stated, proved successful and profitable.

'BUS LIGHTING.—In London several attempts have been made to light the public omnibuses by electricity, but apparently with only a small measure of success. While the owners of the "Star" line of 'buses and the Westminster-Liverpool-street 'buses, not owned by the London and General Company, continue to use the light, other lines have returned to the old and very bad system of lighting by means of the dismal oil lamps. At Nottingham, Mr. E. Mann, the owner of a well-known line of 'buses, has recently constructed a new class of vehicle, into which the electric lamps are fitted. An application has been made to the Electric Lighting Committee of the Corporation for permission to have the batteries filled at the Corporation's works. This is the first time the electric light has been introduced into public vehicles in Nottingham.

CAMBERWELL (LONDON).—The General Purposes Committee recommend the Vestry to give their consent to the application of the County of London and Brush Provincial Company for a Provisional Order.

CANADA.—The Government is negotiating for the extension of the telegraph to Belle Ville, viâ Bonne Bay, Newfoundland. This line will be of great benefit to shipping interests, as it will enable vessels from England to be reported the fourth day out.

CARDIFF.—The Lighting Committee of the Corporation have signified their appreciation of Mr. W. H. Massey's services as consulting engineer in connection with the electric lighting scheme by unanimously passing the following resolution :—

"This Committee desire to place on record their appreciation of the valuable and important services rendered to the town of Cardiff by Mr. W. H. Massey, M.Inst.C.E., as consulting engineer in connection with the laying down of the system of electric lighting within the borough under the Cardiff Electric Lighting Order, 1891, and also to convey to Mr. Massey their sincere thanks for the conspicuous ability displayed by him in the carrying out of this great work, and of the many intricate and important details in connection therewith."

CHELTENHAM.—At the last meeting of the Town Council the Electric Lighting Committee reported that they had received applications for 4,540 8 c.p. lamps, of which 4,134 were connected. Alderman Norman, in moving the adoption of the minutes of the Committee, said they were anxiously awaiting the sanction of the Local Government Board for borrowing an additional sum of £10,000 for extension purposes.

CHURCH LIGHTING.—Messrs. Drake and Gorham, of 66, Victoria-street, S.W., have been entrusted with the contract for lighting St. Paul's Church, Deptford.——St. John's Church, Paddington, has just been fitted for the electric light by Messrs. Rashleigh Phipps and Co. Two hundred incandescents will be used.——The Welsh Presbyterian Church, Princes-road, Liverpool, is now lighted electrically.——The authorities of Redcliff Church, Bristol, are so satisfied with the temporary electric lighting of the building that it has been decided to make a permanent installation. Between 300 and 400 8 c.p. lamps will be used. The work is to be completed before Christmas.

DUBLIN.—The *Freeman's Journal* on Wednesday contains a sketch map of the proposed electric tramway extension in Dublin and an account of the scheme.

DUNDEE.—At the last meeting of the Town Council it was decided to light the Free Library electrically.

EDINBURGH.—At the last meeting of the Town Council a letter from Mr. M. Holroyd Smith, offering to introduce an electric system of traction on the Edinburgh tramway lines, was referred to the Lord Provost's Committee for consideration and report. It was also agreed to extend the electric light mains from the Post Office to Regent-terrace.

ELECTRIC ATHLETIC ASSOCIATION.—The annual *conversazione* and distribution of prizes in connection with this Association was held last week at the Holborn Town Hall under the presidency of the Duke of Norfolk, Postmaster-General. The chief officials of the postal telegraph department were present. A vote of thanks to His Grace for presiding was proposed by Mr. Spencer Walpole, and seconded by Mr. Fischer.

SMOKING CONCERT.—Mr. F. J. Wray presided at the first smoking concert of the season of the cricket club of the City Electric Athletic Association, formed in connection with the City of London Electric Lighting Company, which took place at the Masons' Hall Tavern last week. The Chairman was supported by Mr. J. Cecil Bull and about 130 members and friends.

FULHAM (LONDON).—The Electric Light Committee of the Vestry have instructed Mr. F. H. Medhurst to prepare a report on and draw up a scheme for the electric lighting of this district.

GAS COMPANIES AND THE ELECTRIC LIGHT.—The *London Gazette* contains notices from the following gas undertakings of an intention to apply to Parliament for powers to supply electric current for lighting and other purposes: Bournemouth Gas and Water Company, Bexhill Water and Gas Company, Guildford Gas Light and Coke Company.

GENOA.—The *Daily News* of the 20th inst. is responsible for the statement that the Syndic of Genoa has suspended the work of all the tramways in that city owing to a number of accidents which have recently happened, but fortunately, it is stated, without much damage to passengers.

HALIFAX.—A syndicate has been formed for the purpose of constructing and working a network of electric tramways in this town.

HAMPSTEAD (LONDON).—At the last meeting of the Vestry the matter of extending the electric light mains from Heath-street to The Grove was referred to the Lighting Committee for consideration and report. On the recommendation of the Committee, the Clerk was instructed to make official complaint of the gas lighting.

HAPTON (LANCS.).—This is probably the smallest village in the Kingdom lighted by electricity, both public and private lighting, and the contract with Messrs. Simpson Bros. has just been signed for a further six months' supply of current.

HARROGATE.—The Town Council have decided upon a further extension of the electric light mains.

HARWICH.—The report of the Public Health Committee of the Town Council sets out the terms upon which the Town and Village Electric Light and Power Company offer to take over the Harwich Order, and to instal the electric light in the borough without cost to the local authorities. The Company proposes to enter into a contract for the supply of current lighting for 14 years at 4½d. per unit, and to pay the Corporation £300 by an allowance of 10 per cent. discount off each quarter's account for public lighting until the £300 is absorbed. This proposal was considered at the last meeting of the Council, and, by the casting vote of the Chairman, was agreed to.

JOHANNESBURG (S.A.R.).—The Sanitary Board have decided to adopt the "Brockie-Pell" arc lamp, and Messrs. Johnson and Phillips recently received an order for upwards of 50 lamps.

KETTERING.—A meeting of the District Council has been held to consider the advisability of applying to the Board of Trade for a Provisional Electric Lighting Order. A Committee recently appointed to consider the subject has reported to the Council that the proposed compulsary area was too large and should be somewhat curtailed; that a reasonable estimate would be for an equivalent of 2,500 8 c.p. incandescents and 20 arcs as a start; that the estimated cost of an installation to provide current for this number of lamps and to include accommodation for extension to machinery, &c., would be £9,500, with annual up-keep charges,

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including interest and payments, £1050. 10s., the estimated income being slightly in excess of this sum. The meeting of the Council on Thursday was called specially to consider this report. Mr. Mobbs said that the Committee had gone very carefully into the subject, and had obtained statistics, &c., from all places in the country which compared with Kettering. The Committee found that the electric light was installed in no less than 110 districts in the kingdom, and that a similar number of places had the work either in progress or under consideration, and the Committee therefore considered they were justified in recommending the Council to apply for the Order, although he personally was not in favour of at once starting the works. They had had an offer from one firm to put down the whole of the necessary plant, and to hand over to the town authorities a complete installation at a payment of 3 per cent. on the outlay for a period of 30 or 40 years. Of course, they could obtain the Provisional Order, and could drop it altogether subsequently if they chose. It was stated that the local gas company had no intention of opposing the introduction of electric light unless the application for an Order was made by a private company. The Chairman of the Council, Mr. J. I. Stockburn (also chairman of the local gas company) considered the scheme premature, and did not think it desirable that the Order should be applied for at the present time. Mr. M. T. Gorman, upon whose suggestion the Committee had been formed, went fully into the advantages of the electric light over gas, and strongly urged the Council to proceed with the matter. The adoption of the Committee's report was carried with a good majority.

KIDDERMINSTER.—A Company is about to be formed for constructing electric tramways between Kidderminster and Stourport. It is proposed that the first line should commence opposite the Town Hall buildings, pass along Oxford-street, Bridge-street and New-road to Stourport, and terminate in Bridge-street, Stourport; the second line is to commence at the intersection of Spirit-lane and Comberton-road, and connect in Oxford-street with the line to Stourport; while a third tramway would run westward of the line in the New-road. The Company will apply for Parliamentary powers in the next session.

LECTURES.—Prof. S. P. Thompson delivered the Saturday Public Lecture at Toynbee Hall, London, E., last week, the subject being "The Magnetic Effects of an Electric Current." The lecture was illustrated by experiments and gave great pleasure to a large audience, who cordially thanked the Professor at the close.——Mr. W. A. Douglas Rudge delivered a lecture at the Plymouth Technical Schools, the subject being "Warming and Lighting." The lecture was illustrated by some Crompton electric heating and cooking apparatus, and the use of this apparatus was practically demonstrated. A large audience took great interest in the lecture.

LEEDS.—At the last meeting of the City Council the report of the Highways Committee recommending the engagement of Dr. J. Hopkinson to advise them on the electric traction question was adopted.

LONDON COUNTY COUNCIL.—At the meeting of this Council on Tuesday, Mr. Roberts objected to the recommendation of the Bridges Committee giving permission to the National Telephone Company to lay a telephone cable across Waterloo Bridge, and proposed that the recommendation should be referred back. This was seconded by Dr. Longstaff, and was approved.——Owing to ill health Mr. de la Hooke, the much-respected Clerk to the London County Council, has been compelled to send in his resignation, to take effect in March next. It is stated that the post is to be thrown open to competition to solicitors and barristers-at-law, at a salary which has been fixed at £2,000.

LLANDRINDOD WELLS.—At the last meeting of the District Council a letter was received from the Town and Village Electric Supply Company offering to tender for the electric lighting of the district. The Clerk was instructed to obtain particulars.

LLANELLY.—The Borough Council recently appointed a committee to negotiate the terms as to the sale of their Provisional Order to Mr. J. C. Howell, and it is now stated that the parties have agreed upon the conditions of the transfer, and that the Committee will present a report on the matter to the Council at their next meeting.

NECHELLS (NEAR BIRMINGHAM).—The first meeting of the Committee appointed to consider the proposal of the Birmingham Central Tramways Company to erect an overhead electric tramway was held on Wednesday, and a further meeting is to be held on Monday next to consider a reply from the Tramways Company, giving particulars of the system proposed to be adopted on their Nechells route.

NESTON AND PARKGATE (CHESHIRE).—A meeting of the principal ratepayers of these districts was held last week for the purpose of considering the report on the electric lighting question recently prepared by Mr. Marsh for the Lighting Committee of the District Council. The report was discussed at considerable length, and it was finally decided to call another meeting to further consider the matter.

NEWPORT (MON.).—The local gas company have already become alarmed at the progress of electric lighting in this town, and have appealed to the Corporation for longer notice and other benefits before electric lamps are allowed to take the place of the old gas lamps. The Corporation show an amicable spirit, and have agreed to continue to pay for the gas lamps until December 7th, and to give three months' notice in future before discontinuing gas lighting in any district of the town.

PROVISIONAL ORDERS.—The Corporations of Bath, Cork, Huddersfield and Liverpool, and the District Council of Keswick, give notice of their intention to apply to the Board of Trade on or before December 21st, for Provisional Orders under the Electric Lighting Acts 1882 and 1888.

RAILWAY STATION LIGHTING.—The electric light has just been installed at the Durban Railway Station.

RAWMARSH (YORKS.).—A proposal having been made for the construction of a tramway between this town and Rotherham, the District Council have appointed a Committee to consider the matter, more especially in reference to the question of the adoption of an electric system of traction for the proposed tramways.

SHEFFIELD.—The London and Provincial Tramway Syndicate have prepared a scheme for the construction of electric tramways in Sheffield, which it is ultimately proposed to extend to Rotherham.

SKATING.—The Commons Committee of the Cambridge Town Council at the last meeting recommended that the application from the Cambridge Electric Supply Company for permission to erect poles to carry wires to enable the Company to supply current to the skating ground in the Grantchester Meadows should be granted. As, however, no plan was submitted to show the position of the poles, the matter was referred back to the Committee for reconsideration.

STROUD.—The formal opening of the Stroud Telephone Exchange took place on Monday.

ST. LUKE'S (LONDON).—A proposal from the County of London and Brush Provincial Company to light the public thoroughfares of this parish is before the St. Luke's Vestry.

SUNDERLAND.—The Board of Guardians have under consideration the electric lighting of the new infirmary. Messrs. W. & T. R. Milburn are the Board's advisers in this matter. The lighting by electricity of the main workhouse building has been referred to the House Committee for consideration.

TELEGRAPH WIRE AND APPARATUS EXPORTS.—The export trade in telegraph wire and apparatus connected therewith shews during October a falling-off compared with the preceeding month, the value only amounting to £39,769, against £45,268 in September. Compared with October last year, the returns shew an increase of £17,507. The exports for the ten months ending with October amounted to £423,206, compared with £1,326,856 in the corresponding period of last year and £1,012,305 in the first ten months of 1893.

TELEPHONE EXTENSION.—The National Company have under consideration a proposal to establish a telephone exchange at Bedford.

THEATRE LIGHTING.—A considerable extension has been made to the electric lighting at the St. James's Theatre, London, by Messrs. Rashleigh Phipps and Co.

THE METRIC SYSTEM.—Mr. A. J. Balfour, the First Lord of the Treasury, received a deputation from Chambers of Commerce, the "New Decimal Association," and other bodies, on the subject of the metric system on Wednesday. The deputation recommended (*a*) that the metric system of weights and measures be at once legalised for all purposes; (*b*) that after a lapse of two years the system be rendered compulsory by Act of Parliament; (*c*) that the system be taught in all public elementary schools as an integral part of arithmetic, and that decimals be introduced at an earlier period to the school tuition than is the case at present. Sir A. Rollit, M.P., who introduced the deputation, pointed out that the deputation represented an immense body of public opinion, and it was agreed that the present system was obsolete and disastrous to British trade. Sir S. Montagu, M.P., said that if the United Kingdom adopted the system the United States would also do so. Mr. Balfour gave his adhesion to the recommendations (*a*) and (*c*) without hesitation, but pointed out that the recommendation (*b*) required careful consideration, and that he could see there would be very great difficulty in compelling every class in the community to suddenly alter its habitual practice in the weights and measures in which it deals. He was pleased to learn that all the great engineering firms used the metrical system, which, in his opinion, was the only rational one. To the observation made by one member of the deputation, that the metric system was excluded from the manufactures undertaken by the Government, he thought this was a matter well worthy of consideration, and he would consult with his colleagues to see if anything could be done to meet the wishes of the traders in this respect. He would especially consult with Sir J. Gorst to see if something could not be done to spur on the teaching of this system in the schools, and to so familiarise the imagination

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of the children with the system which they might have to use in later years.

TIME SIGNALS.—It is proposed to add the port of Belfast to the list of ports in the United Kingdom provided with time signals worked by electricity. The towns at present include Greenock, Dover, Southampton, Portland, Liverpool, Edinburgh, North Shields, Dublin, Deal, Portsmouth, Swansea, Dundee, Leith, Cork and Queenstown.

TRAMWAY PROVISIONAL ORDERS.—Notice is given in the *London Gazette* of the intention on the part of the following companies and Municipalities to apply to the Board of Trade for powers to use electric or other motive power on the tramway systems under their respective control:—Hull and Plymouth Corporations, Pwllheli West End and Belfast Street Tramways Companies.

WANDSWORTH.—The Electric Lighting Committee of the Board of Works has notified its approval of the plans for the proposed electric light supply station of the County of London and Brush Provincial Company.

WINDSOR.—In reference to the decision of the Town Council to put their Electric Lighting Order up to tender, a discussion took place at the last meeting, at which Alderman Dyson hoped that the matter would be fully considered before this step was finally taken. Councillor Barber asked whether any particular system (two-wire or three-wire) had been decided upon. It was pointed out that the object of the advertisement was to enable the Council to obtain full information on the subject, and place the same before the Council at a later date. A letter was read from the Thames Conservancy stating that the proposal to use the water power at Windsor Weir for electric light purposes could not be entertained.

WITHINGTON.—The District Surveyor is preparing an estimate of the cost of lighting the Town Hall electrically.

WOKING.—A report by the Sanitary and Lighting Committee on the subject of the lighting of this town was discussed at the last meeting of the District Council. The Committee's report was adopted, and it was decided to advertise for tenders for lighting the district by electricity or gas.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

October 15, 1895.

19,340. P. W. T. DAVIES. London. Improvements relating to electric cars.

19,353. J. JAHNSSON. London. Improvements in electric gas lighting apparatus.

19,374. S. E. COX. London. Improvements in incandescent electric lamps and the method of making the same.*

October 16, 1895.

19,380. G. H. NISBETT. London. Improvements in the manufacture of insulated cables.*

19,389. C. B. CRAWSHAW and R. KENNEDY. Bradford. Improvements in tempering the wire points of textile cards electrically, and in apparatus therefor.

19,402. W. E. HEYS. Manchester. Improvements in and connected with return circuits for electric railways and tramways. (G. Kapp, Germany.)

19,442. A. HIRSCH. London. An improved method of and apparatus for welding by electricity and for other purposes.

19,461. H. B. COX. London. Improvements in thermo-electric generators.*

October 17, 1895.

19,503. C. ADAMS-RANDALL. London. Improvements in telephonic apparatus.

19,509. J. A. MCMULLEN. London. Improvements in alternating electric current transformers.

19,527. J. M. URQUHART and W. H. DINGLE. London. Improvements in high insulation fuses or cut-outs for electric lighting.

October 18, 1895.

19,551. W. D. REID. London. An improvement in conduits for conductors of electricity or other mains.

19,577. P. LINDSAY and J. BRADIN. Glasgow. Improvements in incandescent electric lamp-holders.

19,605. J. V. SHERRIN. London. Improvements in and connected with dynamos and the driving of same and electric motors for the driving of vehicles and machinery.

19,628. A. J. BOULT. London. Improvements in or relating to electric burglar alarms and the like. (R. Damseaux, Belgium.)*

October 19, 1895.

19,647. W. H. WILLATT. Hull. Improvements in secondary batteries.

19,669. A. SCHANSCHIEFF. London. Improvements in secondary battery plates.

19,670. A. SCHANSCHIEFF. London. Improvements in secondary batteries

19,696. J. E. WOODRIDGE. London. Improvement in electric light display systems. [Date applied for under Patents, &c., Act, 1883, Sec. 103, July 8, 1895, being date of application in United States.]*

October 21, 1895.

19,734. COUNT A. DE DIXON and C. BOUTON. London. Improved means or apparatus for electrically igniting petroleum and other like motors.

19,745. J. KÖRNER. Liverpool. Improvements in and in the manufacture of plates for electric accumulators or secondary batteries.

October 22, 1895.

19,815. C. B. WHITE. London. An electromagnetic apparatus for actuating railway brakes and switches. (The St. Louis Brake Company, United States.)*

19,828. R. HEATHFIELD and W. S. RAWSON. London. Improvements in electrolytical apparatus.

19,832. A. G. NEW and A. J. MAYNE. London. Improvements in connection with electrical propulsion.

19,833. A. G. NEW and A. J. MAYNE. London. Improvements in connection with the electrical propulsion of vehicles.

19,837. T. E. ADAMS. London. Improvements in electric arc lamps.*

19,838. T. E. ADAMS. London. Improvements in electric arc lamps.*

19,839. A. DE PUYDT and M. PONCIN. London. Improvements in dynamo generators or motors.

19,860. J. DEVONSHIRE. London. Improvements in regulating electric motors. (W. B. Potter, United States.)*

19,861. J. DEVONSHIRE. London. Improvements in three-wire electric railways. (W. B. Potter, United States.)*

19,862. J. DEVONSHIRE. London. Improvements in dynamo electric machines. (E. Thomson, United States.)*

19,863. J. DEVONSHIRE. London. Improvements in regulators for alternating currents. (C. P. Steinmetz, United States.)*

October 23, 1895.

19,934. C. A. BURGHARDT and G. RIGG. Manchester. Improvements in a process and apparatus for the electrolytic production of metallic zinc and metallic copper from zinc ore containing copper, and oxygen gas as a bye-product.

19,947. C. MORADELLI. London. Improvements in electric contact devices.*

19,973. W. J. DAVY. London. Improvements in or connected with electric lamps.

October 24, 1895.

19,989. J. W. FLETCHER. Stockport. An electrical "tell-tale" or watchman's recorder.

19,992. C. BARLOW. Glasgow. Improvements in the method of laying an electric cable for tramways or railways, and the means of communication between the conductor and the car.

20,047. THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED), and A. WOODLEY. London. An improvement in the caps of incandescent electric lamps.*

20,048. F. E. ELMORE. Leeds. Improvements in or pertaining to electrically-driven pumping apparatus.

20,071. A. PHILIPPI. London. Improvements relating to electric railways.

20,073. S. O. COWPER-COLES. London. Improved means to be employed in the production of sheets or strips, or equivalent forms of metal, by electro-deposition.

October 25, 1895.

20,127. F. E. ELMORE. London. Improvements in apparatus for the manufacture electrolytically of tubes and other articles of circular section.

20,131. P. OPITZ and W. PETSCHEL. London. An improved manufacture of secondary or storage battery plates.

20,132. J. H. DUNN and J. PARSONS. London. Improvements in generating gases or steam by electricity from water, oil, or other suitable material.

20,164. S. O. COWPER-COLES, M. ULCOQ, W. M. GUTHRIE, and C. R. G. SMYTHE. London. Improvements in or connected with the production of metal, in sheets or other form, direct from zinc ores, applicable in part for use in the electrolytical deposit of metals generally.

October 26, 1895.

20,215. E. S. BOYNTON. Wolverhampton. Improvements in tubular galvanic batteries.*

20,214. E. S. BOYNTON. Wolverhampton. Improvements in double-fluid galvanic batteries.*

20,216. E. S. BOYNTON. Wolverhampton. Improvements in galvanic batteries.*

20,237. THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED), and C. F. PROCTOR. London. An improvement in electric safety fuses.

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October 28, 1895.

20,288. W. S. HULL. London. Improvements in electric railways.
20,306. J. LANGELAAN. Germany. Improvements in electric power storage batteries.

October 29, 1895.

20,335. P. COLLINSON. Bradford. Improvements in electric arc lamps.
20,392. M. WHELESS. London. Improvements in and relating to arc lamps.*
20,431. J. J. ROONEY. London. Improvements in secondary batteries.*
20,433. J. DEVONSHIRE. London. Improvements in electric brakes. (Frank E. Case, U.S.A.)*

October 30, 1895.

20,487. E. W. CHEYNEY. London. Improvements in connection with electric indicators for signalling between signal box and station platform.
20,498. C. H. TAYLOR and J. TAYLOR. London. A novel application of electricity to lighting purposes.
20,508. V. A. FYNN and EASTON, ANDERSON AND GOOLDEN (LIMITED). London. Improvements in non-synchronous alternate-current motors.
20,509. V. A. FYNN and EASTON, ANDERSON AND GOOLDEN (LIMITED). London. An improved system and means for electrical distribution by alternating currents.
20,510. V. A. FYNN and EASTON, ANDERSON AND GOOLDEN (LIMITED). London. Improvements in dynamos and motors.
20,529. M. CATTORI. London. Improvements in the construction of electric railways.*

October 31, 1895.

20,542. G. BELL and G. W. BELL. Liverpool. Improvements in or connected with apparatus for the electrolytic decomposition of brine.
20,572. C. MARSCHNER. London. Improvements in and relating to the active material for secondary electric batteries.
20,584. F. J. COX. Birmingham. An improved dynamometer or power measurer.
20,595. C. D. HASTEDT. London. A device for improving the contact of the wires connecting the several rails of electric tramways.
20,600. R. J. BOTT. London. Improvements in electric incandescent glow lamps.

November 1, 1895.

20,636. T. F. J. TRUSS. Liverpool. Improvements in or relating to telephone instruments.
20,639. J. JENNINGS and E. W. L. HARRISON. Manchester. An improved system of wiring buildings and other places for the fitting up of electric light installations.
20,681. L. PENSON. London. Improvements in and relating to the ventilation of transformer boxes, road and junction boxes, conduits and the like, used in the distribution of electrical energy.
20,696. F. H. NALDER and A. SOAMES. London. Improvements in electric switches.

November 2, 1895.

20,728. A. C. BROWN and G. R. NEILSON. London. Improvements in electric tramcar system.
20,734. A. J. BOULT. London. Improved bowl for electric and other lamps. (J. L. Spink and T. W. Horn, Canada.)*

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1894.

17,065. DE FERRANTI. Electric cables, &c.
19,605. ANDREWS. Electrical conductors.
19,634. CONNORS and LANGDON-DAVIES. Electromotors, &c.
19,681. MILLER. Coin-freed telephonic apparatus.
20,152. FABRIS. Incandescent electric lamps.
20,354. MARINO. Electro-deposition of aluminium, &c.
20,382. BROWN and NEILSON. Electric telephones.
21,637. KING. Electrically-propelled vehicles.
21,879. THWAITE and ALLEN. Effecting electro-fusion of metals.
22,029. PICKUP and HINDLE. Electrically propelled fans.
22,197. DAMASKINOS. Recording telegraphic apparatus.
22,531. SMITH. Electric circuits.
23,505. MCFARLANE. Electric light fittings.
23,661. WILLMOT. Electric telegraph instrument.
23,685. SIEMENS BROS. AND CO. (LIMITED) and PERRY. Brackets for telegraph poles.
23,680. CLARK (Société des Cuivres de France). Compressed electrolytic copper, &c.
24,369. BRIERLY. Electric bells.
24,551. COLLINSON. Electricity meter.
24,796. FINDENIGG and SCHWARTZ. Electric igniting apparatus.
24,926. BLACKBURN and BUCHANAN. Dynamo electric machines.
24,714. EPSTEIN. Secondary voltaic batteries.
25,145. NEWBURN (Société L'Electrolyse). Producing copper by electrolysis.
25,340. LEITH and OTHERS. Electric decomposing tanks.

1895.

4,119. HORVATH. Electric contact strips.
5,878. WORDINGHAM. Distributing electricity.
6,000. PEEL. Electrically lighting miners' safety lamps.
12,493. MEIROWSKY. Electrical insulating compound.
16,077. THOMPSON (Fonda). Electromagnetic percussive tools.
16,343. BAERMANN. Incandescent lamps.
16,439. ROYCE. Dynamo electric machines.
16,924. TISDALE and GOULD. Electric fire alarms.
16,925. TISDALE and GOULD. Electric fire alarms.
16,939. DEVONSHIRE (Rice). Electric locomotives.
17,249. WOODHOUSE. Gauging electric wires, &c.
17,287. DIBB and VICKERS. Insulators for telegraph, &c., poles.
17,288. ROSENBAUM. Electrolytic decomposition of alkaline salts.
17,442. STEVENS. Electric resistances.

NEW COMPANIES, STATUTORY RETURNS, &c.

TRAMWAYS CONSTRUCTION COMPANY (LIMITED).—This Company was registered on November 14th, with a capital of £100,000, in £10 shares, to enter into contracts for the construction, repair and maintenance, and to construct, equip, repair and maintain tramways and other roads or ways to be used for traction by electricity or other agency, bridges, subways, waterworks, &c., including the laying of pipes for the distribution of electricity and for telephonic communication, and to work and carry on any electric or other tramway, telephonic, telegraphic, or electric lighting system. The first subscribers are: J. B. Concannon, H. W. Jefferson, H. Oppenheim, J. Morris, and H. Marnham, 500 shares each; H. R. Beeton, 300 shares, and W. Haldinstein, 100 shares.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30⅝d. per oz. (Nov. 21st). Consols (2¾ per cent.) 105⅞–106⅛ for money, 105⅞—106⅛ for account; 2½ per cent. 103½—104 (Nov. 21st). Stock Exchange Settling Days: Consols, Dec. 2nd; Stocks and Shares Continuation Day, Nov. 26th; Ticket Day, Nov. 27th; Pay Day, Nov. 28th.

BRITISH ELECTRIC TRACTION (PIONEER) COMPANY (LIMITED).—Letters of allotment in this Company's recent issue of 5,000 shares have been posted. The applications were, it is stated, largely in excess of the capital required.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The *Financial News* of the 19th inst., in a critical review of the position of the above Company, calls attention to the comparatively small interest which investors are taking in electric railway enterprises in the metropolis. Attention is called to the decrease in expenditure from year to year and to the satisfactory improvement in the dividends paid by the Company. But what is, perhaps, of most interest to investors is the fact that at 40-42, the figures at which the shares at present stand, the yield is nearly 3 per cent., and the stock may certainly be classed with many of the best home railway issues "with a practically certain prospect of a notable increase before long in dividend and capital value."—The traffic returns of this Company for the week ended November 17th (on which day the railway was partly closed for alterations at King William-street Station) were £958, against £972 in the corresponding week of 1894, a decrease of £14. The total receipts for the half-year amount to £17,616, against £17,691 for the corresponding period of 1894, a decrease of £75.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—Our advertisement columns contain the numbers of 381 Five per Cent. Mortgage Debentures of £100 each in this Company, which have been drawn for payment at par on January 1st next by Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C.

GESELLSCHAFT FUR ELEKTRISCHE UNTERNEHMUNGEN (BERLIN).—A meeting of this Company will be held on the 28th inst. for the purpose of considering a proposal to increase the capital of the Company from 15,000,000 to 30,000,000 marks.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 17th inst. amounted to £1,028. The amount for the corresponding week last year was £881; increase, £147.

RUSSISCHE GESELLSCHAFT FUR EXPLOITATION ELEKTRISCHER KRAFT.—A Company bearing this title, and with a capital of 500,000 roubles, has just been formed in St. Petersburg. Herr N. Demtschinsky is president.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED). The recent issue of £20,000 Four per Cent. Debenture Stock by this Company, offered to the existing shareholders at 2½ per cent. premium, was, we learn, largely over-subscribed.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended November 15th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,243.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half-month ended November 15th are £2,120, against £1,994 in the corresponding period of 1894. The July receipts, estimated at £3,488, realised £3,577.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Nov 13.	Price Wednesday, Nov 20.	Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending Nov. 16. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	10/0	Anglo-American	43 45	43 45	5 0 0	Jan., Apr., July, Oct.	44	43
£2,993,560	Stock	20 0	Do. Preferred	84½ 84½	84½ 83½	5 7 9	" "	85½	85½
£2,993,560	Stock	5/0	Do. Deferred	6½ 6½	6 6½	.. ..	" "	6½	6½
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	102 105	101 105	3 17 1	January and July	..	..
130,000	£10	5/0	Brazilian Submarine	13½ 13⅝	13 13½	5 3 8	Mar., June, Oct., Dec	15⅛	13
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111 115	111 115	4 8 4	June and December	..	..
10,000,000	$100	$ ½	Commercial Cable Capital Stock	164 163	164 163	4 3 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	13 14	13 14	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	21½ 21½	4 13 0	" "	21⅛	21
12,931	5	2/0	Direct Spanish (fully paid)	4 5	3½ 4½	4 8 11	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 5 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104⅞ 107⅞	104⅞ 107⅞	4 6 9	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½ 8⅝	8½ 8⅝	4 11 5	Jan., Apr., July, Oct.	8⅝	8½
400,000	10	2/6	Eastern	16½ 17	16 16½	3 18 9	" "	16⅝	16½
70,000	10	6%	Do. 6 per Cent. Preference	17⅝ 18½	17⅝ 18	3 6 8	" "	..	..
£1,297,857	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	126 129	125 128	3 2 6	May and November	130	126
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 12 2	February & August	..	..
250,000	10	2/6	Eastern Extension	17⅛ 18	17⅛ 17⅞	3 13 11	Jan., Apr., July, Oct.	18	17½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	127 130	128 129	3 2 6	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	108 107	108 107	4 16 8	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	108 107	108 107	4 16 8	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108 111	108 111	3 12 9	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 115%	3 9 7	May and November	103½	03½
180,227	10	1'3	Globe Telegraph and Trust	9½ 10	9½ 10	4 5 0	Jan., Apr., July, Oct.	9⅞	9⅞
180,042	10	6%	Do 6 per Cent. Preference	16 17	16 17	3 10 7	" "	16⅞	16⅞
150,000	10	5/0	Great Northern	21½ 22½	21½ 22	3 17 3	Jan., April, and July	..	..
£18),000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	104 107	104 107	4 14 4	March & September	..	..
17,000	25	12.6	Indo-European	47 50	46 49	5 2 0	May and November	48	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	.. ..	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	108 110	108 110	5 10 10	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	102 112	109 112	3 12 3	" "	..	..
11,839	8	4/0	Reuter's	5½ 6½	5½ 6½	.. ..	April and October	..	..
3,381	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	127 133	127 133	4 10 11	" "	129½	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	.. ..	" "	..	..
£233,300	100	5%	* Do. 5 per Cent. Debentures (red.)	104 107	103 108	4 15 3	March & September	..	..
30,000	10	2/0	West Coast of America	1 2	1 2	.. ..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	100 105	98 103	7 19 3	June and December	..	..
88,321	10	1/3	West India and Panama xd	¾ 1⅛	¾ 1	.. ..	" "	1⅛	..
84,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10⅝	10 10⅛	5 14 3	May and November	10½	10⅛
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½ 9⅛	8½ 9⅛	6 6 4	" "	9⅛	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	111 114	111 114	4 9 1	June and December	..	..
64,242	15	6/0	Western and Brazilian	9⅜ 10½	9⅜ 10½	4 17 0	May and November	10½	9⅜
33,129	7½	4/6	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 6⅝	.. ..	—	6⅝	..
33,129	7½	1/6	Do. 5 per Cent. Deferred	3½ 3⅝	3½ 3⅝	.. ..	—	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 14 3	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 14 3	" "	..	..
£1,177,000	£1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	110 115	110 115	6 1 9	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100 103	100 103	5 18 10	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3½ 3⅝	3½ 3⅝	.. ..	—	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ¼	⅛ ¼	.. ..	May and November	..	..
171,504	£1	5'215	Oriental Telephone and Electric (fully paid)	⅛ ¼	⅛ ¼	.. ..	Yearly	..	..
484,597	5	2/6	National	5½ 6⅛	6 6⅛	4 0 0	June and December	6⅛	6
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	17	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15⅜ 16⅛	15⅞ 16⅛	3 12 9	" "	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6¼ 6⅜	6¼ 6⅜	3 16 11	—	6⅜	5⅞
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	105 107	105 107	3 6 4	January and July	106½	106
58,000	5	5/0	United River Plate	2⅞ 3⅛	2⅞ 3⅛	.. ..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	92 97	92 97	5 5 6	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12½ 13½	12½ 13⅜	1 17 0	—	..	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	16 16⅝	16⅜ 16⅝	3 13 10	—	16½	16
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	131 135	131 135	3 15 4	June and December	..	..
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	.. ..	—	..	..
£80,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	6½ 6⅝	5½ 5⅝	.. ..	—	5⅝	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	.. ..	—	..	..
8,322	£5	..	House-to-House Electric	.. ..	.. ..	.. ..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	.. ..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	.. ..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅛ 8⅛	7⅛ 8⅛	.. ..	—	..	..
111,000	5	..	London Electric Supply	.. ..	.. ..	.. ..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid) xd	10 11	11½ 11¾	2 12 2	—	10⅝	..
150,000	Stock	4½%	* Do. 4½% Debs.	117 120	117 120	3 16 3	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9⅛	8½ 9⅛	.. ..	—	..	..
..	..	..	Rand Electric	⅜ ½ prem	⅜ ½ prem	.. ..	—	..	..
19,930	£5	2/0	St. James and Pall Mall	8 8½	8 8⅛	.. ..	—	8⅝	..
20,000	£5	7%	Do. 7 per Cent. Preference	9 10	9 10	3 10 0	—	9½	8½
59,900	5	2/6	Westminster Electric Supply (fully paid)	8 8½	8 8½	3 2 10	—	8⅝	9½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1½ 1⅝	1½ 1⅝	11 2 3	—	1½	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝ 2⅛	1⅝ 2⅛	5 12 11	—	1⅝	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 19 0	March & September	118½	..
28,080	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1⅛ 2⅛	1⅛ 2⅛	.. ..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1⅝ 2⅛	1⅝ 2⅛	.. ..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 5 9	..	106	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	—	..	..	..	..
110,000	2	..	Electric Construction	¾ 1	⅝ ¾	.. ..	..	..	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 11 0	..	—	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅝	⅜ ⅝	.. ..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¼ ½	¼ ½	.. ..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	19 20	18½ 19½	3 16 11	February & August	19	19
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101 103	101 103	4 8 0	March & September	..	..
15,993	£10	..	International Okonite Ordinary	.. ..	.. ..	.. ..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	.. ..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	.. ¼	.. ¼	.. ..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	40 42	40 42	5 14 3	March and July	42½	40
£150,000	100	5%	* Do. 5 per Cent. Bonds	104 10	104 107	4 15 6	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	.. ..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	.. ..	..	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	14 14½	14 14½	4 2 9	..	14½	..
£30,000	10	7/0	Do. 7 per Cent. Preference	15½ 10½	15½ 16⅛	4 4 0	..	..	..
£60,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108 111	108 111	4 1 11	..	110	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway	40 42	40 42	2 19 6	May and November	40½	..
7,650	10	5%	Do. 5% Perpetual Preference	14⅜ 15½	14½ 15½	3 5 7	..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture xd	134 134	132 134	2 19 9	May and November	..	..
37,500	£10	2½%	Liverpool Overhead Railway	11⅜ 11⅞	11⅜ 11⅞	1 18 4	—	..	..
10,000	10	5%	Do. 5% Preference	15⅜ 15⅝	15⅜ 15⅝	3 3 6	—	..	..
125,000	Stock	4%	Do. 4% Debenture	112 114	112 114	3 9 7	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

On the whole, approximate justice has been done in the action Fareham Electric Light Company (Limited) *v.* Fareham Urban District Council, a report of which will be found in another column. The local authority, several members of which were more or less interested in the Electric Light Company, decided, by a narrow vote, just previous to the elections, to purchase the electric light undertaking. The elections resulted in a majority adverse to the purchase scheme and and the new Council consequently refused to go through with the bargain. Hence the lawsuit in question, which has resulted in a verdict for the Company with £3,800 damages. It is well that the principle of the continuity of municipal liability should be vindicated, but we should have preferred to have seen it vindicated with less to be said for the other side.

It has been said that a man's views, when he believes them to be so absolutely correct that express them when, where, and to whom he will they cannot but be acceptable, are almost sure to be half wrong. We earnestly hope that this dictum does not apply to Mr. Sam. Mavor and his views on concentric wiring, though he most certainly has not failed to insist in season and out of season on the pre-eminent virtues of this system; and he has now wound up his crusade at the Institution of Electrical Engineers by a slashing indictment of double-wiring, wood-casing and crockery ware. If strong language were synonymous with strong argument there could be no discussion of this vigorous Paper. The question would be straightway settled for all time by its mere perusal. As it is, however, strong language by a strong man is an excellent prelude to a warm exchange of opinions, and we anticipate an informing debate, and shall look forward with some curiosity to the defence which we have no doubt will be made by the advocates, or if there be none left, by the sellers of the type of electric light fittings so unsparingly denounced.

The question opened up by this matter of house-wiring is an exceedingly wide and difficult one. It is without a doubt to the general interest of the industry, and, in the long run, to the interest even of competing wiring contractors, that good work should be put in. The problem is how to attain this desirable end without killing the goose that lays the golden eggs; that is to say, how are we to reconcile the small householder, who is generally a tenant, to the increased *first* cost? The owners of big West-end mansions, hotels, factories, &c., can afford the luxury of a consulting engineer, and will not look askance at a 20 per cent. bigger bill than they were led to expect. One might reasonably have anticipated that the rules of the various fire offices would have effected all that was required, but apparently fear of competitors is greater than fear of fires. Hence stringent rules are made, but leniently enforced. In the same way the rules of the electric supply companies are largely neutralised by considerations of a similar character and a desire not to frighten away intending consumers. Hence the strongly-expressed wish at the recent Board of Trade Conference that our great regulation machine should turn out a set of house-wiring rules and see to their enforcement, thus securing uniformity and safety. An admirable idea, which only suffers from the disadvantage that the Board of Trade has no power or desire to issue minute regulations of the kind.

Then, again, the sweet simplicity of the concentric system resides largely, if not entirely, in the outer being earthed. The objections of fire offices having been overcome, buildings served by isolated plants can now be wired on this plan. The Board of Trade, however, still remains obdurate with regard to the earthing of the middle wire of a three-wire system, and the development of concentric wiring with the outer earthed is, therefore, to a large extent barred. Could not the expert committee of three, which is to assist that Department in defining "low pressure," also assist it in the equally important question of the earthing of the neutral wire? Is it to be or not to be? We quite agree that it is better to bear the ills we have than fly to others we know not of; but meanwhile, Board of Trade or no Board of Trade, three-wire engineers assert that their currents *will* "turn awry." Would it not be as well to definitely ascertain if there be in reality any danger in recognising and legalising this state of things? The questions raised by Mr. Mavor's Paper are, therefore, as we have said, numerous, important and far-reaching, and we trust the discussion on his paper and on the one by Mr. Bathurst, which loudly proclaims the virtues of "interior conduit" wiring, will tend to their elucidation.

The type of steam engine which Mr. P. W. D'Alton has recommended for the new plant recently erected at Deptford is a somewhat novel one to this country, although we believe that in Germany the particular arrangement of cylinders

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therein adopted is not uncommon. A glance at the illustration of the engine, which we publish this week, might suggest that it is a type of marine engine; but it will be seen that the engine differs from the standard marine pattern, in having its three cranks driven by three tandem compound engines. In our opinion this possesses, for alternator driving, a distinct advantage over the side-by-side compound or triple-expansion arrangement, inasmuch as it tends to maintain the regularity of the crank effort at all loads. With a side-by-side triple-crank engine, though the distribution of steam may be regulated ever so nicely at full load, there will be irregular driving at light loads. This is due to the fact that, though at full load the cylinders may share the work equally between them, the duty will be divided when the load falls, with increasing disproportion between them. As a consequence, alternators driven by such engines will not infrequently cause unsteadiness in the light at low load, even though the light may be faultless at other times. Of course, it is possible to provide side-by-side cylinders, each with a separate variable expansion gear, which will equalise the duties at all loads; but such gears are not commonly used, and in electric light stations they would probably be found to be too complicated. With a tandem arrangement the same expansion gear will actuate both cylinder distributions.

While speaking of valve gears, we are reminded that the new engine introduces a fresh type of gear into the Deptford station, where until lately the Corliss gear reigned supreme. The recent addition is provided with piston valves for the high-pressure cylinders and ordinary slides for the low-pressure cylinders. There is no comparison between the older and the newer gears, neither in the matter of simplicity nor of silence. For electric lighting work the merits of Corliss gear have been sadly over-rated; and in the haste to get a pretty indicator diagram many engineers have forgotten the complicated structure of these gears, and the consequent risk of an entire engine being thrown out by the derangement of one of countless little studs and pins. Under some conditions, not met with in electric light work, the Corliss gear will, no doubt, save steam; but we strongly suspect that not infrequently it saves it only to make a noise with it. The energy wasted in hubbub has not yet taken its place in a thermal balance-sheet; but if it were to do so, it would loom large in the statistics of some patterns of Corliss engine.

Judging from an article by Mr. Hermann S. Hering, in a recent number of the *Electrical World* of New York, the Americans have not yet given up entrusting the construction of their tramways and railways to the electrical engineer. "The civil engineering work of roadway construction is seldom designed and superintended by competent civil engineers," we are told. Our contemporary reflects that "in time electric railway engineers will probably have that part of civil engineering which relates to roadbeds included in their professional instruction." We sincerely hope that nothing of the sort will happen, at any rate, in this country. The proper person to set out curves and gradients, and to settle such matters as relate to foundations, cuttings, embankments, rails and their super-elevation, &c., is not the engineer who designs or superintends the manufacture of rolling stock. It was never so in steam railway work; where the functions of the civil and of the mechanical engineer have been always kept distinct. Why, then, adopt a polyphase system of duties for the electrical engineer when life is not long enough for him to learn his own work properly?

Mr. Hering passes on from the consideration of track construction to dilate upon other matters which affect the working expenses of an electric railway. He enlarges so ominously on the cost of stopping a car, and shows so convincingly how much would be saved if it were not stopped, that we can almost imagine a conference of managers debating the question: "Does it pay to stop our cars?" Another lamentable waste of money arises from the fact that when doing his "supper" trip—or the last trip at night—"the motorman will accelerate (use his controller on starting) as rapidly as possible, and these trips are always expensive to the Company." Turnouts also are wasteful, when they are too numerous; and this, we may add, is especially the case where frogs are used on the overhead trolley wire. We had occasion last week to describe a tramway blessed with no less than 27 turnouts in a length of six miles. A delay of but 60 seconds due to slowing down at each of these would add some 13 minutes to the time of a single run, and would necessitate the building of three additional motor cars to maintain a ten-minutes service.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Cadiz-Teneriffe	Sept. 25, 1895.	Nov. 22, 1895.
Perim-Assab	Nov. 19, 1895.	Nov. 26, 1895.

Electric Motors in Works.—The report of the Middlesbrough engineering firm of Dorman, Long and Co. (Limited) states that a saving of between £3,000 and £4,000 per annum is now being realised by the introduction of electric power for driving the outlying machinery.

Errata.—On page 110 of our issue of last week, under the heading of "Contemporary Electrical Science," there occurred two printer's errors. The seventh line from the bottom of the column should read: "gives the melting point of platinum as 1,780°C.," instead of "178°C.," as stated. On the sixth line read: "the cooling effect of air currents," instead of the "evolving" effect.

The Pollak Rectifier at Zurich.—The first application on a large scale of the Pollak system of charging accumulators by alternating currents (see *The Electrician*, August 9, 1895, Vol. XXXV., p. 488) has been made at Zurich in connection with the lighting of the new concert hall. The electric lighting of this building is carried out by 1,200 16 c.p. glow lamps and 50 large arc lamps. As the local supply station has nearly reached its full load in the evening, but has an available energy in the day time, a large battery of accumulators has been laid down in the building in question, which is charged during the day by the rectified alternating current from the mains.

Railway Carriage Lighting.—On Wednesday Messrs. J. Stone and Co., of Deptford, invited the Press to witness a trial run on the Tilbury and Southend Railway of a train fitted with their patented system of electric lighting. The train, consisting of an engine and tender, with two coaches, left Fenchurch-street at 5:5 p.m., and made a run as far as Grays, Essex, and back. In this system the dynamo is suspended under the frame of the carriage, and is driven by a belt off the carriage axle, the current obtained being used to charge a small accumulator. Provision is made for preventing the vibration of the carriage

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axle being communicated to the dynamo, and, however much the speed of the train may vary, that of the dynamo is constantly uniform.

Horseless Carriages.—A meeting for the purpose of forming an Association in connection with self-propelled traffic is to be held on Tuesday, December 10th, at the Cannon-street Hotel, at three o'clock, at which Sir David Salomons, Bart., will preside. A series of resolutions will be proposed at the meeting, with the view to starting such an Association. As the trade may become an important one in England, it is hoped there will be a large attendance at the meeting. Tickets for the meeting may be had on application to Mr. Andrew W. Barr, 30, Moorgate-street, E.C., who is acting as honorary secretary for the time being. We may also remind our readers that Mr. W. Worby Beaumont is about to deliver a course of three Cantor lectures on "Mechanical Road Carriages." The first lecture of the course will be given on Monday evening next at eight o'clock, at the Society of Arts, John-street, Adelphi.

La Compagnie Française des Cables Télégraphiques.—This Company's Atlantic cable system, the breakdown of which was reported some time ago in *The Electrician*, is still interrupted, inasmuch as, after the "Faraday" had restored the Brest-Penzance section, and had finally recovered the Penzance-St. Pierre cable at the localised portion of the main break, which was found to be in upwards of 2,500 fathoms, another interruption was discovered some 200 miles further to the westward in 1,700 fathoms, and this was not touched. Moreover, the Brest-Penzance section again broke shortly after its restoration early in October last by the "Faraday," and is still interrupted, attempts made during the past few weeks to repair it with a small steamer having failed. The French cable-ship "François-Arago" has now returned from Madagascar, and it is rumoured that, the advanced season notwithstanding, the Compagnie Française propose chartering that vessel to proceed early next month to try and repair both of their cables.

Rapid Electric Tramway Construction.—Several American papers have lately published accounts describing the rapid construction of an electric tram line in Chicago. The road in question was about 1½ miles long. All the overhead material for the construction was in readiness before the equipment of the line was begun, and at 11·30 p.m. a gang of 300 men was set at work. In 22½ hours the work was completed and a car was running over the line. "There is no doubt that this was a remarkable performance," says the *Electric Railway Gazette* of New York, "but it is not as extraordinary as some of the papers have assumed. The equipment of the line from Weehawken to Fort Lee in New Jersey was a much more formidable undertaking, and under the circumstances the rapidity of construction was even more noteworthy." In this case about 100 men constructed over four miles of overhead line in six days, and it was even found necessary to blast rock before the majority of the poles could be set, while in Chicago the holes were dug in soft earth. It is to be hoped that the depreciation of this property will not be correspondingly rapid.

Use of Electricity on Railways.—Mr. J. R. Kendrick, third vice-president of the New York, New Haven and Hartford Railroad, referring to the proposed extension of electrical equipment on the Old Colony division, is reported to have said:—"We are entirely satisfied with our experiment on Nantasket beach business, the season having demonstrated the fact that the cheap and frequent trains create traffic. The passenger statistics for the summer just closed show an increase of 300 per cent. over those for the season 1894, and next year we expect these figures will be beaten. In regard to the report that our Company was taking steps looking to the equipment of the link between Nantasket junction and Braintree with electricity, I am at liberty to say that it is in every way correct. The plan that will be carried out provides for four tracks, the two outer for trolley cars and the inner for steam. The centre tracks will be fenced in so that there will be no possibility of injury to passengers when using the electric cars."

American Street Railway Finance.—At the recent annual meeting in New York of the American Society of Railroad Superintendents, Col. H. G. Prout, editor of the *Railroad Gazette*, delivered a lengthy address on "The Use of Electricity as a Motive Power on Railroads Now Operated by Steam." In the course of this address the following noteworthy passage occurred: "There is, however, a set of conditions at work which will change the situation of the present electric railroads a good deal before long. Up to the present time it has been, and still is, easy to finance them, because rail mills and electrical manufacturers are glad to help float the bonds of new electric railroad projects; the public is credulous and investors look for great profits. We are, therefore, in the midst of the 'kiting' epoch of electric railroads, when bonds which are sold to-day pay the interest on the bonds sold last month or last year. But, naturally, this situation must come to an end before long." Once more we repeat the hope that we shall not import into this country America's financial methods along with its admirable electrical devices.

British Association Speakers.—An American, who attended the recent meeting of the British Association at Ipswich, has been criticising the style of speaking current at these gatherings. He says that among the leaders of the various sections of the Association there are few good speakers, and he could not help contrasting the oratory, as he passed from room to room, with that which he had heard only a fortnight before at the Trades Union Congress at Cardiff. The labour leaders, he remarks' know nothing about science, but they understand the art of speaking without hesitation and circumlocution, and know how to hit the mark. The educated professors, with few exceptions, do not speak well. "They have a halting, hesitating manner, are constantly 'hemming' and 'hawing' and changing the construction of their sentences. An accurate phonetic transcription of speeches delivered at this session would be a curious and amusing study. It would be punctuated with sighs, ejaculations and groans, and would be a veritable maze of mixed constructions and circumlocution. There are some excellent speakers among the regular attendants at section work, but the majority of them are careless and slovenly talkers to whom it is almost painful to listen."

The Fastnet Lighthouse Cable.—We are requested to state that the paragraph which has recently appeared in many of the daily papers relating to the breaking of the Fastnet lighthouse and Crookhaven cable is somewhat misleading. The communication is effected by means of the non-continuous cable system, first suggested by the late Mr. Willoughby Smith, and has worked satisfactorily for over four months. The system necessitates two short lengths of strong bare copper cable being bolted to the rock from the lighthouse to the water's edge, and this can only be done when the sea is exceptionally smooth—a very rare thing at the Fastnet. Owing, however, to the persistent bad weather, the cable down the north face of the rock could not be absolutely secured, and has, therefore, given way. Communication can be, and has been, maintained, except in the very roughest weather, by means of a temporary copper wire which the lighthouse men throw over the side of the rock so that the end just enters the water. The main cable, about nine miles long, which terminates at a mushroom submerged in the vicinity of the rock at a depth of about 80ft., still remains in perfect order.

Ships' Side-Lights.—The *Shipping Gazette and Lloyd's List* publishes the substance of the report of the departmental committee appointed by the Board of Trade to inquire into the subject of the screening of ships' side-lights. The Order in Council of January 30, 1893, professed to secure compliance with the international regulations affecting the screening of side-lights by providing that the rays from the red and green lights must be screened to an angle of four degrees from the outside edge of the wick. The position taken up by the shipping interest was that this requirement constituted a serious danger to navigation, and was calculated to increase rather than diminish the risk of collision. The Committee conclude their report in the following terms:—"(1) That the Order in Council of January 30, 1893, be cancelled. (2) That in the case of oil lamps the forward edge of the screen or chock on it should be in a line parallel to the keel with the inside edge of

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the wick. (3) That in the case of electric lights there should be a similar screening in regard to the inside edge of the filament. (4) That the breadth of the wick of oil lamps, and of the filaments in the case of the electric light, should be not more than 2in. nor less than 1in., measured at right angles to the fore and aft line of the ship. (5) That the visibility of the green light should as nearly as possible be equalised to that of the red by the employment of higher candle-power, and that the mast-head light should not be so powerful as to diminish the visibility of the side-lights."

The "Belt Line" Tunnel Electric Locomotive.—The 96-ton electric locomotive has now been in operation on the Belt Line of the Baltimore and Ohio Railway since August 4th last, and according to the American Electrical Journals has been hauling the entire north bound freight service of that railway. Some tests have been made of its capabilities, and in the following we give a few of the more important data. A train consisting of 27 loaded freight cars and two steam locomotives, not working, of a total weight of 1,125 tons, was hauled up a gradien of 42ft. to a mile. At the end of one minute the train was moving at a speed of 10½ miles an hour, and at this point the speed was increased to the usual rate. The distance moved in 40 seconds was 150ft., and in one minute 450ft. Another test was made with a dynamometer car placed between the electric locomotive and the train, which consisted of 22 cars loaded with coal, one guard's brake and two locomotives. The total weight was 1,068 tons. On the 10 per cent. grade in the tunnel an average drawbar pull of some 25,000lb. was obtained from the dynamometer diagram. The speed at this point was 11⅛ miles per hour. A test with a train of 1,600 tons weight showed a drawbar pull of 45,000lb. On October 6th a train over 1,800ft. long and weighing about 1,900 tons was started from rest in the tunnel. It consisted of a north bound freight train of 28 loaded cars and two locomotives coupled to a local freight of 15 loaded cars and one locomotive. The maximum drawbar pull in this instance was 60,000lb., and a speed of 12 miles an hour was obtained.

Light Railways Association.—A meeting of gentlemen interested in the encouragement and construction of light railways in Great Britain was held on Wednesday last at 17, Victoria-street. The meeting was convened to consider (1) what steps should be taken to amend the laws at present governing such enterprises; (2) to appoint a deputation to wait upon the President of the Board of Trade to formulate the views of the Conference; (3) to establish an association to support and foster the movement; and (4) generally to take all such steps as may be considered desirable in connection therewith. Among those present were Gen. Hutchinson, Major-Gen. Webber, Mr. J. G. B. Elliot (Secretary of the Tramways Institute), Mr. W. M. Acworth, Mr. W. J. Carruthers Wain. Mr. Carruthers Wain was voted to the chair. The Chairman suggested that a strong committee should be formed—a council of administration—to be guided by the advice of experienced engineers and solicitors; and with their aid the association might be able to formulate suggestions, or a scheme, which might be useful to the new President of the Board of Trade when he came to submit his proposals to Parliament. The following committee was nominated:—Gen. Hutchinson, Major-Gen. Webber, Mr. A. C. Payne, Major Rasch, M.P., Sir Douglas Fox, Mr. Hamilton Smythe, Mr. W. J. Carruthers Wain, Mr. R. Harding Milward, the Duke of Sutherland, Lord Wantage, Mr. Beachcroft (of the London County Council), Dr. Carte and Mr. W. M. Murphy (of Dublin), with power to add to their number.

Portland (Oregon) Electric Transmission Plant.—American electrical papers of recent date contain descriptions of a 12-mile electric transmission plant at Portland, part of which has been in operation for some time, the current being employed for lighting, power, and traction purposes. As motive power the falls of the Willametta river, near Oregon city, are used. The power house is situated alongside a head-water canal, and consists of 20 sections, 5 of which are already built, and the remainder are in course of construction. The fall is 40ft., with an estimated total capacity of 50,000 H.P. The ultimate generating capacity of the station, however, will be only 12,800 H.P. At present there are three units, each consisting of a pair of vertical Victor turbine wheels 42in. and 60in. in diameter respectively, and a 450-kilowatt generator coupled direct to the shaft of the smaller. The larger wheel is an auxiliary, to be brought into service only at periods of excessive high water, which the records show occur about once in every five years. The smaller wheel runs at a speed of 200 revolutions per minute, and the larger at 100 revolutions per minute. Both turbines are set at the same level, and each carries a pulley. When the large wheel is in operation, the two pulleys are belted together, the smaller wheel is disconnected, and the large wheel drives the generator at a uniform speed of 200 revolutions. When the smaller turbine is operated alone, the belt lies upon a shelf surrounding the pulleys. The generators are of the three-phase type, with a frequency of 33 cycles per second, and an E.M.F. of 6,000 volts. Two exciters of 250 kilowatts each are provided. Each of these machines is capable of exciting the whole 20 generators which it is proposed to ultimately put down. At present one of the exciters is used for supplying current to the electric tramways at Oregon city. From the generators the current is carried to Portland by overhead conductors, a separate circuit being installed for each machine. At the sub-station the current is transformed. Forty-five transformers are at present in use, of which 15 are connected to each generator, five being placed between each pair of wires of the three-phase system. The distribution of light from the secondaries is effected on the Edison four-wire system. The direct current for the railway service is obtained by conversion from the three-phase alternating current. This is effected by means of rotary transformers, two of which are at present installed in the sub-station, each having a capacity of 500 H.P. The long-distance transmission lines for this railway service as in the case of the lightning circuits, are connected to step-down transformers, transforming the current from 6,000 volts on the line to 400 volts at the secondaries. The secondaries are connected to the three collector rings of the rotary converter. The alternating current at 400 volts is then converted into direct current at 500 volts at no load, and 550 volts at full load.

Contemporary Electrical Science.—An accurate method of measuring specific inductive capacities is described by H. Pellat in the November *Journal de Physique*. It is founded upon the increase of attraction between the armatures of a charged condenser on replacing the air between them by the dielectric under investigation. The way this is managed is by an attracted disc electrometer with two discs attached to the top and bottom of a vertical rod, and suspended by one arm of a balance between two attracting discs above and below. The attracted discs are surrounded by stationary guard rings. After equilibrium is established, a slab or layer of the dielectric is placed upon the upper guard ring, and the upper attracting disc is shifted until equilibrium is once more established. This point is determined by observing through a telescope the motion of the rod carrying the attracted discs. This method can be carried to a point of extreme accuracy, and the practical limit only lies in the measurement of the thickness of the dielectric. Liquids can be dealt with in the same way, by putting them into flat dishes, or they may be introduced between the lower pair of discs in contact with the metal itself.—Wladimir de Nikolaieve introduces us to the somewhat unfamiliar phenomena of magnetic self-induction, by a discussion of the cause of the repulsion of Elihu Thomson's ring. "A piece of iron," he says, "attached to the end of the core of an electro-magnet, will drop off if a disc of copper is moved along the core. An increase of the magnetising current is observed at the same time. This diminution of the attraction of the iron is due to magnetic self-induction." If there are magnetic (displacement) currents, why not magnetic self-induction?—E. von Aubel and R. Paillot scrutinise the validity of the law enunciated by Wiedemann and Franz, that metals of fairly good thermal conductivity have an electrical conductivity varying in proportion. Taking the case of aluminium bronze, "constantane" and ferro-nickel—all alloys of high electrical resistance—they find that this law is anything but verified, although a rough kind of correspondence may be observed. The law evidently holds for pure metals only of homogeneous structure.

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MOTIVE POWER AND GEARING.*

(*Continued from page 7*).

BY E. TREMLETT CARTER.

Water-jacket Heat.—Undoubtedly the exigencies of construction make the chiefest inroads upon the heat account, and cause large amounts of energy to be thrown away. Were it not that, at all costs, the working parts of the gas engine must be kept from growing red hot, or even approaching the temperature of free explosion, we might have a much more economical gas motor. No doubt whatever this difficulty will in time be overcome; and, instead of the materials we now use, we shall make our explosion chambers, and the working parts which are directly exposed to the hot gas, of some more highly refractory materials. It will, perhaps, scarcely be credited that in an "Otto" cycle gas engine of modern construction it is quite usual for *more than 50 per cent.* of the total energy of the gas to be passed into the water jacket.

One of the partial remedies for this great waste of heat has already been referred to—viz., an increase in the piston speed. It needs no saying that to this remedy there is a limitation which is soon reached; indeed, with the highest speeds found to be practicable at the present time the jacket losses are rarely, if ever, lower than 40 per cent. A high piston speed was advocated even by de Rochas, who perceived the supreme necessity for getting useful effect from the gas before it had time to give up its heat to the surrounding metal.

A slowly-moving piston is a fatal mistake, because it permits the gases to remain long in contact with the water-cooled walls of the cylinder.

It may here be remarked that Dr. Witz has shown experimentally that an increase in the piston speed causes a corresponding increase in the rapidity of the explosion, the maximum pressure of the gas and the completion of the combustion taking place earlier when the piston speed is raised.

Ignition Gas.—It is not customary to include the volume of gas used in maintaining an ignition flame, or in heating an ignition tube, in any estimate of the performance of a gas engine. From the nature of the case, it is clear that this volume of gas is very nearly independent of the size or power of the engine. Ignition tubes are now almost universally employed, and the gas required to keep one of these properly heated is about 4 cubic ft. to 10 cubic ft. per hour. The gas is usually burned in a Bunsen type of burner. At the Belfast electric supply station the ignition gas for the engines is being specially metered.

Incomplete Combustion.—Strictly speaking, loss due to the escape of unburnt or partially burnt gas is not directly loss of heat, but of the potential energy of the substance from which heat might have been obtained. It has already been stated that the whole of the gaseous fuel admitted in one charge does not become burned by the time of the maximum pressure and temperature of the gases, but that a considerable part of it liberates its heat at a later period, when the pressure and temperature are falling. This phenomenon is called *after burning*; and when it is carried beyond the moment when exhaust commences, loss by incomplete combustion may be said to result. That this after burning really takes place, a careful examination of the indicator diagram of a gas engine will show.

To make this clear, however, it is necessary to mention a restriction of the combined law of Boyle and Charles, which correlates pressure, volume and temperature. *That law is not necessarily true if chemical change goes on within the gas.* For example, it is not true for a mixture of hydrogen and oxygen at temperatures at which the fired gases would condense into water. There is, then, no *a priori* necessity that the P.V. law of the gaseous charge fired in a cylinder shall remain unchanged throughout the working stroke. As a matter of fact, however, experimental data warrant the conclusion that, at the high temperatures found in a gas engine cylinder, the products of perfect and of imperfect combustion have the same P.V. law as the explosive mixture of gas and air. In analysing the indicator diagram, therefore, we may ignore altogether the chemical changes which have been going on in the cylinder, and may treat the working substance as if it were a stable gas.

Proceeding upon this datum, if we compare the actual line of working pressure throughout the working stroke, with the adiabatic line drawn through the point of maximum pressure, we discover one or another of the following surprising results: (1) The two lines will be almost identical; or, (2) the working line will actually rise above the adiabatic line; or, (3) the difference between them will be smaller than is necessary to account for the great abstraction of heat by the water jacket. All these three relations are met with in gas-engine practice, in general. Now, it is evident from any one of these results, but most forcibly from the second of them, that during the process of expansion the gas has been receiving heat from some source. The heat represented by the state of the gas at its maximum pressure is not sufficient in amount to account for the behaviour of the gas. The only admissible inference is that combustion has been going on at a later stage than the point of maximum pressure. We may carry the investigation further, and determine the rate of combustion at each part of the stroke, obtaining a curve showing the extended combustion of the entire charge. But for this investigation the reader is referred to a more ample treatise on the subject.

It has been found that the percentage of after burning, and therefore the liability to loss from incomplete combustion, increases as the percentage of gaseous fuel in the charge is diminished. The loss by the rejection of unburnt gas into the exhaust is therefore more likely to arise when an engine is working on a small fraction of full load.

Engines Worked on the Otto Cycle.

Before passing to the study of one or two complete examples of gas engines working on the Otto cycle, we will consider the structure and action of some of the details of these engines. It will be as well to state at the outset that none of these details have any logical connection with this cycle. Any one of them might be used in engines working on other cycles; or it might be replaced in an Otto-cycle engine by another kind of mechanism. The details have been chosen with a view to represent the best or the most common modern practice in Otto-cycle engines.

Ignition Apparatus.—Various devices for igniting the explosive mixture in a gas engine have been adopted, but these all have by now become almost obsolete, with the exception of the hot tube. Electric spark ignition has two principal defects: the deterioration of the spark electrodes inside the cylinder, owing to the high temperature; and the complications due to the use of induction coils or other spark-producing apparatus. Flame ignition, by means of sliding valves, was for long in use; and its disappearance came about, not so much because the flame ignition itself was defective as for the reason that slide valves had to be abandoned. The admission and exhaust of the gases exclusively through lift valves, which is now general practice, rendered flame ignition practically impossible. The hot-tube method of igniting was first introduced in 1879, by Mr. Atkinson. In its simplest form it consists of a short stout tube of wrought iron, steel or porcelain, with its lower end in communication with the back of the cylinder and its upper end sealed in some suitable manner. This tube is maintained at a bright red heat—sufficient to ignite the compressed gases—by means of a Bunsen flame applied to it externally. When unprovided with a timing valve, the ignition tube is always in communication with the back of the cylinder; and explosion is determined by the fact that the mixed gases will not ignite until a certain degree of compression has taken place. The compression stroke of the engine forces some of the explosive charge into the hot tube, and at a certain point ignition results. When thus used, the ignition tube is liable to be uncertain in its action; and for all but very small engines it is now commonly provided with a timing valve, by which the communication with the cylinder is not opened until the proper

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moment for explosion to take place. Fig. 75 shows in section one arrangement of hot tube and timing valve used in the "Robey" gas engine. The flame of the Bunsen burner, A, heats the tube, E, which is fitted inside the chimney, F. The lower end of this tube communicates, through the timing valve, D, with the ignition port, B. The

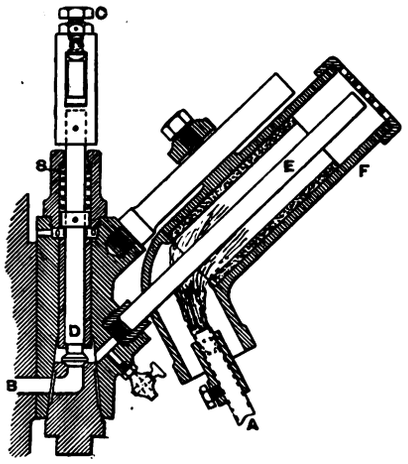

Fig. 75.—"Robey" Ignition Tube and Timing Valve; Early Form.

timing valve is lifted by a rod which slides insides a sleeve, and which is normally held down by the spring, S. The lifting is effected by a lever, actuated by a cam on the valve shaft of the engine; and this lever presses upward against the stud, C, which may be adjusted within small limits. These adjustments will determine the instant of explosion. A later form of the apparatus is shown in Fig. 76.

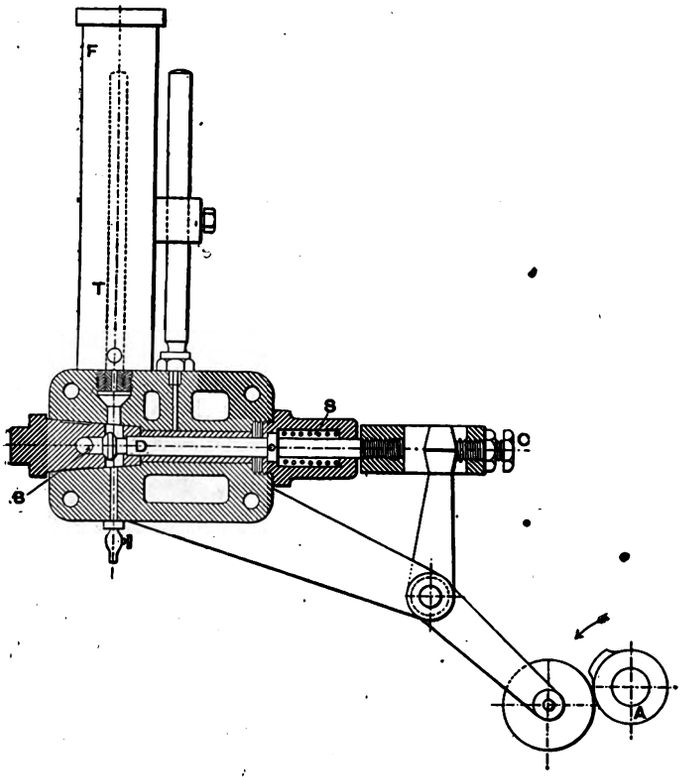

Fig. 76.—"Robey" Ignition Tube and Timing Valve; Later Form.

The chief defect in a properly constructed hot-tube ignition apparatus is the rapid deterioration of the tube, whereby it becomes necessary frequently to renew the tube in order that the engine may not break down through the tube bursting. The longest life of a good wrought-iron tube is not much in excess of 100 hours; and it is more common to have to renew the tube after from 50 to 60 hours. A six-inch length of wrought-iron steam pipe, of ½in. bore, well plugged at one end, makes as serviceable and cheap an ignition tube as the author knows. This will generally last about 50 hours, and the cost does not exceed 1·5 pence. The longest life of tube the author has met with has been in very short porcelain tubes, but these are more expensive initially than those of wrought iron.

Governors and Governing Gear.—Gas engine governing may be classified under two heads: (1) Governing by miss-fire, or the omission of explosions; and (2) governing by a graduation of the explosive force, generally by varying the amount of gas admitted in each charging stroke, but sometimes by variation both of the amount of air and of gas. In some engines these two methods are combined, the graded charges regulating the speed down to a certain fraction of full load, below which explosions are missed.

Miss-fire Governors.—There are many objections to the omission of explosions for one or more cycles; but this method of governing has the advantage of simplicity and convenience, besides that under great variations of load it is more economical than the graduation of the charge. Its main objections are: (1) That it tends to unsteadiness of speed; (2) that it is not sufficiently fine for small variations of load; and (3) that consequently a heavier flywheel is required, with the attendant increase in the weight and friction of the engine. It tends to unsteadiness of speed, because, although the

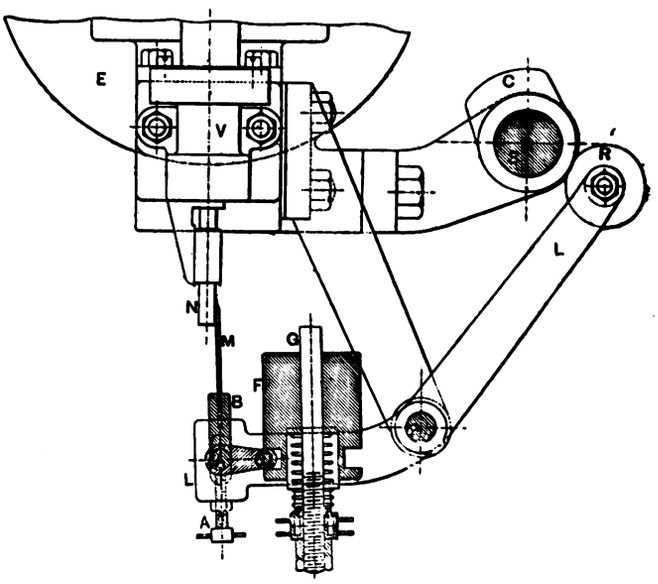

Fig. 77.—Vibrating Governor of "Stockport" Gas Engine.

omission of an explosion may seem theoretically simple, as a matter of fact almost all, if not quite all, governors will miss two or three explosions in succession, where only one omission is required; and then will allow a rapid succession of explosions, where one or more should have been omitted. It also tends to unsteadiness, for the reason that after the omission of one or more of the explosions the cylinder is free of waste gases, and the next explosion will therefore be exceptionally violent, through the excessive richness of the charge. The heavy flywheel is partially a necessary consequence of a cycle which involves an idle revolution and a-half; but it is all the more necessary when, by the omission of an entire cycle of activity, the task of doing work for three and a-half revolutions or more is wholly thrown on the flywheel.

Fig. 77 shows the form of miss-fire governor used in the "Stockport" engines. The gas admission valve, V, is lifted by the spindle, N. A cam, C, on the valve shaft, S, when it presses on the roller, R, causes the lever, L, to be depressed in its right-hand part and lifted in its left-hand part, this lever moving about the pivot, P. Upon the extreme left-hand part of this lever there is carried a bell-crank lever, B, which has at one end a pin, D, and at the other end a lifting rod, M, the upper end of which rod is bevelled down to a sharp edge. The bell-crank lever can be turned about the pivot, A, by the action of a collar, F, carried on a rod, G, which is raised or

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lowered by the centrifugal governor. It will be seen that when M is shifted so as to fall just underneath N, as M rises and falls with the motion of the lever, L, its rise will cause the valve, V, on the cylinder end, E, to be opened, and gas will be admitted. Whereas, when the governor lifts with rise of speed, the rod, G, will be depressed, and M will be forced aside; with the result that M will miss the valve spindle, N, and will rise beside of it, causing the omission of an explosion, by preventing the entry of gas. The governor used in the "Robey" gas engine is shown in Fig. 78. In this, a

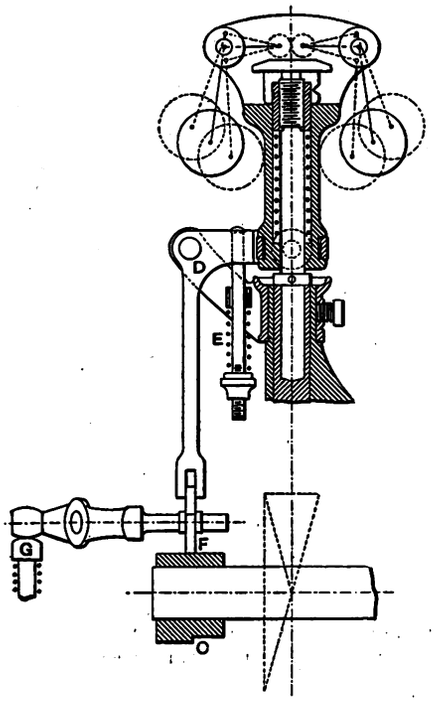

FIG. 78.—"Robey" Gas Engine Governor.

"Richardson" governor actuates a lever, D, on the lower end of which a roller, F, is carried. By the play of the governor this roller will be shifted to the right, on to the cam, C, when it will actuate the gas valve, G; or else it will be shifted to the left, leaving the cam and causing the omission of gas supply. An adjusting screw, E, enables the speed to be regulated, by supplementing the controlling force on the governor.

(To be continued.)

A 1,000-UNIT FLYWHEEL ALTERNATOR.

The latest addition to the generating plant at the Deptford station of the London Electric Supply Corporation is a 1,000-unit flywheel alternator, direct coupled to a 1,500 H.P. compound triple-crank steam engine. The alternator is by Messrs. S. Z. de Ferranti and Co., and the steam engine—or engines, for there are really three engines on one crank shaft—by Messrs. Plenty and Sons. Through the courtesy of Mr. P. W. d'Alton, the chief engineer to the London Electric Supply Corporation, we are able to publish two illustrations and some particulars of this interesting and imposing piece of engineering, which, we may say at the outset, reflects the highest credit upon all who have been concerned in its design and manufacture.

Nominally rated at 1,000 kilowatts, the alternator will usually develop 100 amperes at 10,700 volts, allowing for the 700 volts drop in the transmission system; and it is capable of giving continuously a very much larger output if called upon to do so. The radial-field type, adopted by Mr. Ferranti in his Portsmouth alternators, has not here been followed; a return having been made to the parallel-field type of his earlier machines, on account of the higher frequency at Deptford. The armature coils, 64 in number, are mounted in pairs on ebonite-insulated spokes projecting from the rim of the flywheel. The coils are thus carried between two circles of field-magnet coils, 64 of these latter coils being placed on one side and an equal number on the other side; and all the field coils being mounted upon the inside of the cast-iron circular frame (upon which, in Fig. 1, is the name plate). The armature complete weighs 35 tons, and its extreme diameter is 22ft.; the diameter of the pitch circle of the coils is 20ft. The speed at all loads is 156 revolutions per minute; and as this involves a linear velocity of 10,800ft. per minute, it will be seen that the centrifugal stresses against which the copper coils have had to be designed are something enormous. The armature coils are wound with hard-drawn copper ribbon, $\frac{3}{4}$in. wide, upon a core of laminated brass insulated with asbestos. The windings, both of the armature and of the field coils, are bare. The current density in the armature does not exceed 2,000 amperes per square inch, at full load; and in the field coils it does not exceed half that figure. The field coils are wound on solid cores of hammered scrap wrought iron, the cores being of circular section, 5in. in diameter, in the main part, and fitted with a pole-piece shaped in a rectangle with rounded ends, of 9in. diameter across the circular ends. Over the pole face a 9in. circular cap of insulating material is securely fixed, the purpose of this being to prevent sparking from the armature to the field coils or cores. Some hard experience had to be gone through before the right sort of material for these caps could be found, as it is no easy matter to prevent sparking at 10,700 volts through a mere $\frac{1}{8}$in. or $\frac{5}{32}$in. of material. Woodite was tried, and while some caps of this material could stand over 20,000 volts, others broke down rapidly under normal pressure. The present caps are of enamelled micanite, $\frac{5}{32}$in. in thickness. Into the gaps between the rectangular pole-piece and the circular cap, gunmetal filling pieces have been bolted. The clearance between any pole and the opposite pole on the other side of the armature is, when the machine is running, $1\frac{3}{4}$in.; and this is composed of $\frac{3}{4}$in. for the armature, $\frac{5}{16}$in. for the two insulating micanite caps, and $\frac{1}{32}$in. for each air clearance between the armature and the pole caps. So narrow an air gap necessitates that the armature coils should be securely mounted, and that some means of adjustment should be provided for bringing them into exact centre. These provisions are made in the following manner: Each pair of armature coils is first held in position in a frame and placed between two heavy bronze castings, with a sheet of mica between each casting and the metal of the coils. The castings are then hydraulically squeezed towards one another, so as to grip the coils tightly; and while in this position the castings are riveted together. The solidly-built armature pair is now mounted upon a pair of radial pillars or spokes projecting outwards from the rim of the flywheel. These pillars are arranged in pairs, side by side, and the bronze holder of the armature coils is bolted between the pillars in such a way that by the adjustment of a locked nut on the end of each pillar the coils may be shifted laterally and thereby be brought into exact centre. The nuts on the pillars are ebonite insulated.

The rim of the flywheel which carries the armature coils is in two parts, held together at the rim by two steel rings shrunk over lugs or bosses on the inner side. Each ring is 23in. in diameter and 5in. by 3in. in cross-section, and is of Siemens-Martin forged steel. The rim is also held by eight double spokes of rectangular section and eight mild steel tie rods. These ties are of $5\frac{1}{2}$in. diameter in the body, and have 6in. screws at their ends. At their inner ends they are secured to a mild steel block shrunk on to the armature spindle. This spindle is 18in. in diameter in the main portion, coned to 12in. in the bearings, and it is flange coupled to the end of the engine shaft. The bearings are each 3ft. long, and are of the spherical pattern admired by Mr. Ferranti. A collar on the shaft outside each bearing serves to prevent end motion. We should mention that the frame of the field magnets is in two separate portions, one on each side of the armature; and that by means of an electrically-driven worm gear these two halves may be drawn apart some 20in., for cleaning or repairs. They had been partially opened out when the photograph, Fig. 2, was taken.

Several electrical and mechanical conditions have had to be complied with in the construction of this alternator. The rim

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of the flywheel has been made strong enough to hold itself together if it could be run up to speed without any other support than its own material and the rings at its joints; its arms are strong enough to hold the wheel intact, if it could be run with the rim fractured between each adjacent pair of arms; and the same strength has been given to the tie rods, they being strong enough to hold the rim should the arms be fractured. The chief electrical conditions were that the electrical efficiency of the alternator should not be less than 97 per cent.; that the current density in the armature and field coils should not exceed 2,000 and 1,000 amperes per square inch respectively; that the C^2R loss in the armature should not be more than 0·8

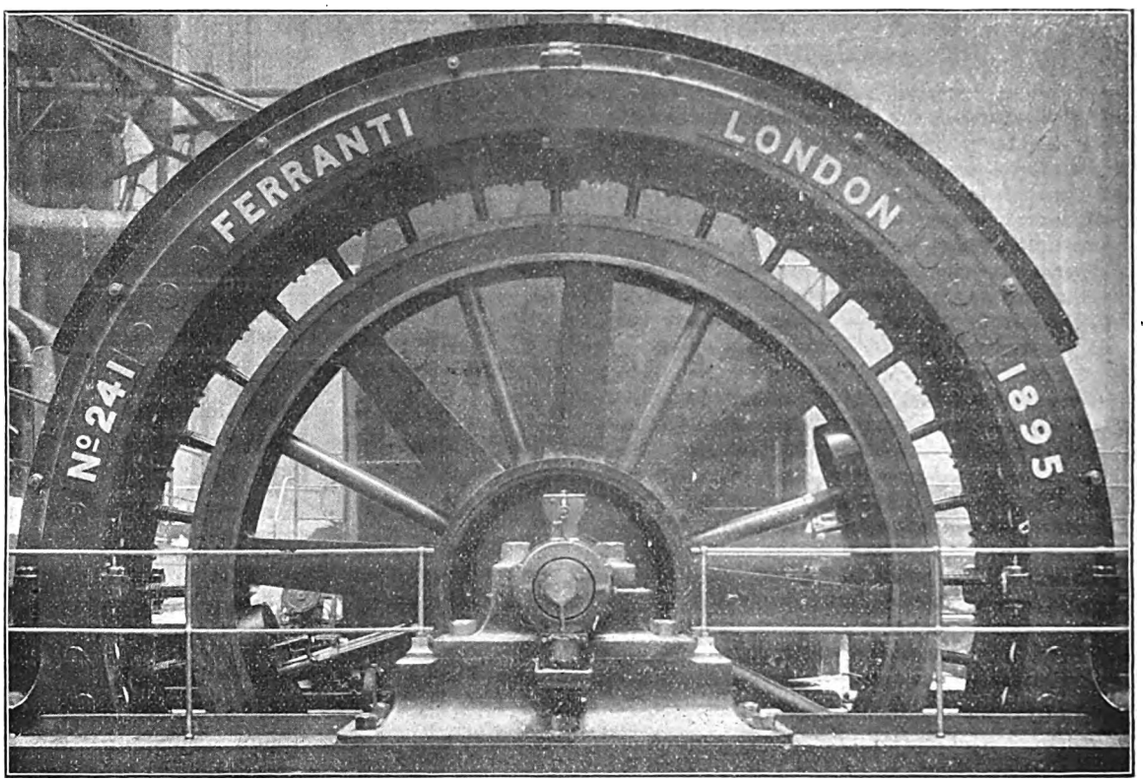

FIG. 1.—1,000-unit Flywheel Alternator at Deptford.

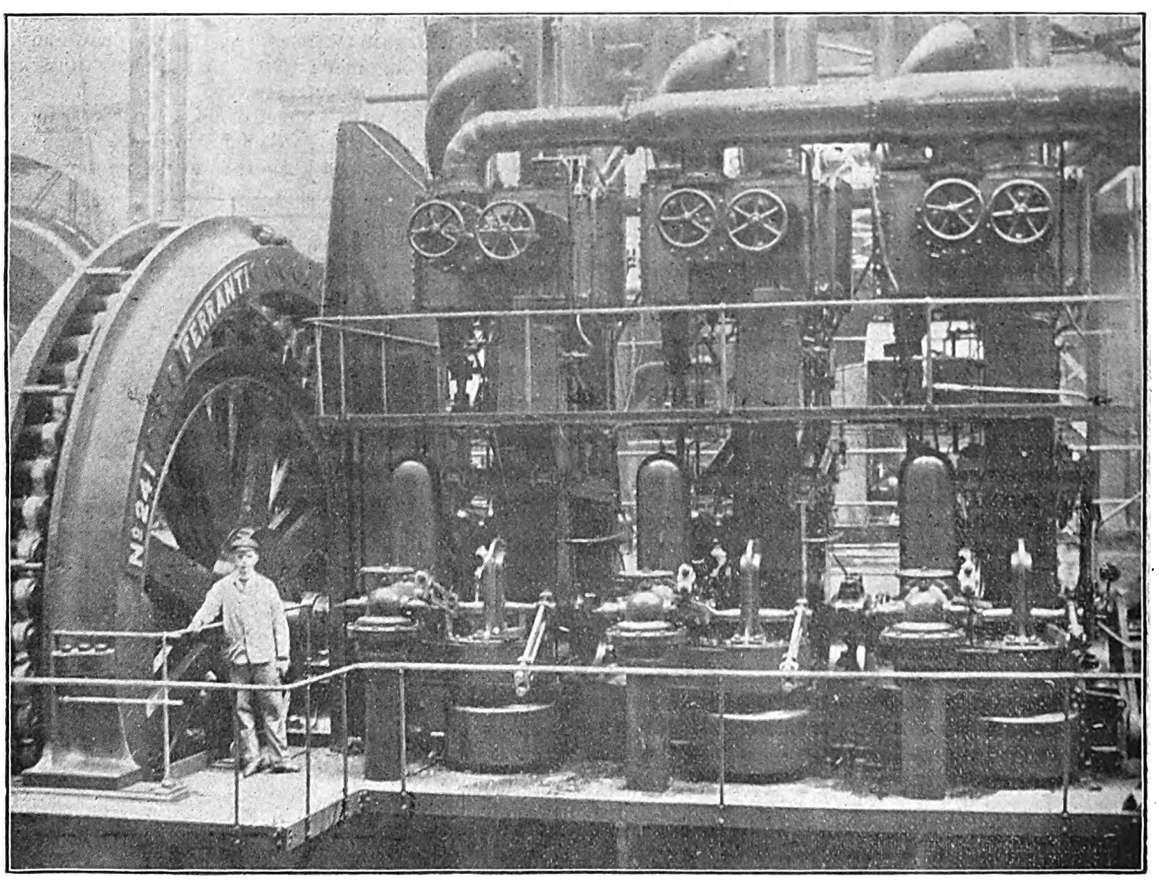

FIG. 2.—1,500-H.P. Steam Engine coupled to Flywheel Alternator at Deptford.

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per cent. of the output; and that the excitation should not be more than 2 per cent. of the output. As a matter of fact, the excitation is well within the limit, being 300 amperes at 50 volts.

Turning now to the engine, a view of which, with a portion of the alternator, is shown in Fig. 2: this is in reality three separate tandem compound engines driving three cranks on the same shaft. The three sections of the crank shaft are interchangeable, as are all similar parts of all three engines; so that the breakdown of any one engine need not long stop the set, as the other two can be run by themselves, the only delay being that necessitated by the disconnection of the damaged engine or the interchange of a broken crank section and a good one. Each engine is built to develop 500 I.H.P. with steam at 140lb. on the engine side of the stop valve, and running at 156 revolutions per minute. The steam pressure at Deptford is often 180lb., so there is ample reserve of power, and it is estimated that 2,000 I.H.P. will be available from the three engines. The stroke is 26in., and the diameters of the high and low-pressure cylinders are 17½in. and 36in. respectively. The steam is distributed to the high-pressure cylinder by piston valves, and to the low-pressure cylinder by a D-slide valve, all these valves having the same travel, and being carried by the same valve rod and eccentric gear. The weight of the valve gear is supported by the pressure of live steam on a piston in a small cylinder on the top of valve chest; and in the down travel steam acts on the top of this piston. Variation of cut-off in both cylinders is effected by varying the travel of the valves, which in turn is controlled by Joy's hydraulic valve gear. The action of this expansion gear consists in hydraulically shifting the position of the eccentric with respect to the shaft, the throw of the eccentric being varied between zero, or in-centre—when the cut-off would be close to the commencement of the stroke—and the full half-travel, when the latest cut-off of about five-eighth stroke would take place. The eccentric is continually pressed in-centrewards by means of steel springs, and outwards by means of water pumped through a 1in. hole passing through the crank shaft. The hydraulic pressure, and therefore the position of the eccentric, is regulated by means of a small centrifugal governor.

Each engine is provided with a separate jet condenser and air pump. The condensers are formed inside the back cast-iron columns which support the engines (these columns are seen in Fig. 2), and the air pumps are situated at the bases of the columns. Inside the condenser chamber the steam is indrawn from the top and meets the injection water, which is sprayed upwards from a nozzle at the bottom. Water from the adjacent Thames is used for injection, this water being carried into the condenser by the vacuum, and without an injection pump. The tank is filled by the river every high tide, and contains more than enough water to condense all the steam used in the station between tides. The ejection from the air pumps is conveyed direct to the river, only a small portion being returned to the reservoir at times when the water in the latter is liable to freeze. Occasionally, however, the particular engine set under consideration is run non-condensing, when the pump rods are disconnected from the beams, as shown in Fig. 2.

The Third Rail Patent in the United States.—"Answers have been filed," says the *Street Railway Review* of Chicago, "in the cases of Siemens and Halske Electric Company *v.* The Metropolitan West Side Elevated Railroad for infringement of third rail patents issued in July and August, 1885, to Ernest Werner Siemens, Nos. 322,859 and 324,176. The case is defended by the General Electric Company, and the answers were filed by defendants November 4th. They enumerate several hundred United States and foreign patents which were issued previous to those of Siemens, and which, it is claimed, cover the same grounds. The answer further claims that the use of the third rail was well known and had been applied in the art prior to the issuance of the patents to Siemens in 1885. As proof of this are cited numerous articles in the technical Press, and especially a Paper read before the Society of Arts by Alexander Siemens and Edward Hopkinson on the 'Portrush (Ireland) Electric Railway,' in April, 1883."

THE DESTRUCTION OF THE CROMPTON WORKS.

On Friday morning last a fire occurred at Messrs. Crompton and Co.'s works at Chelmsford, which resulted in the destruction of the greater portion of the premises. The Arc Works were of a somewhat peculiar nature, comprising, as they did, not only a manufacturing concern, but also a generating station of no mean order. This station, which was packed in between the shops, was the primary cause of the disaster.

One side of the station was open to a large erecting shop, and was separated by a wall from the tool shop on the south. On the east a main gangway through the works separated the engine room from the chief machine and fitting shops, above which were the armature shops. On the west a wall divides the station entirely from the portion of the works on that side. Adjoining is an erecting shop, over which is a large pattern stores. Beyond this are the lamp and switch shops. Above the engine room and tool shop were the copper and general stores respectively, and again above were the drawing and general offices. The dynamo stores adjoin the lamp shop. The lighting plant consisted of three Crompton-Brunton alternators of 80, 50 and 35 kilowatts respectively, and one Mordey-Victoria alternator of 100 kilowatts, and also three Crompton continuous-current generators. These machines were driven by four Willans engines, having a total indicated horse-power of 410, and were responsible for the lighting of the town of Chelmsford, both public and private, and for the driving of the shop motors in the works. A new main alternator switchboard had recently been erected in the engine room, near to but quite apart from the distributing board.

The outbreak occurred at about twenty minutes to nine, when most of the workmen were away at breakfast. An engine driver was sitting in front of the main board eating his own breakfast, when, smelling something burning, he hastily turned round and saw that the back of the board was on fire. He at once ran for a fire bucket, at the same time calling out for assistance. On returning, however, the smoke was so dense that he was unable to get near the flames, which had risen to the wooden rafters above. The men in the works at the time had got out the works hose, but within two or three minutes were driven away from the fire by the volumes of smoke. The continual blowing of the steam horn which summons the workmen after meals soon brought the staff and workmen to the scene; but nothing that was done could check the tremendous rush of the flames in all directions. In ten minutes the inside of the engine room was one roaring furnace, and the flames were shooting up into the air and licking the side walls of the stores, and above that of the drawing office. At half-past nine the whole block of buildings above and around the unfortunate generating plant was in flames—tool shop, general stores, copper stores, and general and drawing offices, also the machine shops, fitting shops and armature shops. The heavy wooden floors soaked with oil from the machinery burned furiously, and crash after crash resounded as one machine after another fell from above. At half-past ten roofs and floors had all gone through, and the fire brigade had difficulty in getting near enough to play well into the fire because of the great heat.

Among the first on the scene were Mr. S. L. Brunton, the works manager, and Mr. J. W. Rook, the head of the clerical staff, and very hard did these gentlemen, together with Mr. George Mason, Mr. W. P. Whitehead and others, work. Mr. J. P. Nelson, of the power department, Mr. E. A. N. Pochin, and Mr. H. J. Fereday were among the most active members of the staff. Mr. Crompton, who had been summoned from London, was unable to get down till about half-past eleven, by which time the place was entirely gutted. He was accompanied by Mr. W. A. Chamen, of the engineers' department. Mr. H. C. Hawkins was also hastily summoned from London. Fortunately the wind was calm, otherwise not a portion of the works could have been saved. By one o'clock the fire had almost burnt itself out, but all through the day several jets of water were playing on the smoking ruins. During the night the firemen were kept constantly at work,

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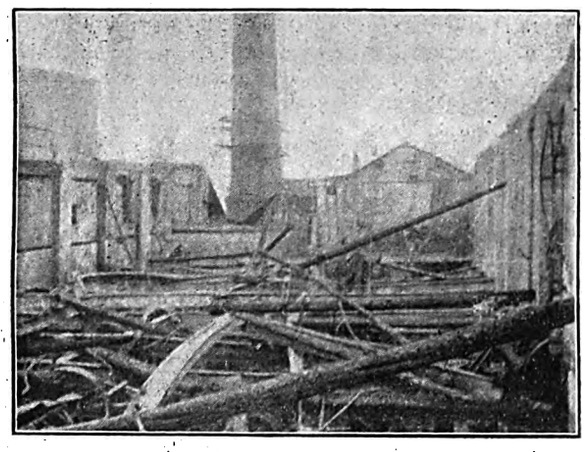
and they continued at work all through Saturday. On Tuesday portions of the wreckage were still smoking.

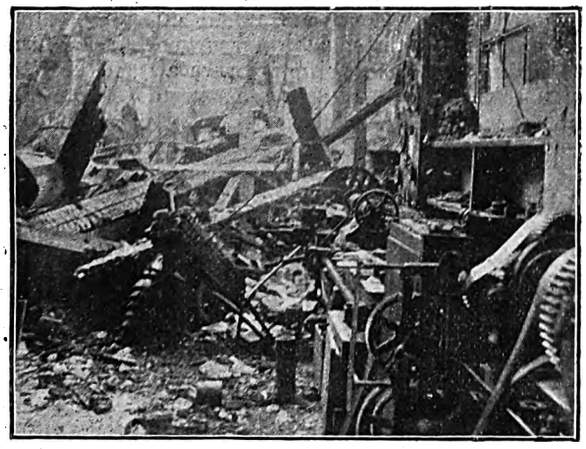
The damage wrought in the two or three short hours during which the fire lasted was almost incredible. Portions of the walls only remained standing, and these had all to be pulled down, so dangerous were they. In the engine room Willans engines were seen emerging from heaps of blackened rubbish. Lengths of copper rod, in twisted and fused masses, lay mixed up with bent girders, charred *débris*—representing chiefly the contents of the drawing office—and fallen brickwork. What was once the machine and fitting shop was, as will be seen by the accompanying views, a confused mass of lathes, planing machines, girders twisted into all shapes, broken castings,



Armature Shop. (1st floor).

remains of armatures, shafting, &c. The task of pulling down the remains of the walls was carried on through Sunday and Monday. The portions of the works saved include the dynamo and lamp stores, the switch and lamp shops, and the pattern stores. The carpenters' shop, the smithy and the boiler house being separate from the main block, also remained unhurt.

On Friday night Chelmsford was in darkness. The power department, however, got to work with a portable engine and a 400-volt Crompton arc-lighter, taken from stores, and which was run up to 700 volts on the emergency. On Saturday night every alternate arc lamp through the main thoroughfares was alight. By Tuesday night more than half of the incandescent public lighting was also in use.



Machine Shop. (Ground floor).

There is an obvious moral for general edification and warning to be drawn from this regrettable conflagration. But we are not disposed to draw it, at any rate just at present, preferring to-day to express our sympathy with a firm which is endeavouring so pluckily and so promptly to repair the consequences of a great disaster which has overtaken it at an unusually busy time.

THE BEHAVIOUR OF TRANSFORMERS UNDER THE INFLUENCE OF ALTERNATING CURRENTS OF DIFFERENT WAVE FORMS.*

BY DR. G. ROESSLER.

(Continued from page 126.)

After the foregoing explanation of the procedure for the interpretation of the readings of the measuring instruments, an example is given to show the accuracy which may be expected of the number of observations, and the method of tabulation.

Each of the values given in the results is the mean of a number of observations. The method of observation was so arranged that one observer took 10 readings of the wattmeter, while the other observer took as many observations as possible. Then, if a set of

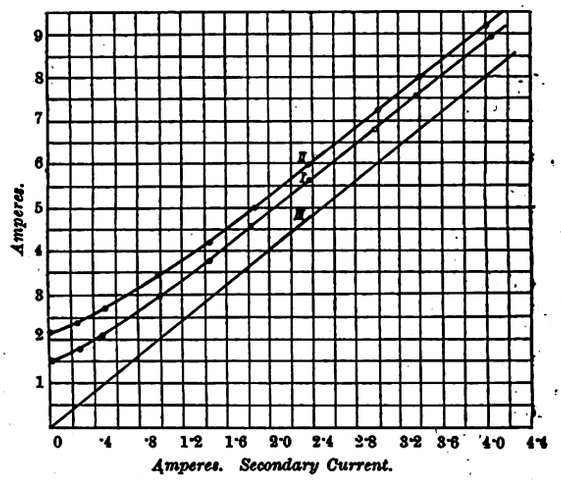


FIG. 7.—Primary Current. I. Ganz Machine. II. Wechsler Machine. III. 2 × Secondary Current.

speed observations showed no perceptible variation, the times occupied by the readings were very short, and varied little. Tables II. and III. give an example of a set of observations.

The lines denoted by similar figures in these two tables give the behaviour of the transformer under approximately-similar loads. A comparison of the values of the electrical quantities leads to the following important conclusion :—

For equal primary potential, and equal loading of the transformer, the primary current and power are smaller, and the efficiency is thereby greater, when the Ganz machine, with pointed potential curve, is used to supply the electrical power. The regulation of the secondary potential E_{p_2}, on the other hand, is better when the Wechsler machine, with approximately sinusoidal potential curve, feeds the transformer.

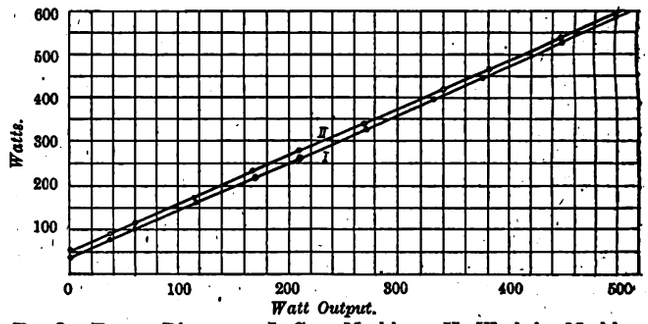


FIG. 8.—Energy Diagram. I. Ganz Machine. II. Wechsler Machine.

The differences in J_1 and A_1 are very great, especially for low loading of the transformer. As an illustration, the primary winding takes, with the Wechsler machine, one and a-half times as much energy, and one and a-half times as much current as with the Ganz machine. When one considers that a transformer in connection with a central station is, for the greater portion of the day, working at very low loads, these quantities become very important items in the working of the system, and we see that the form of the potential curve is of great significance in the economy of a transformer system.

* "Das Verhalten von Transformatoren unter den Einflusse von Wechselströmen verschiedenen periodischen Verlaufs." A Paper read at the third annual meeting of the Verband Deutscher Electrotechniker, Munich July 6, 1895.

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Table II.

Ep_1. Cardew voltmeter. $c=1{\cdot}0028$.	J_1. Current balance. $c=1{\cdot}00$.	A_1. Wattmeter. $c=0{\cdot}004536$. Shunt coil, 750 Ω.	Ep_2. Cardew voltmeter. $c=1{\cdot}083$.	J_2. Dynamometer. $c=0{\cdot}02590$.
60·3 60·6	528·0	158·8 360—203·5	102·6 103·0	145·0
60·5 60·6	529·0	161·0 —204·0	102·9 103·0	143·5
60·7 60·5	526·0	160·3 —204·5	103·3 103·0	146·1
60·6 60·6	526·1	160·4 —204·3	103·2 103·1	144·5
60·5 60·5	527·5	161·3 —204·2	103·0 103·1	145·6
60·5 60·6	528·0	158·13	102·9 103·2	144·5
60·54	527·5	A = 537·96 watts.	103·0 103·2	145·9
60·70 V	527·44	$\frac{Ep_1^2}{w}=\frac{60{\cdot}7^2}{227}=16{\cdot}2$ watts.	102·9 103·0	143·9
	J = 9·188 A.	$A_1=521{\cdot}8$ watts.	102·8 102·9	145·0
	$\left(\frac{Ep_1}{w}\right)^2=\left(\frac{60{\cdot}7}{227}\right)^2=0{\cdot}0716$.		102·9 103·1	144·4
	$\frac{2A}{w}=\frac{2537{\cdot}96}{227}=4{\cdot}740$.		103·01	146·0
	$J_1=8{\cdot}929$ A.		$Ep_2=111{\cdot}56$ V.	144·3
				144·89 = 3·753 A.
				$\frac{Ep_2}{w}=\frac{111{\cdot}56}{390}=0{\cdot}286$ A.
				$J_2=4{\cdot}039$ A.

These measurements give the following results :—

Table III.—*Behaviour of the Transformer under Different Loads.*

—	No.	Ep_1.	J_1.	Ep_1J_1.	A_1.	$F=\frac{A_1}{Ep_1J_1}$	Ep_2.	J_2.	$A_2=Ep_2J_2$.	$\eta=\frac{A_2}{A_1}$.	Ep_2'.
1. Measured with the Ganz machine.	1	60·5	1·474	89·3	35·1	0·393	...	0·0	0·0	0·0	...
	2	59·9	1·806	108·2	71·4	0·660	117·3	0·301	35·3	0·494	117·5
	3	59·9	2·141	128·3	99·1	0·772	116·8	0·510	59·5	0·607	117·0
	4	59·8	2·972	178·0	155·9	0·876	116·3	1·001	116·4	0·747	116·7
	5	60·7	3·805	231·0	210·1	0·910	116·4	1·444	168·1	0·800	115·0
	6	60·2	4·527	272·5	254·5	0·934	114·7	1·823	209·1	0·822	114·3
	7	60·3	5·582	336·6	321·2	0·954	114·6	2·356	270·0	0·841	114·0
	8	59·6	6·742	401·8	385·3	0·959	111·8	2·951	329·9	0·856	112·5
	9	60·3	7·603	458·5	438·0	0·955	111·9	3·382	378·4	0·864	111·3
	10	60·7	8·929	542·0	521·8	0·963	111·6	4·039	450·7	0·864	110·3
	11	60·1	...	...	578·8	...	108·9	4·588	499·7	0·863	108·7
2. Measured with the Wechsler machine.	1	60·1	2·104	126·5	55·2	0·421	...	0·0	0·0	0·0	...
	2	60·2	2·413	145·3	89·5	0·616	117·8	0·302	35·6	0·398	117·4
	3	59·4	2·673	158·8	113·1	0·712	116·3	0·517	60·2	0·532	117·4
	4	59·6	3·434	204·7	168·7	0·824	115·5	0·991	114·4	0·677	116·2
	5	60·1	4·228	254·1	224·6	0·884	115·6	1·433	165·6	0·737	115·4
	6	59·8	4·992	298·5	272·3	0·912	115·1	1·840	211·8	0·777	115·5
	7	60·0	5·960	357·6	334·7	0·936	114·6	2·352	269·6	0·806	114·6
	8	59·9	7·191	430·7	410·0	0·952	113·3	3·000	339·8	0·829	113·5
	9	60·0	7·986	479·2	457·5	0·955	112·6	3·393	382·1	0·835	112·6
	10	59·9	9·208	551·6	530·5	0·962	111·3	4·014	446·8	0·842	111·5
	11	60·1	...	...	604·6	...	110·4	4·652	513·5	0·849	110·2

Also, at higher transformer loads, there are great differences in the values J_1, A_1 and η, depending on the form of the potential curve. Fig. 7, which shows J_1 as a function of J_2, and Figs. 8 and

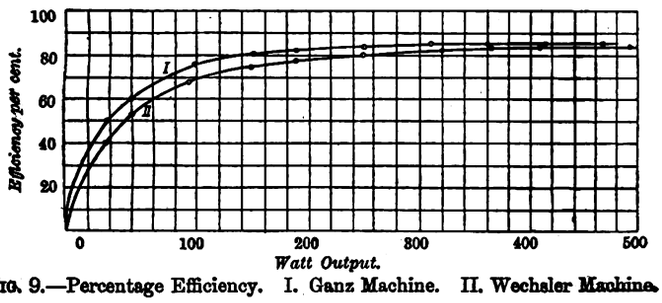

FIG. 9.—Percentage Efficiency. I. Ganz Machine. II. Wechsler Machine.

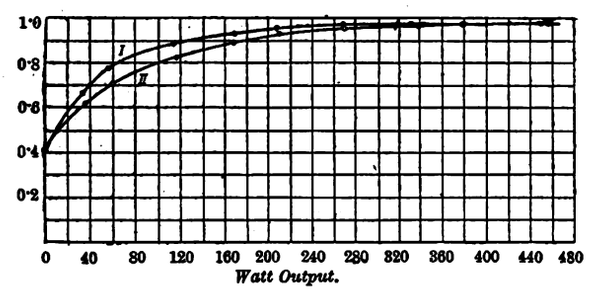

FIG. 10.—Power Factor. I. Ganz Machine. II. Wechsler Machine.

9, which give A_1 and η as functions of the load, show these differences more clearly. It is worthy of remark (Fig. 10) that the ratios of the power A_1 to the apparent power Ep_1J_1, for both sets of measurements, are not very different. If all the waves were sine curves, then $\frac{A_1}{Ep_1J_1}$ would be the cosine of the phase difference between the primary current and potential. In practice, the influence of the magnetic properties of the iron renders the current curve unsymmetrical, and the phase difference of the maximum points differ from that of the null points. The lag is therefore unknown, and the quantity $\frac{A_1}{Ep_1J_1}$ loses its geometrical signification. In practice, however, this quantity has a very important bearing in judging of the behaviour of a transformer; for calling $\frac{A_1}{Ep_1J_1}=F$, then $A_1=Ep_1(J_1F)$, the quantity J_1F being that portion of the current which is used in giving out power, while the power lost in the leads to the transformer depends on the *total* current. The quantity F has this meaning in the above table, and is called the "power factor." In consequence of the approximate equality of the values of F at high loads in both cases, where Ep is kept constant, the quotients $\frac{A_1}{J_1}$ are nearly equal. The values of A_1 and J_1 alone, however, are very different; hence the extra current taken by the transformer when run off the Wechsler machine, as compared with what it takes when run off the Ganz machine, is in much the same proportion as the extra power.

The values of the secondary potential Ep_2' occupy the last column in the table. These numbers are calculated from the observed values Ep_2 in the seventh column, on the assumption that Ep_2 varies an equal percentage, up or down, as Ep_1 varies from 60 volts; Ep_2' is thus the secondary potential which results when $Ep_1=60$ volts. For the open circuit measurements no reading was made of the secondary potential, since for this measurement the Cardew voltmeter had to be used, which took 0·3 ampere, which is an appreciable part of the normal load of the transformer. From the curves, Fig. 11, which graphically represents the drop of potential, it is seen that the secondary potential

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on open circuit would be 117·5 volts with both machines. From the ratio of the windings this value should be $E p_2' = 60 \frac{265}{132} = 120{\cdot}45$; thus the transformer on open circuit has a drop of 2·5 per cent. for magnetisation. At the normal load of 480 watts the potential with the Wechsler machine is 115·7 volts, whilst with the Ganz machine it is 114·5 volts. With the peaked potential curve $E p_2'$ is thus 1 per cent. smaller. When one considers that the potential drop at no load shows an exceedingly bad magnetic circuit, which increases also the drop at higher loads, and compares this defect with the great differences of the primary current and power at low loads, this objection to the peaked potential curve will appear of small consequence in comparison with its great advantages.

The great influence of the form of the wave on the efficiency of transformers, which is shown by the foregoing measurements, makes the choice of the curve form a matter of great importance. The results are admittedly only given for one transformer, yet

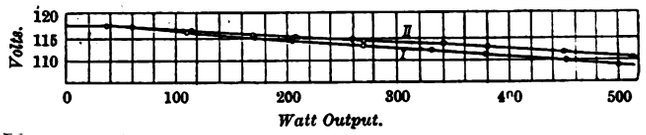

FIG. 11.—Secondary Voltage. I. Ganz Machine. II. Wechsler Machine.

their general applicability is manifestly justified if the differences found admit of a general explanation not depending on any peculiarities in the circumstances of the investigation under consideration. In order to get a clear idea of the foregoing facts, which have as their result a great difference in the behaviour of the transformer, I will now give the potential and current curves of both machines for no load, and for various loads on the transformer.

Shape of the Potential and Current Curves.

The fixed points of the curves were determined by the method brought before last year's meeting, by means of a contact apparatus fixed on the shaft of the alternator, which could be turned on the

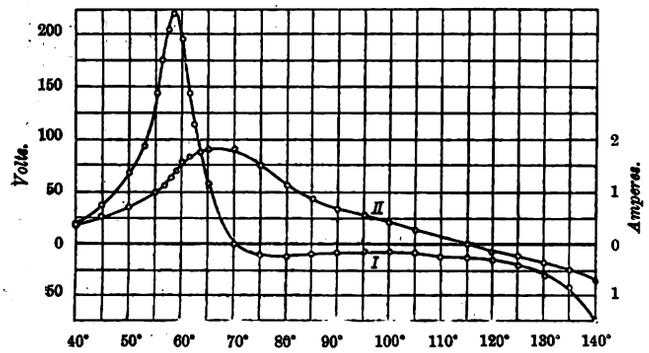

FIG. 12.—Ganz Machine. I. Primary Voltage. II. Primary Current.

shaft, and was connected in such a manner that, at each turn, it gave a momentary connection between the alternator terminal and a condenser, for different positions of the armature in the field. Through the uniform and rapidly-repeated (1,217 times per

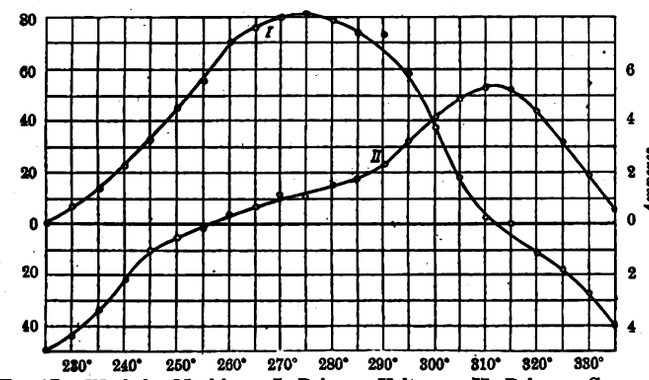

FIG. 13.—Wechsler Machine. I. Primary Voltage. II. Primary Current.

minute) charging of the condenser, it attains a constant potential, which can be measured directly by a Carpentier electrometer, idiostatically connected, or by discharging the condenser through a ballistic galvanometer. Since the alternator terminal is not always, but only for an exceedingly short part of each revolution, in contact with the condenser, there is a small amount of discharge between the successive contacts, and the mean potential difference on the condenser is smaller than the momentary potential difference on the transformer. This error was eliminated by considering the readings of the instrument as empirical, a known variable potential difference derived from a compensation apparatus of the Physikalisch-Technischen Reichsanstalt being introduced in place of the alternator. The variation of the current was determined by the variation of the potential difference across a known inductionless resistance. For the investigation of the current and potential curves at no load the electrometer only was used; for the loaded transformer the ballistic galvanometer was used for the two potential curves, and the electrometer for the current curves. Both instruments were connected alternately to the primary and secondary circuits by a switch. In each set of measurements the readings with the two instruments are taken one immediately after the other.

The results of these measurements are as follows:—

TABLE IV.—*Variation of the Primary Potential and the No-Load Current of the Transformer.*

Ganz machine.			Wechsler machine.		
Position of contact in grades.	E.	J.	Position of contact in grades.	E.	J.
40	+ 17·7	+0·34	225	+ 0·0	−4·94
45	+ 38·0	+0·49	230	+ 6·0	−4·40
50	+ 65·3	+0·66	235	+13·5	−3·45
52½	+ 93·0	...	240	+22·1	−2·16
55	+145·5	+1·01	245	+32·2	−1·00
56½	+175·0	+1·15	250	+45·0	−0·64
57½	+204·0	+1·24	255	+55·3	−0·24
58½	+219·0	+1·40	260	+70·0	+0·33
60	+195·0	+1·55	265	+75·3	+0·60
61½	+142·0	+1·66	270	+79·6	+1·16
62½	+114·4	+1·70	275	+81·1	+1·13
63½	+ 85·3	+1·75	280	+79·0	+1·56
65	+ 60·7	+1·80	285	+73·0	+1·77
70	0·0	+1·82	290	+73·0	+2·28
75	− 10·5	+1·49	295	+58·9	+3·13
80	− 11·5	+1·12	300	+37·5	+4·06
85	− 10·5	+0·85	305	+18·2	+4·92
90	− 8·5	+0·65	310	+ 2·0	+5·32
95	− 7·0	+0·53	315	0·0	+5·22
100	− 7·0	...	320	−11·0	+4·38
105	− 7·0	+0·23	325	−18·2	+3·16
110	− 10·0	+0·10	330	−27·6	+1·90
115	− 11·0	−0·03	335	−40·3	+0·55
120	− 14·5	−0·07	...	...	...
125	− 21·0	−0·25	...	...	...
130	− 30·0	−0·40	...	...	...
135	− 42·4	−0·53	...	...	...
140	− 79·8	−0·73	...	...	...

The potential and current curves given by these tables are shown in Figs. 12 and 13, for the Ganz and Wechsler machines respectively. From these figures it will be seen that the current curve differs widely from the potential curve in both machines. With the Ganz machine the potential curve is very pointed, the current curve very flat; with the Wechsler machine the potential is almost a sine curve, but the current curve is not so flat. These differences exhibit in an interesting manner the influence of the magnetic properties of the iron on the shape of the current curve. The relation between the current and potential is given by the equation

$$E p_1 = J_1 w_1 + n_1 \frac{d N}{d t},$$

where $E p_1$, J_1 and N are, respectively, the instantaneous values of the primary potential, current, and the magnetic flux cut by the coil, and w_1 and n_1 are the resistance and number of turns of the primary coil.

If H is an instantaneous value of the magnetising force due to the current J_1, B the resulting magnetic induction density, s the section of the iron core, and l the mean length of a line of force, we have the equations

$$H = 0{\cdot}4\pi \frac{n_1}{l} J_1$$

and

$$N = Bs.$$

Hence we get the equation

$$E p_1 = J_1 w_1 + n_1 s \frac{d B}{d H} \frac{d H}{d t}$$

$$= J_1 w_1 + 0{\cdot}4\pi \frac{n_1^2}{l} s \frac{d B}{d H} \frac{d J_1}{d t}.$$

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for all forms of the potential and current curves. If the permeability of the iron were constant we should have $\frac{dB}{dH}=\mu$ constant. But in practice $\frac{dB}{dH}$ is the trigonometrical tangent of the angle which a geometrical tangent to the hysteresis curve makes with the + direction of H; hence, for a given current J_1, the variation of Ep_1 depends greatly upon the hysteresis curve, and *vice versâ*. This influence of the hysteresis curve upon the shape of the curves Ep_1 and J_1 is clearly shown in Figs. 12 and 13.

If J_1 attains its maximum value, $\frac{dJ}{dt}=0$, and as $J_1 w_1$ is always very small Ep_1 has a very small value. The figures demonstrate this point. If, also, the alternator gives a very pointed potential curve, and very high maximum value, the maximum value of $\frac{dB}{dH}\frac{dJ_1}{dt}$ must be very great. But $\frac{dB}{dH}$ is independent of the alternate-current curve, and only depends on the hysteresis curve, hence the value of $\frac{dJ_1}{dt}$, which is simultaneous with the maximum value of the potential, must be greater with pointed curves than with flat. Simultaneously with the maximum value of the potential, for flat curves, there is a slower rise of current than in the case of peaked curves. It is thus evident why the current curve with the Wechsler machine, at the ordinate where Ep_1 is a maximum, is flat, and why J_{max} is sharper than Ep_{max}. These peculiarities of the current curve are always to be expected when the current-producing machine gives a sine potential difference. Simultaneous sinuous variations of Ep_1 and J_1 never exist; the form of the current curve is always very different from that of the corresponding potential curve.

In the present case there is a lag with the Ganz machine, between J_{max} and Ep_{max}, of about 11·5deg.; and between the null points of these curves a phase difference of 46deg. With the Wechsler machine, the maximum points and null points are 30deg. and 35deg. apart respectively. In general, for any potential curve, the magnitude of the lag is not greater. The phase difference cannot be given for the whole of the curves, but only for the characteristic points.

Planimetering the curves we have :—

Table V.

*With the Ganz Machine.**

$M(Ep_1)=36{\cdot}9$ V, $M(J_1)=0{\cdot}733$ A,

$\sqrt{M(Ep_1)^2}=62{\cdot}5$ V, $\sqrt{M(J_1^2)}=0{\cdot}938$ A,

$c=\frac{M(Ep_1)}{\sqrt{M(Ep_1^2)}}=0{\cdot}590$, $c=\frac{M(J_1)}{\sqrt{M(J_1^2)}}=0{\cdot}782$.

Also

$Ep_{1max}=219{\cdot}0$ V, $J_{max}=1{\cdot}82$ A,

$K=\frac{\sqrt{M(Ep_1^2)}}{Ep_{1max}}=0{\cdot}285$, $K=\frac{\sqrt{M(J_1^2)}}{J_{max}}=0{\cdot}515$.

With the Wechsler Machine.

$M(Ep_1)=45{\cdot}25$ V, $M(J_1)=2{\cdot}378$ A,

$\sqrt{M(Ep_1^2)}=53{\cdot}83$ V, $\sqrt{M(J_1^2)}=2{\cdot}922$ A,

$c=\frac{M(Ep_1)}{\sqrt{M(Ep_1^2)}}=0{\cdot}841$, $c=\frac{M(J_1)}{\sqrt{M(J_1^2)}}=0{\cdot}814$.

Also

$Ep_{1max}=81{\cdot}1$ V, $J_{max}=5{\cdot}35$ A,†

$K=\frac{\sqrt{M(Ep_1^2)}}{Ep_{1max}}=0{\cdot}663$, $K=\frac{\sqrt{M(J_1^2)}}{J_{max}}=0{\cdot}546$.

(To be continued.)

Superfluous Tracks.—The Street Railway Association of the State of New York has been asking itself the heart-searching question: "Are we laying too many miles of track to reach a few people?" It came to the conclusion that it is not, and found that the tramway lines are far more profitable than the trunk railway lines. The conditions favourable to the success of tramway enterprise were discussed, and the curious opinion given that "all parks and pleasure resorts introduced along existing lines, even though built at a considerable expense, if properly managed, will prove a booster to the net receipts of the lines."

* In this table $M(Ep_1)$ and $M(J_1)$ represent the simple mean of the varying values of Ep_1 and J_1. $\sqrt{M(Ep_1^2)}$ and $\sqrt{M(J_1^2)}$ are the R.M.S. values.

† Taken from the current curve in Fig. 13.

WHICH ELECTROLYTIC METHODS CAN BE USED WITH ADVANTAGE IN ANALYTICAL PRACTICE?*

BY DR. BERNHARD NEUMANN.

This article, which, through considerations of space, we have been unable to reproduce in full, contains much valuable information, and is so replete with references that it forms a veritable index to the literature of the subject.

The history of electrolysis is traced from the time of the elder Becquerel (1823) to the discovery of electroplating by Jacobi (1839), and it is shown how the experience gained by Messrs. Elkington, Ruolz and others in this work was turned to account to yield analytical tests for the presence in food of small quantities of certain metals (antimony, arsenic, copper, lead and mercury). These methods are in partial use to this day. The first notice with respect to the employment of the electric current for chemical analysis dates, however, from a much earlier period, and is found in the works of Davy in 1805. But the elder Becquerel must be considered the real father of electro-chemical analysis. He found out in 1830 a practical method for the separation of small quantities of lead and manganese from other metals. He separated these as a peroxide at the positive plate from acetic acid solution. In this way he separated iron from manganese. He showed further that 1 gramme of the manganese acetate could be completely separated in about 24 hours. The real experiments to introduce electrolytic methods as an assistance in practical quantitative analysis date only from the beginning of the '60's. Thus W. Gibbs in 1864 showed, after previous experiments, how the copper could be plated from a sulphuric acid solution of the coinage alloy of copper and nickel. At the end of the communication he mentioned that the nickel also can be separated by the current, and even from the same solution, by rendering it ammoniacal. In 1865 C. Lückow communicated his experiences with electrolytic separations to *Dingler's Journal*. Since that date a great number of most widely differing propositions for the quantitative estimation of metals are to be found scattered throughout the literature of the subject; but statements as to the applicability and usefulness of electrolytic, as compared with gravimetric and volumetric methods of analysis, are rather scarce. In May, 1867, the Mansfeld Ober-Bergund Hütten Company, at Eisleben, published a prize essay on the discovery of a copper test for the rapid determining of the metallic contents of the Mansfeld slates. At the same time an electrolytic method proposed by C. Lückow was distinguished by an award.

In order to discover the methods which are most suitable in practice, it is best first to answer the general questions: What is required of an electrolytic method in order that it may be employed with advantage in place of those ordinarily used in analysis, and what are the conditions under which electrolysis is specially applicable? It is only after these questions have been answered that one can proceed to consider which substances can be determined electrolytically, which are the particular methods which offer a real advantage over those ordinarily employed in analysis, and what these advantages are. The choice of an electrolytic in preference to a gravimetric or a volumetric method will be determined by considerations corresponding to those which would be taken into account in deciding which of the two latter forms of analysis to employ. There is no chemist who, out of love for the one kind of quantitative determination, would carry out all his analyses either only by the gravimetric or only by the volumetric method, for then time and accuracy could not be taken into account. A titration is generally quicker than a gravimetric method, but the latter is more often employed because of its superior accuracy. It is just the same with electrolysis. Out of the great number of proposed methods, a considerable number give, with the precautions directed, analytically useful results; but despite that, they are not suitable in practice. The chief advantage of electrolysis lies in the great simplicity of the whole manipulation, consisting as it does in first putting the electrodes into the liquid, regulating the conditions of the current, and at the end, after the separation has been accomplished, stopping the current, washing the one electrode in water and alcohol, and drying and weighing it. The whole operation takes up very little time. Besides that, in most cases the substance sought is weighed direct as metal, and so every calculation is avoided. A much greater advantage is that by the employment of two or three accumulators a whole series of analyses can be carried on at the same time without their interfering with each other. Electrolysis is, therefore, under certain circumstances, a very useful auxiliary in the laboratory of the analyst.

In the choice of electrolytic methods the factors time and accuracy naturally are the guides. The analyst as well as the works chemist must often require that their analytical methods should give accurate results in a given short time. Leaving time out of

* From *Zeitschrift für Elektrochemie*, 11, p. 231-234 (1895); 12, p. 252-260; 13, p. 269-272.

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consideration, it is always desirable that the electrolytic process employed should be one that can be watched throughout its whole course. Hence it arises that a great number of methods are not usable because they do not satisfy these requirements; such are all the processes which only yield "over-night" results whose duration lasts from 12 to 24 hours and more. Also all those in which a metal is separated from a solution in which it is contained in the form of a complex salt, especially as double salt of cyanide of potassium and pyrophosphates, and also from oxalates, tartrates and caustic potash or ammoniacal solutions. Take, for example, the separation of copper; we find solutions of neutral salts, with free nitric acid, sulphuric acid, ammonia, oxalate, tartrate, phosphate and cyanide of potassium solutions and others suggested. The time required for the deposition 0·25 Cu (= about 1 gramme $CuSO_4$) amounts to about 1½ to 2 hours for neutral, nitric acid, sulphuric acid, and oxalic acid solutions, with a current density of 1 ampere for 100 sq. cm. The deposition in the presence of ammonia requires only a very weak current, and is ended in 6 hours with 0·2 ampere. That from potassium cyanide and phosphoric acid solutions requires still longer. One of the first methods is therefore to be chosen. But it is not immaterial which. That method is always to be preferred which allows of the deposition of the metal from the solutions yielded direct in practice. Therefore the choice falls on the nitric acid and sulphuric acid methods. Moreover, in the case of the nitric acid, sulphuric acid and neutral solutions (when the neutral salt is copper sulphate), electrolysis can be left to itself; whilst in the case of the oxalic acid bath constant attention is required, since the continued addition of oxalic acid is necessary if the metal is to be deposited in a usable form. The quantity of metal which can be separated in an adherent form, and the character of the deposit, must also be considered, since, unless the latter is metallic, bright and shiny loss is apt to occur in washing and drying it. A method to be useful must also allow of variations in the current strength within certain limits. The conditions of electrolysis are such that by its means at least as accurate results could be obtained as by any other analytical method, but that the current does not always act on the metal required alone. Attempts have been made to obtain separations of the metals by varying the conditions of electrolysis; for instance, lead and copper have been separated, the former being deposited on the anode as peroxide, while the latter metal goes to the cathode. Also, by the addition of strong mineral acid, the deposition of iron, &c., has been prevented, thus separating them from the noble metals. Freudenberg has also shown that by paying attention to the voltage a large number of separations can be effected, since the metal with the lowest decomposition potential is deposited first. In practice, only the separations of the first kind and some of the second are suitable, the others requiring too much time; but it has been established by experience that it is generally better only to use electrolysis in the case of pure or almost pure solutions which have been obtained by ordinary chemical methods. The constituent parts of an alloy can all be determined by electrolysis as an exercise, but that is not sufficient for the practical analyst.

Before discussing particular methods it is necessary to remember that substances are separated at both electrodes. At the cathode hydrogen and the metals are separated, of which only the latter are used for analytical purposes. At the anode oxygen, halogens, sulphuric and carbonic acids, and other substances are freed, of which only the two first are of any use for analysis. Now, while the employment of peroxide dates from the '30's, the endeavour to make the halogens appearing at the anode analytically valuable is still rather recent. Kinnicutt and Whitefield (1887) had published indirect methods for their estimation; but Vortmann (1894) has shown that the halogens can be quantitatively determined if their separation takes place at a silver anode—that is to say, at an anode which can combine with them. Both electrodes must be weighed, since some silver goes into solution at the anode, and is deposited at the cathode. In a similar manner the author has separated fluorine from a soluble fluorine salt, using an aluminium electrode. Experiments are still in progress, but the method can never have more than a theoretical value, since the quantity of the halogen which can be fixed is limited by the surface of the anode, and also because an electrolytic separation of the different halogens is not possible. A whole series of metals (silver, bismuth, manganese, lead, thallium, cobalt and nickel) separate at the anode as peroxides, but the majority of them are also simultaneously deposited at the cathode, so that only lead and manganese can be estimated practically as peroxides.

Manganese.—This metal separates out from solutions of neutral salts, or solutions acidified with sulphuric, nitric, and acetic acids. The formation of peroxide takes place best in the presence of free acid, but if there is more than 3 per cent. of nitric acid, permanganic acid is formed and there is no deposit. Classen recommends the acetic acid solution which had already been used by A. Becquerel in 1830. But as even by this method only 0·15 gramme manganese can be deposited under the best conditions, and doubt exists as to the exact nature of the deposit, electrolysis is not satisfactory for the determination of this metal.

Lead can be deposited either in the metallic state at the cathode, or as peroxide at the anode; but it is only in the latter form that it can be estimated accurately. The separation takes place best from a nitric acid solution which Lückow showed in 1865 must contain not less than 10 per cent. free acid if all the lead is to be separated as peroxide. The deposit may contain traces of bismuth and silver, but Lückow states that in a 15 per cent. solution of nitric acid, to which a few drops of oxalic acid have been added, no silver goes to the anode. The best current density is from 1 to 2 amperes per 100 sq. cm., with a potential difference of from 2·3 to 2·7 volts, and the temperature should not exceed 60°C. to 70°C., for the peroxide is apt to fall off. The peroxide contains water, and according to Classen drying at 130deg. is not sufficient, but a temperature of 180deg. to 190deg. is required.

Iron.—A large number of solutions for the electrolytic separation of iron have been proposed, but they none of them yield as accurate results as can be obtained by the ordinary analytical methods. Electrolysis, however, is useful as a means of obtaining pure iron for standardising purposes.

Cadmium.—This metal is an exception to the general rule that metals which are precipitated by hydrogen sulphide in acid solutions can also be deposited electrolytically from such solutions. It belongs electrolytically to the series of metals which have a greater ionising tendency than oxygen, and hence it follows that it cannot be deposited in strongly acid solutions. Lückow has found that 1 to 2 per cent. of free sulphuric acid is the utmost limit permissible, and that with most of the solutions proposed it was only with the greatest difficulty that a bright, silvery deposit could be obtained, as it has a great tendency to come down in a spongy form. The amount of the metal which can be deposited (0·15 gramme) is too small to be useful for purposes of analysis. From caustic potash solutions the cadmium separates better, but the time required is very long, only 0·08 to 0·09 gramme being deposited per hour. It is not practically possible to separate cadmium electrolytically from other metals, and therefore ordinary chemical means must be resorted to, and the cadmium sulphide thus obtained can be more easily estimated gravimetrically than by electrolysis.

Cobalt and Nickel.—The conditions for the successful electrolysis of these two metals are so similar that they may be considered together. Both metals separate imperfectly from solutions of their neutral salts, but the addition of a little acetic or other acid remedies this; excess of acid prevents the deposition. The simplest method, and the only one used in practice, is that introduced by W. Gibbs in 1864, which consists in supersaturating with ammonia their sulphuric acid solutions. Schweder, who used this method in the analysis of ores and coinage, recommends the addition of a great excess of ammonia in order to prevent the separation of peroxide. Fresenius and Bergmann find that the best conditions are obtained with a solution containing 0·1 to 0·15 gramme nickel as sulphate, 6 to 9 grammes ammonium sulphate, and a minimum of 2·5 to 4 grammes ammonia. The proportion of ammonium sulphate need not be accurately maintained, but the ammonia must be in excess throughout the whole operation, although too great a quantity retards the separation. The same applies to cobalt. The author has got good results from a solution containing ten times as much nickel as that given above, and Winkler, who used the electrolytic method for obtaining pure cobalt and nickel for the purpose of determining their atomic weights, has also found that the proportion of nickel may be increased without detriment. The best current density to employ is 0·5 to 1·5 amperes per 100 sq. cm. at a pressure of 2·8 to 3·3 volts at the ordinary temperature. Experiment has shown that two hours is sufficient to deposit all the nickel from 1 gramme of ordinarily rich ore or alloy. The Mansfeld Ober-Bergund Hüttendirektion employ a solution of nickel chloride and ammonia, but find that an excess of ammonium chloride or of nitrates disturbs the results, and this is confirmed by Wrightson. The advantage of the electrolytic determination of nickel is that in alloys, and ores which have been dissolved in acid, all metals, except iron, cobalt, nickel, zinc, manganese and aluminium, can be separated by electrolysis, or precipitated by hydrogen sulphide. The electrolytic determination of nickel is one of the methods which can be used with real advantage, and is much to be preferred to the gravimetric methods of analysis, where only small quantities of nickel are concerned.

Zinc is another metal which cannot be deposited in strongly acid solutions. In solutions of neutral salts it comes down in a spongy form. But the addition of sodium acetate or of a small quantity of free acid, such as acetic, remedies this. Solutions of ammonium acetate, ammonium oxalate and cyanide of potassium also give good results. The zinc deposit on the cathode appears to alloy with the platinum, and is only removed with difficulty; therefore it is advisable to first plate that electrode with silver or copper. Even with the best methods the deposition is slow, 0·15 to 0·2 gramme being deposited in about two hours, with a current density of 1 to 1·5 ampere. As in the case of iron, nickel and cobalt, the last traces of zinc are only removed from the solution with

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difficulty, and a current density of at least 1 ampere must be maintained to the end. A portion at least of the failures in the electrolysis of zinc are due to a neglect of this precaution. As the electrolytic determination of zinc is slow and attended with difficulty, it cannot compete with ordinary analytical methods, since the zinc must first be separated from other metals by chemical means.

Gold.—This metal can be easily plated out from a neutral solution of its chlorine, and from solutions of various of its salts. But electrolysis cannot be employed in analysis, since the gold is apt to be deposited in a powdery form, and as the weight of the electrode is large compared to that of the gold, the results are not accurate. Before electrolysis also the gold must first be separated chemically from silver, copper and bismuth.

Bismuth.—Electrolysis of its solutions yield either the metal, or mixtures of the metal and peroxide, according to their nature. The latter are yielded by solutions of the neutral salts, and by those containing free nitric acid. From sulphuric acid, oxalic acid, and some other solutions the metal alone is obtained at the cathode, but as it is nearly always deposited in a black and powdery form, the electrolytic method of determination is not suitable for analytical purposes.

Arsenic.—This metal cannot be deposited at all from acid solutions, and only imperfectly from neutral ones.

Silver.—As in the case of bismuth, the electrolysis of many silver solutions yields the metal at the cathode, and peroxide at the anode. With nitric acid solutions the formation of peroxide ceases on greatly diluting them, and employing a very weak current. The cyanide bath yields good results with a current of 0·02 to 0·05 ampere per 100 sq. cm. and a potential difference of 3·5 to 4·5 volt, at the usual temperature. Unless, however, the silver has been freed from copper, gold, mercury, cadmium and other metals, they are deposited with it if the potential difference is not kept below 1·7 to 1·8 volts, at which voltage the rate of deposition becomes so slow as to be useless for practical purposes. Since pure silver solutions rarely require to be examined, the ordinary dry and wet methods give quicker results than the electrolytic.

Mercury.—The separation of mercury from other metals is possible (in nitric acid and cyanide of potassium solutions), but only under the conditions which obtain in the case of silver. For the determination of mercury in ores containing other metals Rose's dry method is preferable. But for the estimation of mercury in pure ores electrolysis in chloride or sulphate of sodium solutions can be advantageously employed. The latter method is in practical use in the case of cinnabar at Almaden, in Spain.

Copper.—An electrolysis for its determination was first used by Gibbs in 1864, as has already been mentioned, and at the same time it was also employed by Lückow in the estimation of the amount of copper in the fireboxes of locomotives, who found that the quantity of free acid present should not exceed 8 per cent. Various solutions have been suggested, but only the nitric and sulphuric acid are employed in practice. In this way the copper is freed from iron, cobalt, nickel, cadmium, zinc and manganese, which cannot be deposited from strongly acid solutions, but large quantities of iron act prejudicially. Lead in nitric acid solutions is deposited on the anode as peroxide, but any silver, bismuth, mercury, arsenic, antimony and tin which may be present, go to the cathode with the copper. Arsenic, antimony and tin only come down after the bulk of the copper has been deposited, but no complete separation can be effected in this way. Freudenberg states that an electrolytic separation can be made if the voltage does not exceed 1·2 to 1·3 to 1·9 volts. But this method is more applicable to the preparation of pure metal than to commercial purposes. Copper can be easily separated from all other metals by chemical means, but as in most cases only a few are present, the electrolytic method can almost always be used with advantage, and the results obtained are as accurate as those yielded by other analytical processes. The best conditions of electrolysis for a copper solution containing 8 to 10 per cent. free nitric acid are a current density of 1 to 2 amperes per 100 sq. cm., at a potential difference of 2·2 to 2·7 volts, the temperature being 50°C. to 60°C. The current density, however, may rise to over 3 amperes without injuring the character of the deposit, but the amount of copper deposited does not increase proportionally to the increase of current. The same conditions apply to sulphuric acid solutions containing 3 per cent. free acid.

Antimony.—For the electrolytic determination of this metal a solution of the sulphate in sodium sulphide is recommended. For a solution containing 50 to 70 per cent. of a cold, saturated solution of sodium sulphide, the best conditions are a current density of 1 to 2 amperes per 100 sq. cm., at a potential difference of 1·3 to 3 volts. The electrolysis can be effected at the ordinary temperature, but is shortened by raising it. Thus 0·3 to 0·4 gramme antimony can be deposited in 1½ to 2 hours, at a temperature of 80°C.

Tin.—This metal can be plated out of various solutions, but the only one used in practice is the ammonium sulphide. The electrolytic method is particularly suitable for the separation of the antimony-arsenic-tin group. The solution containing these three metals is first freed from arsenic by means of ammonium carbonate, and then the antimony is plated out as described above; 20 to 25 grammes ammonium sulphide are added, and the solution boiled 10 to 15 minutes, and electrolysed when cold. The best conditions are a current density of 1 to 2 amperes, with a potential difference of 3·3 to 4 volts, and, as in the case of antimony, the deposition takes place more quickly at a higher, though the metal plates out well at the ordinary, temperature. The electrolytic method of analysis is very useful in many cases. On reviewing the electrolytic methods, it appears that many of them offer real advantages over those usually employed. This is more especially so in the case of lead, copper, nickel, and antimony, but on the other hand there are metals, such as iron and manganese, for which they are unsuitable, and in the case of the other metals circumstances will decide what method to adopt. Nissenson's and Rust's reports on the analyses carried out in the laboratory of the Stolberg Company in 1892 show the aid which can be given to the analyst by electrolysis. Experience has proved that accumulators are by far the most useful source of current for electrolytic determinations, and they may be charged by means of a thermopile if the necessary power to drive a dynamo is not available. No form of primary battery gives satisfactory results, and if accumulators cannot be employed, a Gulcher thermopile is recommended. Platinum is the only material to be used for the electrodes; platinised tin is not durable. Various forms of electrodes have been recommended, but in practice only two are found, and the selection between these may be left to the analyst. One sort consists of a cylinder of platinum foil as cathode, split up at the side and open at the top, whilst the anode consists of a cylindrical spiral of platinum wire contained within the cathode. The electrodes are immersed in a beaker which contains the solution to be electrolysed. The openings allow of the metal being deposited on both sides of the cathode, and facilitate its removal. In the second typical form of apparatus the cathode takes the shape of a bowl which contains the electrolyte, whilst the anode is a piece of platinum curved to the shape of the bottom of the bowl. This latter form of apparatus is objected to by some on the ground that, on the stoppage of the current, the cathode cannot be freed from the electrolyte and washed as rapidly as can the cylindrical cathode; but experiment shows that in skilled hands the inaccuracy caused by this delay is inappreciable. In conclusion, the author states that the reason that electrolysis has not found as universal admission to the laboratory of the analyst as it deserves, is owing to the fact that the selection of useful methods from the many proposed is a matter of difficulty and causes waste of time, and that the unpleasantness and difficulty of management of the primary batteries formerly used did not encourage experiment. The analyst, however, who has once availed himself of the aid of electrolysis, either by the employment of accumulators or of the thermopile, will not again willingly do without it.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

SATURDAY, November 30th.

ROYAL SOCIETY.

4 p.m. Anniversary Meeting.

THE ELECTRO-HARMONIC SOCIETY.

8 p.m. Concert (Ladies' Night) at the St. James's Hall Restaurant (Banquet Room), Regent-street, W.

MONDAY, December 2nd.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture: "Mechanical Road Carriages," by W. Worby Beaumont.

SOCIETY OF CHEMICAL INDUSTRY.

8 p.m. Meeting of the London Section at Burlington House. Paper to be read: "Alkali Manufacture by the Hargreaves-Bird System of Electrolysis," by J. Hargreaves.

TUESDAY, December 3rd.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Papers to be read: (1) "The Influence of Carbon on Iron," by John Oliver Arnold; (2) "The Dilatation, Annealing and Welding of Iron and Steel," by Thomas Wrightson.

WEDNESDAY, December 4th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Mural Painting with the Aid of Metallic Oxides and Soluble Silicates," by Mrs. Anna Lea-Merritt and Prof. W. C. Roberts-Austen.

FRIDAY, December 6th.

INSTITUTION OF JUNIOR ENGINEERS.

8 p.m. Meeting at the Westminster Palace Hotel. Paper to be read: "Considerations with respect to Water, Gas, and Electric Mains, &c., in connection with the Formation of Urban Roads and Footways," by J. Julian.

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INJUNCTIONS.

We have previously had occasion to comment upon the effect of certain legal decisions which have pressed severely upon electric lighting undertakings, and to discuss the principles which we have always understood to govern such cases. Central stations have frequently been threatened with injunction for nuisance alleged to be caused by their operations carried on in pursuance of statutory powers, but which powers were found to be an inadequate protection against this terrible engine of the law. In some cases the unlucky offenders have been able to escape on payment of a pecuniary ransom; in others the injunction has been granted absolutely or conditionally, thereby paralysing the station operations, or only permitting them a precarious existence with a threatening sword hanging overhead. We are not surprised, therefore, that under such circumstances electric lighting undertakers should have become restive, and should display extreme anxiety to escape from so uncomfortable a position. They say, and no doubt with truth, that they are made a mark for speculative actions, and are looked upon by neighbours who have small interests but great expectations as fair game out of which to make profit by threats of legal penalties, and they ask such protection for their works as is necessary to enable them to carry out their statutory obligations. These feelings found expression at a meeting held last week under the auspices of the City of London Electric Lighting Company, who have themselves passed under the harrow. The proceedings at this meeting were of a more or less private nature, but as we stated last week the meeting was attended by representatives of a good many Electric Lighting Companies and Local Authorities, both metropolitan and provincial, and we were informed that a suggestion was approved that a deputation should wait on the Board of Trade on the subject of the unworkable clause or clauses in the Electric Lighting Acts, which are described as enabling an individual to obtain an injunction to stop electric lighting works. As we do not

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know all that passed at this meeting, nor the actual terms of the resolution adopted, we have no desire to criticise the language of the communication made to us; but as it accords very much with expressions we have heard elsewhere we should like to point out what appears to us to be a misunderstanding going very much to the root of the whole matter.

There seems to be an impression that the Electric Lighting Acts impose some liabilities or restrictions which have not been imposed upon the undertakers of other similar schemes, and that the omission or amendment of certain restrictive clauses is all that is necessary to secure the immunity which is desired. But the fact is that in order to secure such immunity, positive legislation would be required of an entirely novel character. It is true that Parliament habitually grants to railway companies and others power to compulsorily take lands which are clearly defined by the grant, and to do thereon acts which would otherwise constitute a nuisance liable to be restrained by injunction. In these cases, however, ample notices have to be given before the Bill is brought in, and persons whose rights are affected have an opportunity of being heard in opposition; but Parliament has, so far as we are aware, never granted, and we should doubt if it ever will grant, to anyone a roving commission, enabling the holders thereof to set up works for the purposes of their undertaking upon any piece of land which they may be able to acquire by purchase, and thereby to cause a nuisance to the surrounding neighbourhood, which has had no opportunity of expressing an opinion on the subject. It is no answer to say that compensation will be paid for any injury proved to be done. The very existence of the weapon of injunction shows that the law clearly recognises the fact that there are many injuries for which it is difficult to assess compensation, and some for which no pecuniary payment could compensate. The grant of such powers would therefore undoubtedly curtail the proprietary rights of individuals, and Parliament before ordaining any such curtailment has always hitherto required satisfactory proof, not only that the act to be done is for the public benefit, but that the site selected for the commission of this act is the most suitable one for the purpose, and that its selection is likely to entail the minimum of inconvenience to the public or individuals. There would be no such safeguards if this fundamental rule were relaxed, and although we should gladly see electric lighting undertakings relieved from such oppressive litigation as may sometimes savour of the nature of blackmail, we should hesitate before advocating a remedy which would secure such immunity at the cost of injustice to individuals, and not least because of the doubt we entertain whether it would prove to ultimately advance electric lighting interests.

The object of the Electric Lighting Acts was to afford undertakers facilities to lay their mains in streets, and generally to carry on their business so far as they might be able to do so without interfering with rights of property. Compulsory powers to acquire or diminish such rights were expressly withheld, because Parliament in this as in all other similar cases deemed that such powers could not be justly granted by a general Act, but that each case must be separately considered. It was assumed that undertakers might be able to find a site, as in many cases they do in fact, where the carrying on of their business would not be open to any objection, whether public or private. If in any instance this should prove impossible, it is open to them to apply by Bill in the usual way for compulsory powers, when a committee will decide whether a case has been made out for such a grant, after considering any objections that may be brought to their notice. Everyone, however, who seeks power to take away compulsorily the property of his neighbours, whether such property be land or only peace and comfort, must pass through the same narrow entrance, over which is written, "Every case on its own merits." There is no royal road to be sought for by a general enactment.

We can imagine that our good friends the gas companies will smile at what they may regard as the frantic struggles of their less experienced *confrères* to get free from the trammels of the law, which others have found long ago were not to be broken through. They will tell us that they too have gone through the mill, and have found their way out without resorting to any heroic remedy. They can point to the annals of the Courts which record injunctions against some of their fraternity, granted at the instance of neighbours who had the bad taste to dislike gasworks fumes quite as strongly as people in these later days abhor the rhythmic thud of engines and the soothing hum of dynamos. They have got over these troubles mostly by evincing a becomingly retiring disposition and settling their works at spots which, if not exactly solitudes, are inhabited chiefly by their own workpeople, and they will perhaps say that their competitors for public favour might find the same way out of *their* difficulties. The Board of Trade may give some help indirectly towards this desirable consummation in their forthcoming revised rules, by a new definition of "low pressure," but we hardly expect that if the proposed deputation should ever reach the Board it will be encouraged to hope for positive legislation in the direction they desire. We fear that so long as central station chimneys are found in close proximity to the residences or business premises of the wealthy, they will have to pay somewhat heavily for the luxury of their aristocratic associations. Meanwhile, who can withhold sincere sympathy from electric light concerns which are under statutory obligations to maintain the supply, but which nevertheless may at any moment have the misfortune to unearth a hard-hearted judge who will issue an immediate injunction at the instance of an angry suitor? Hitherto the wind has been tempered to the shorn lamb by the distinct disinclination of the Courts to allow injunctions to actually issue; and on this chance support we fear that electrical undertakers will have perforce to rely until electric lighting stations become eccentric in position instead of eccentric in behaviour.

REVIEWS.

The People of the Moon. By TREMLETT CARTER. (London: "The Electrician" Printing and Publishing Company.)

Before we had read a word of this book, we saw that it would present great attractions to the boy mind. Its title would attract much, its cover more, and its illustrations most of all. There is a suggestion of strangeness and horror about these last which causes a delicious thrill before ever the tale is begun.

The story itself is of the Jules Verne type, but the author has been at some pains to make his science as nearly accurate as may be, considering that most of it depends on a vivid imagination. Whether or not, for instance, it would be possible for persons to be changed into ether, transported through space, and re-embodied when they had reached their destination, is open to doubt—it is not a mode of travelling that we should care personally to try—but it seems pretty certain that if it *were* possible, our feelings would quite answer to the description of Mallâla's when he went to Tella by the lightning transmitter. "He felt an almost insupportable sensation of being torn limb from limb, and as if his entire body was undergoing dissolution.'

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The desire for consistency in scientific foreshadowings has led to rather too many explanations, but the ordinary boy will probably imitate the example of Imberto's magnificent air ships, and, when he sees an avalanche of rocky scientific terms, he will swiftly avoid the obstacle and steer his previous delightful course. He will travel through a strange country indeed, and among an almost bewildering variety of marvels; he will meet with a metal that repels matter instead of attracting it, a viaduct with no visible means of support, a granite-boulder-eating dragon, grapes made from the ether, "annihilators" capable of destroying a whole town at one fell swoop, gemmating giants, and the lightning transmitter already alluded to.

It appears that the present inhabitants of the moon, or Oolaâla, as they call it, live, not on its surface, but in the interior, in a series of huge rocky caverns and tunnels. It is true that there were two races of beings on the surface when this veracious history was begun, but one of these killed off the other, and was in its turn destroyed by a sort of moon-quake, if we may coin the word, so that we should now search in vain for any traces of either.

Indra, Prince of Sarâva, the kingdom of the interior of the moon, started off on an expedition to the surface, the very existence of which was denied in Sarâva, in search of a lady with whom he had fallen in love in a vision. On his arrival, after a series of most thrilling adventures, he was accidentally precipitated into space, with a whole inverted basin full of zukâra—the metal that repels matter—in the cage with him, and next to no matter of the usual heavy sort to counteract it. The result was unpleasant. When he awoke from the swoon into which he had fallen, he found himself literally "All among the little stars, sailing round the moon." His sensations when he discovered himself to be some hundred thousand miles or so away from the Oolaâla are very graphically described; but the part that gave us the most deliciously horrible thrills, as of cold water running down one's back, was the description of his leap from his cage through the final six thousand miles that separated him from the moon. To fall alone through silence and darkness, for seven days and seven nights—what a gruesome conception!

Among them, the people of the moon seem to have carried scientific research and invention to a pitch at which we poor earth mortals can hardly hope to arrive in the course of another thousand years or so. Indeed, one race became extinct before this story was written, by reason of the very perfection of its mechanical devices; for it had reduced life to such a complete system of button-pressing that its members grew too weak and lazy to take care of themselves, and were all carried off one fine day and immolated on a mountain top by a race of giants—an awful warning to such as would trust too implicitly to the devices of inventors.

There is one power which we confess we envy the Sarâva more than any other—that is the power to enjoy a lightning bath. We are told of the "ineffable enchantment of a plunge into such a perfect electric torrent as was now raging." "Into their very lungs they breathed the vitalising and energising electric force; and as the tingling action thrilled through their frames, they felt themselves renewed in the strength and elasticity of both mind and body."

We hardly like to point out literary blunders in so lively a book; yet there are certain expressions against which we feel bound to wage war. The phrases "who it belonged to," "it might result in exactly the opposite of the user's intention taking place," "to stand steadily to their ground," are not elegant, while the word "contraption" is new to us. Is it straight from Indra's book, and untranslatable? The pleasantly vague word "infinite" is rather too plentifully scattered over the whole book, and it seems misleading to say "Tantalus himself could not have devised anything more irritating." Tantalus, poor fellow, was the last person to devise things irritating; it was the gods who devised the irritating fruits and water for Tantalus, because he revealed their secrets. But we do not wish to be captious. "The People of the Moon" presents, in a most alluring manner, some of the problems that Science hopes to solve in the future, and for many a schoolboy the book will throw a new light over those she has already solved.

We cannot finish without giving one instance of Oolaâlan ethics, of which we think most earthly editors would disapprove. "On gaining the main road at a point only a few yards from the Post Office the men espied a bevy of newsboys running towards them. . . The boys carried news rolls . . slung . . around their necks, . . and they displayed large scrolls announcing . . the chief items of the day's news. Indra and the inventor watched the little group, . . and when they were near enough to them, eagerly cast their eyes over the contents scrolls which the boys displayed." But Indra and the inventor did not *buy* a news roll.

A. C. H. A.

Kalendar fur Elektrotechniker. 1896. Thirteenth edition. Edited by F. Uppenborn. (R. Oldenburg, Munich and Leipzic.)

The 1896 edition of this well-known annual pocket-book shows additions in the chapters on photometry, lighting and mechanical engineering. There is an entirely new article on Dr. Kallmann's method of fault finding in town-[illegible] circuits.

THE CROMPTON POTENTIOMETER: ITS USE AND CAPABILITIES.—I.

BY W. C. FISHER.

The recent universal adoption by central-station engineers and others of the potentiometer system marks the commencement of a new era in electrical measurement, an era which the engineer, as apart from the scientist, has sadly wanted—namely, an instrument capable of accurately comparing with some acknowledged standard any unknown current, E.M.F., or resistance, such an instrument to be capable of universal use, of infinite range and extreme simplicity, involving no calculations as to results or correction for temperature error, resistance of leads, &c. Judging by the general adoption, this want seems to have been met by the Crompton form of potentiometer; for, whilst there are other forms in the market, they do not seem to have been studied and worked out to such a complete state, due possibly either to want of faith in the system or an inadequate knowledge of the requirements of engineers at large.

As beyond a general description of the instrument in question, published in your columns in May, 1893, Vol. XXXI., p. 32, there exists no printed matter on the subject, it is to be hoped that the following notes and suggestions upon the working and capabilities of this special type of instrument may be of some assistance to those whose lot it may be to have such an instrument under their charge.

Originally suggested by Prof. Fleming to Mr. Crompton as a commercial or workshop method, it has from its first cumbrous form by successive stages been worked up to what might fairly be described as a scientific instrument of no mean calibre, an instrument by means of which electrical measurements from the lowest to the highest value may be taken by direct comparison with the official Board of Trade standard, certainly to well within $\frac{1}{10}$th per cent. under ordinary circumstances, whilst by special care a far higher degree of accuracy may be attained.

Describing the instrument as briefly as possible, it might be said to consist in its present form of 15 sections of wire connected in series, 14 of which are in the form of coils concealed in the instrument, the 15th being stretched along a scale suitably divided; each are accurately adjusted with each other, so that with a fixed E.M.F. of 1·5 volts over the whole each section has a fall of $\frac{1}{10}$th of a volt, the scale beneath the slide wire being divided into 1,000 parts, each part corresponds to $\frac{1}{10000}$th of a volt (*see* Fig. 1).

The unknown quantity x to be measured is placed in series with a galvanometer G and attached to the movable contacts A and B, the intermediate reading between the contacts or main sections of A being obtained by the movement of B along the slide or scale wire, x being so connected up that its E.M.F. opposes that of the main circuit. No deflection of the galvanometer takes place when the point of balance between the

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opposing E.M.F.'s is obtained; such position, supposing it to exist in the diagram given, would be represented by the contacts 4 and 500 divisions of the scale wire, which, taking into account that each section is equal to $\frac{1}{10}$th of a volt, is equal to 0·450 volt. This represents the ordinary working conditions of the main instrument when used in measuring E.M F. or current. Under certain circumstances, more especially when measuring resistances, it is advisable to alter the main E.M.F., in which case the values of the sections are correspondingly altered; such conditions will be described as they arise in the study of the capabilities of the instrument.

Although the above represents roughly the diagram of the main instrument, there are fitted in it certain switches and a rheostat for adding resistance in the main current, so reducing the E.M.F. of the secondary cell ordinarily used to the proper value, and for connecting any series of x into circuit in due

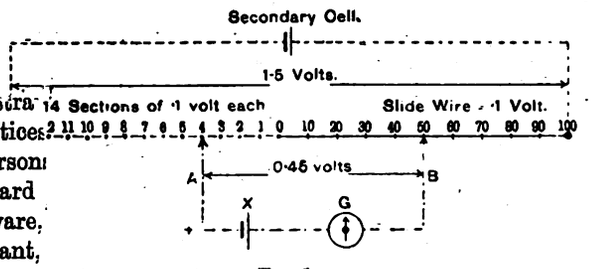
Secondary Cell.
1·5 Volts.
14 Sections of ·1 volt each
Slide Wire ·1 Volt.
2 11 10 9 8 7 6 5 4 3 2 1 0 10 20 30 40 50 60 70 80 90 100
0·45 volts
A
B
X
G

Fig. 1.

so that measurements may rapidly be taken in ne[illegible]eter and a due array of necessary terminals, the true or[illegible]m of the instrument therefore being that shown in Fig. 2.

In using the instrument for the measurement of power, the first operation necessary is its due calibration—*i.e.*, the adjustment of 1·5 volts at the terminals of the whole of the sections; as shown in the diagram, a secondary is used as the source [illegible]ain E.M.F., and having, roughly speaking, an E.M.F. of [illegible]lts, resistance has to be inserted in circuit to bring it [illegible] to the 1·5 volts required. This value is ascertained by [illegible]stituting for x a known value or standard—*i.e.*, a Clark's standard cell; its temperature is noted, and the two points A and B are placed upon the figures corresponding to the value of the cell at that temperature, which we will suppose to be, in

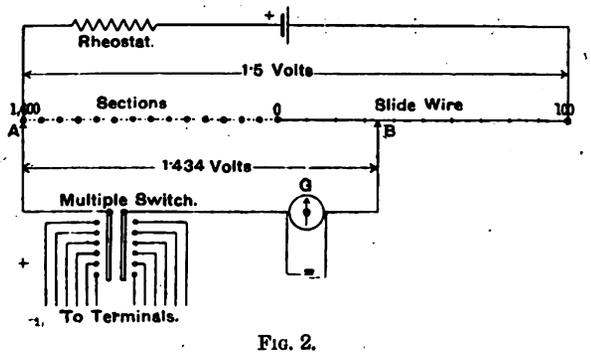

Fig. 2.

the case of Fig. 2, as 1·434 (in which it is seen that the contacts A and B are at 14 and 34 respectively), that being the certified value by the Board of Trade in volts of the standard cell at 15°C. Resistance is added in main circuit until there is no deflection of the galvanometer, due to the fact of the two E.M.F.'s—that in the main and galvanometer circuits—equalling one another; the instrument is thus standardised from what afterwards becomes the x circuit, and is then ready for working and obtaining the value of unknown E.M.F.'s. The act of switching *in* the unknown puts the standard cell *out* of circuit, so that no possible accident can happen to it, and it need only be brought into circuit again for occasional check purposes.

It will be noticed that the maximum observed E.M.F. on the potentiometer is 1·5 volts; all values therefore to be measured must fall within that range. To meet this requirement multiples and submultiples of the ohm are used, and are so proportioned that their maximum carrying capacity is some definite value proportional to that of the instrument, and it is entirely upon them that the range of the set of apparatus depends, the maximum standards made up to the present being for the measurement of 10,000 amperes on the one hand, and 3,000 volts upon the other, but this does not in any way suggest the limit, which might almost be described, in the case of current, as illimitable, whilst with voltage the question of insulation alone steps in.

Current Measurement.

Taking, first, the question of the measurement of current, this is done by passing the current to be measured through a standard low resistance (Fig. 3) of such value that the fall in volts with maximum current over the whole does not exceed that measurable on the potentiometer. The usual units adopted by the majority of the English central stations allow of standards for maximum currents of 1,500, 750, 150, 15 and 1·5—the last three for meter and lamp testing, the preceding two for machine and instrument tests. To be effectively used with the instrument described they should be so proportioned as to be direct reading—that is to say, the first, with a load of 1,500 amperes, should allow of a fall of 1·5 volts. Each section of the instrument having $\frac{1}{10}$th of a volt, will therefore correspond to 100 amperes, each division on the scale to 0·1 of an ampere; the second standard should be similarly proportioned, 750 amperes reading at 0·750 volt; the third standard, for 150 amperes, should have 10 amperes per section and 0·01 per division of scale; the fourth, for 15 amperes, having 1 ampere per section and 0·001 per division; the fifth, for 1·5 amperes, having 0·1 per section and 0·0001 per division. If, therefore, any of these standards are placed

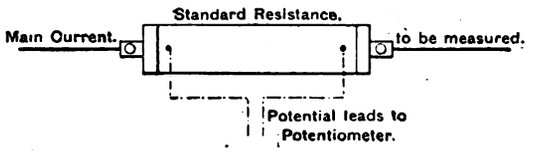

Fig. 3.

in the circuit, current through which is to be measured, the fall of E.M.F. over same is balanced on the potentiometer, and value in current read off accordingly direct. For economy in material or weight, when standards are carried about, it is customary in some instances to adopt half values—that is to say, the standard for 1,500 amperes would be half the resistance of that already described, the consequent E.M.F. would be halved, and the value would be read at 750 on the instrument corresponding with the fall of volts over standard with full load; other values would be in similar proportion, and all would need to be multiplied by 2 to obtain true values. This, however, whilst giving economy in material, or a standard having twice the carrying capacity of the former, is not to be recommended, as, when introduced with other standards having no multiplier, errors arise and quick reading becomes impossible. Recently the question of weight and economy of space, &c., has been overcome by the design of standards of tubular form artificially cooled by the circulation of water and very heavy connections. In this manner a current density of from 25 to 30,000 amperes per square inch is possible, which allows of a very compact standard being constructed. However, this will be treated separately when the construction of such standards is considered. It is, however, interesting to note in connection with these standards that no danger is to be anticipated in connecting them to the ordinary supply, as a moderate length of ordinary hose pipe amounts to practical insulation. In fact 30ft. of ordinary three-ply rubber tubing, $\frac{3}{4}$in. bore, supplied by the Silvertown Company, filled with ordinary "commercial London water," and practically armoured by being laid its whole length along a lead floor, had, when tested from end to end of the liquid with 100 volts, a resistance of one megohm.

To one not accustomed to the use of the different standards it is puzzling at times to give, off-hand, the value obtained.

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Very little practice, however, is required, and a very simple guide to the memory is merely to note the value and maximum-carrying capacity. For instance,

$\frac{1}{1000}$th	ohm	1,000	amperes	at 1 volt,	or	1,500	amperes at 1·5 volts
$\frac{1}{100}$th	,,	100	,,	1 ,,		150	,, ,,
$\frac{1}{10}$th	,,	10	,,	1 ,,		15	,, ,,

Measurement of E.M.F.

The maximum E.M.F. ordinarily measurable on the potentiometer, as has been previously described, is 1·5 volts, but for secondary cell tests, &c. it may be made 3 volts by adding another secondary, and balancing with the Clark cell at half value, but in that and other cases in which it may be done it is necessary to multiply the reading by 2 to obtain the true result. When, however, some very much higher E.M.F. has to be measured, it is necessary to place it across a very high resistance, the fall over some portion of which only is measured (*see* Fig. 4). For instance, taking a box of 100,000 ohms, across which is placed 1,000 volts, the fall over 100 ohms corresponding to $\frac{1}{1000}$th of the total, and represented by 1 volt only, is carried to the potentiometer; in the same manner, if it be 100 volts, the fall over 1,000 ohms, or $\frac{1}{100}$th of the whole = 1 volt, is connected; or again, if 10 volts, that over 10,000 ohms, or $\frac{1}{10}$th of the total, still 1 volt only is taken to the instrument. The instrument is, therefore, direct reading, unless, as in the case of current measurement, half values are taken and the reading doubled—a practice equally bad in this case, and for the same reasons, therefore, to be avoided.

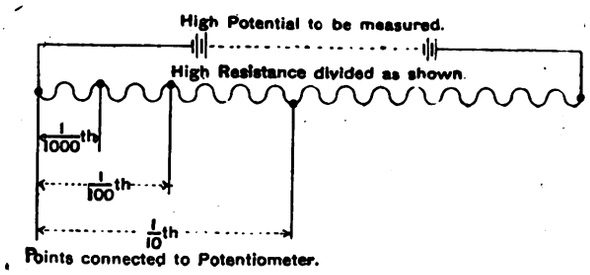

FIG. 4.

The true value to be assigned to the reading may be again somewhat puzzling to the unpractised, and is best got at by remembering or noting the terminals connected, if to the

highest	1,000	volt	reading wuold be	at 1 volt
next	100	,,	,,	,,
again	10	,,	,,	,,
or	1,500	reading	would be	at 1·5 volt
	150	,,	,,	,,
	15	,,	,,	,,

One point only remembered, and the rest is easy and no mistake is possible.

Measurement or Comparison of Resistances.

The measurement of resistances by the potentiometer method is a matter of great simplicity and accuracy, and has the great advantage that, as in the case of E.M.F. and current, results may be obtained direct without calculation.

In the standards supplied for current and E.M.F. measurement we have accurate submultiples of the ohm—*i.e.*, $\frac{1}{1000}$th, $\frac{1}{100}$th, $\frac{1}{10}$th of the ohm, and also multiples of 100, 1,000, 10,000, and 100,000 ohms, the missing 10 ohms to complete the series being easily obtainable with these. It is therefore possible to measure from the infinitesimal part of an ohm to many megohms, in the following manner: The unknown is placed in series with the standard with which it is to be compared (*see* Fig. 5); a current suitably adjusted is passed through both, the E.M.F. at the terminals of the standard being duly connected with x and balanced at any point most suitable on the instrument; the E.M.F. at the ends of the unknown is then brought into instrument circuit at x, and its value compared with that of the standard.

Whilst it is usual and best to balance the standard at a number corresponding to its value, and the value of the unknown is accordingly read off direct, it is not absolutely necessary that this should be done (more especially if the operator is an adept at the slide rule, in which case it is immaterial where the standard is balanced, as the unknown being in direct proportion its value is found at one setting). Very often it is more convenient to balance at some multiple of the standard, the value of the unknown being obtained by dividing the figure of its balance by the multiple adopted.

Taking an example, we will assume it is desired to measure a circuit of approximately 100 ohms; it is placed in series with the 100 ohms standard and a source of E.M.F., a pair of potential lines being run from each to the potentiometer, as shown in Fig. 5. We now have four methods of procedure open to us in balancing the standard:—

1. The points A and B are put at the figures representing the exact value, or some multiple of the standard, and the adjustable resistance in unknown circuit altered until balance is obtained.

2. A and B are put to any point where balance of the standard may be obtained.

Both these methods are advisable when the instrument is already adjusted for use with the Clark cell.

3. Balance of standard is obtained by adjustment of E.M.F. in main potentiometer circuit by means of the rheostat.

4. Balance of standard is obtained by adjustment of potentiometer and unknown circuits.

In the No. 1 case the balance of standard is effected, say, at 100 (A = 1, B = 0, or A = 0, B = 100), the potential of the unknown is brought into circuit and value obtained by movement of points A and B; this will correspond with the resistance, supposing it to be A = 1, B = 270. The resistance therefore is 127 ohms, being as 100 is to 127; if greater accuracy is required the

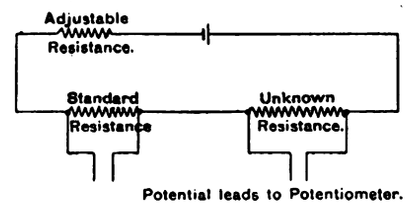

FIG. 5.

standard may be balanced A = 10, B = 0, in which we might get the unknown as A = 12, B = 753, or 127·53 ohms.

In No. 2 case, with the same resistances, the standard balanced at 325 (A = 3, B = 25), x would duly balance at 414 (A = 4, B = 14).

$$\therefore\ 325 : 100 :: 414 \text{ to } x, \text{ or } 127{\cdot}5 \text{ ohms.}$$

Cases Nos. 3 and 4 would be but a repetition of the above, as would also be the procedure if other standards were employed.

Conductivity Tests.

In conductivity tests the procedure is, of course, the same as that pursued in measurement of resistances. The sample strip, wire, cable, or sheet is placed in series with the standard considered most suitable, and its resistance ascertained as accurately as possible; this is duly compared with that calculated in the usual way, from its known length, section, weight, &c., and the percentage conductivity at given temperature ascertained. This, however, is not necessary, if comparison is made with a known copper standard, duly protected from atmospheric influences and injury, in which case the conductivity may be read off direct, which is very much more simple and occupies less time.

Thermometry.

Nothing has so deservedly called forth the attention of the scientific world and the thanks of those interested than the investigations into, and development of, the platinum thermometer by Messrs. Callendar and Griffiths. To anyone accustomed to the use of the ordinary thermometer, its sluggishness and vagaries—the difference between it and the platinum thermometer is as darkness to light; acting almost instantaneously, and with precision, true temperature readings by its means are obtained far more quickly and accurately, and at times under circumstances not attainable by the earlier method. To the measurement of temperatures by means of the platinum

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thermometer the potentiometer lends itself well by reason of its flexibility and range, and the total disregard of resistance of leads and consequent compensation. Whether it be ordinary atmospheric changes of temperature, or those produced by friction or intense heat, from the melting point of ice to that of the platinum wire itself, all comes easily within the

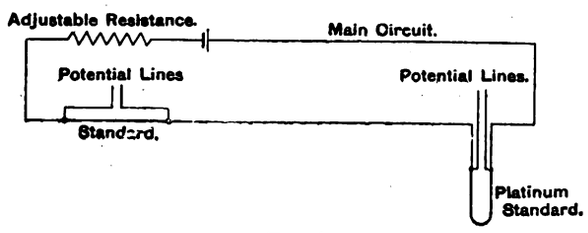


FIG. 6.

range of the instrument; therefore, by its means temperatures of liquids, flue gases, hot bearings and journals or of the atmosphere may easily be measured in the following manner, shown in Fig. 6, in which the platinum spiral is placed in series with a battery and standard resistance R (which may be simple, compound, or compensating) having a temperature coefficient known or practically negligible. This standard is equal in resistance to the pyrometer when at the temperature of melting ice; when, therefore, placed in circuit, as described, and balanced at any point of the potentiometer, any change in the resistance of the platinum spiral is at once detected by comparison, assuming it to be caused by temperature. Such temperature may be measured by means of the constant supplied with the thermometer, and which may be practically taken as 0·38 per cent. per degree Centigrade, which, divided into the difference between the balance of standard and spiral, gives the actual temperature in degrees Centigrade.

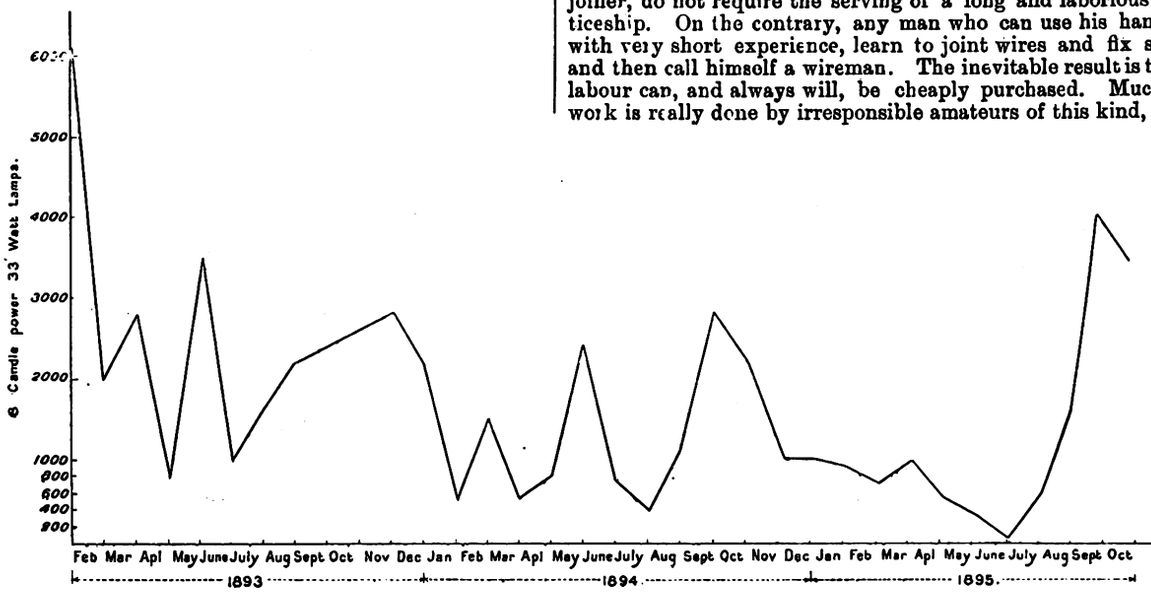
As an instance, we will assume the standard as balanced at 10 on the slide wire of potentiometer, and upon switching in the potential at the terminals of the platinum spiral we find it represented by 13·8 on the slide wire. The difference in the two readings divided by the above constant gives the temperature as 100°C.; if the balance of the platinum spiral had been at 138 the corresponding temperature would be 1,000°C.

Of course it is easily seen that the scale of the thermometer, as indicated by the potentiometer, may be made anything that is convenient; as indicated above it is somewhat contracted, but by balancing the standard at 100, instead of 10, we increase it tenfold, the maximum reading being 1,500, corresponding to 1,315°C., or 1,000°C. being indicated at 1,380.

CONCENTRIC WIRING.*

BY SAM. MAVOR.

Considering the importance of the subject of electric light wiring, it does not seem to have had an adequate share of the attention of this Institution. This is the more unfortunate as the tendency now is to allow the business of wiring to drift out of the hands of experienced electrical engineers into the hands of the legion of plumbers, gasfitters, and others who, often with small claim to the title, write "Electrical Engineer" upon their signboards. It is inevitable that wiring shall fall more and more into the hands of tradesmen of this class. They will follow more or less closely the methods of their predecessors, and defects in existing practice will thus be widely propagated. This is a question which seriously affects the whole industry, and hence the importance of this Institution setting an example by aiming at and endeavouring to secure a high standard of excellence in wiring work. It is a characteristic of the business of electric light wiring that it is peculiarly liable to the risks attending bad workmanship. Internal wiring—that is, the laying of insulated conductors in grooved wood casings, the jointing of these conductors, and the fixing of switches, fuses, &c.—is a comparatively simple matter. Apart from the distribution of lights and arranging the circuits and their routes, it is not work which must necessarily be done by a highly-trained and skilled tradesman. For such work as the mason's, the bricklayer's, the joiner's, cabinetmaker's, &c., a man requires the training of a long apprenticeship, which entitles him to the wages of a skilled craftsman; but the mere laying of wires already manufactured in grooved wood casings erected by a joiner, and fixing ready-made switches on bases also prepared by the joiner, do not require the serving of a long and laborious apprenticeship. On the contrary, any man who can use his hands may, with very short experience, learn to joint wires and fix switches, and then call himself a wireman. The inevitable result is that such labour can, and always will, be cheaply purchased. Much wiring work is really done by irresponsible amateurs of this kind, who are ignorant of the consequences which might result from their carelessness or lack of experience.



Curve showing the number of Lamps connected to the Electric Supply Mains of the Glasgow Corporation during each month from February, 1893, to October, 1895, inclusive.

A further reason why electric light wiring is often not carried out by first-class labour lies in the intermittent nature of the employment. There are certain seasons of the year when the wiring contractor has little of such work, and must then discharge men. Indeed, wiremen are many times taken on at the beginning of a job and paid off at the end of it. Workmen of skill and intelligence soon find this out, and they seek employment in branches of the business where their qualifications find a better and more steady market. We all know how demoralising it is for men to be idle for months at a time, and how apt they are to drift into lazy and careless habits. The diagram showing the number of 8 c.p. lamps connected to the Glasgow Corporation mains during each month from January, 1893, till the present time illustrates the fluctuations in the demand for wiring. You cannot expect a man to have a thorough interest and

* Paper read before the Institution of Electrical Engineers, November 28th.

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sense of responsibility in his work who knows that he will be paid off at the completion of the job. As wiring jobs often last only a few weeks, the poor wireman may have been in the employment of half-a-dozen masters in the course of a season, with intervals of enforced idleness. In the case of joiners and plumbers and kindred trades, when outside work is slack, the men may be employed in the shop at preparing material or in manufacturing; but not so with the wireman. The material is all already prepared for him by skilled hands—his business is only to erect it. The larger firms who have a variety of electrical work can find employment for the best of their wiremen in other branches when internal wiring is dull. But they, too, when business is brisk, have to fall back upon the shiftless creatures who often present themselves as "wiremen." The proportion of "improvers" and apprentices employed at wiring is very much larger than in any similar trade.

The business—if it may be called a business—of electric light wiring has thus several features peculiar to it making for unreliable workmanship, which, in the absence of competent supervision and careful inspection, lead to defective work and resulting fire risk.

The plumber's and the gasfitter's work are to a great extent self-testing. If a water pipe leaks we see the water, and if a gas pipe leaks we usually smell the gas; but we have no sense—no physiological sense—to enable us to find hidden defects in our electric wiring. A building may be wired in the most dangerously slipshod style, yet the lamps may for years burn none the less brightly, until the latent faults have opportunity to discover themselves.

Insulation tests after the completion of the work, if in dry and well-seasoned buildings, are of little value. The insulation tests of the wiring of an old building might show results three or four times higher than the most stringent rules require, and yet there might be a score of dangerous defects only awaiting opportunity to develop. No tests can be applied for the detection of these defects after the work is completed and covered in. On the other hand, in a new and damp building the insulation might be far below the requirements of the rules, and yet be absolutely safe. The important thing is that the work shall be carried out in such a style that the insulation attained shall be permanent, and tend to increase, rather than decrease, with time. Wiring has to be carried out in situations so different, and must comply with conditions so varied, that it is impossible to formulate rules which can in all cases be adhered to. Modifications must be allowed to meet special requirements, and the extent of these must be left to a great extent to the discretion of the contractor. That such discretion ranges over very wide latitudes is indicated by the large discrepancies between the tenders of different contractors for the same wiring work. When the prices of experienced contractors estimating for wiring work to a carefully drawn-up specification vary as we know they do, it is not strange that inexperienced contractors tendering in the absence of a specification, and without the prospect of any supervision, should quote prices which would not purchase suitable materials alone. These are matters of primary importance to the fire insurance companies, and they are much too lax in looking to their interests in this regard. Bad work is being carried out every day, and the insurance companies are complacently taking the risk. Several offices have issued wiring rules, and it is a very good thing for them to have rules; but what is the use of rules if they are not enforced? At present they are really only recommendations, and anyone who is so inclined may evade or ignore them. It is common knowledge that this is constantly done.

The present procedure of the insurance companies is most ingenuous. They send a schedule to the contractor who is carrying out the work—or, rather, who has done the work, for it generally arrives after the job is completed—and they then request the contractor to oblige them by giving replies to a list of questions. They receive the document filled up by the contractor, who has no responsibility beyond a moral one, and file it away, and presumably are satisfied that the thing is all right. They thereby exhibit a trust in human nature very flattering to the wiring contractor, but of the wisdom of which some of us may have our doubts. Until the insurance companies have organised a thorough system of inspection they will not have taken the steps necessary for their own protection. It seems to me that in every considerable town there ought to be a permanent official (in the pay of the fire offices collectively) whose duty it would be to inspect all electric light wiring while in course of erection, and to ruthlessly condemn defective workmanship or material. If such a staff of well-chosen, reliable and sufficiently well-paid inspectors were scattered over the country, they would soon put a stop to jerry work. The moral influence of their presence in the town would be a wholesome check upon the cheap-jack. The cost when spread over all the companies would be trifling, and would be amply repaid by the reduction of fire risk. The insurance companies already have one man in their collective employment in each of several of the larger cities. This man is an *attaché* of the Salvage Corps, and his duties are confined to the warehouse district. His functions are to familiarise himself with the positions of main switches, fuses, and cables, &c., in the warehouses with a view to his being of service to the Fire Brigade in case of emergency.

Before leaving this subject it may be noted that Lloyd's Register of Shipping some years ago issued a set of recommendations for the guidance of shipbuilders and owners in fitting electric light on their vessels; but, as they took no steps to ensure that effect was given to their suggestions, these remained a dead letter. The large number of electric fires on board ship during recent years, chiefly due to inferior work resulting from the practice of accepting the lowest tender, has impressed upon Lloyd's the imperative necessity for supervision. They have, therefore, issued a new set of rules, and they are now arranging for such a system of inspection as will ensure these rules being followed. The fire insurance companies would do well to profit by the dearly-bought experience of Lloyd's. If they do not, they will assuredly have to learn the lesson at their own expense. Although the insurance companies are primarily interested in this question of fire risk, the matter has a direct and important bearing upon the electric lighting industry. We must all recognise the desirableness of ensuring that wiring shall be carried out in a style which shall be fire-proof, electrically and mechanically good and durable, and shall not be offensive to the eye.

There is a steadily growing dissatisfaction with the generally adopted practice of enclosing the conductors in wood casings, and a steadily growing conviction that something better might be done. In most factories and warehouses it is possible to have the casings laid upon the surface, but in dwelling-houses or in good hotels or clubs it should not be tolerated. Everyone is familiar with the unsightly wood casings and clumsy crockery ware which disfigure so many of the best hotels and other buildings in this country. How often we hear that electric light is not adopted because of the dread of the wood casings, and the cutting about and disturbance which their erection involves! Those casings are a standing reproach to the people who erect them. One has only to see the interior of a good building which a contractor has dared to wire on the prescribed lines with wood casing to realise how utterly unsatisfactory is the system. Those hideous casings are entirely out of harmony with their surroundings, and offend the eye at every turn. They blunder across ceilings and cornices, intrude upon decorative panels, and push their ruthless way through frieze and dado; while out of sight beneath the floors the joists are cut away to clear the casings until the margin of strength is often perilously low. The truth of the matter—and we all know it—is that we cannot carry out the wiring of, for example, a private residence in compliance with the recognised rules for double wiring and wood casing without excessive cutting of floors and plaster work, and disfigurement of walls and ceilings. At every turn we have to compromise between the decorations of the house and the fire insurance rules, and the concessions must needs be generally in favour of the decorations. In short, the modifications of the rules require to be so many and important that this system of wood casing is one which cannot be consistently and thoroughly carried out.

When the usual double wiring is carried out in situations where moisture charged with acid from cemented or plastered walls of interiors, or in such buildings as paper mills, wet spinning mills, dye houses, breweries, distilleries, chemical works, and the like, the destruction of the insulation is only a matter of time, and the casing, by harbouring the moisture around the conductors, hastens the process. After the insulation has broken down, electrolysis, assisted by the acidulated moisture, takes place, and deposits away the copper of one of the conductors, with the consequent risk of heating and ultimately of sparking. The presence of moisture being a necessary condition of the development of such faults, the dampness of the surroundings of the conductors greatly reduces the danger of fire, but that the risk is not absent is proved by the charred and burned casing or woodwork found at such places. It must be remembered, however, that heating due to diminished section of the conductor may occur at a time when the moisture which caused the fault has disappeared, and this is a danger which no amount of fuses will modify. How can you ensure that your wood-cased conductors shall never be subjected to such conditions? And how many of your average wireman's joints would stand 24 hours' immersion in water or soaking in moisture? The miserably futile expedient of attempting to waterproof the casings with putty and varnish is sometimes resorted to; such makeshifts are too childish. Lead-covered conductors are occasionally used where much moisture has to be encountered. But these for double wiring are a mistake, unless the positive and negative wires are both enclosed in the same lead sheathing. The objection to separate lead-covered conductors is that, if there should be an earth or leak on the negative wire, and the lead and insulation of the positive wire becomes punctured at a damp situation, the lead becomes charged positively, and will be deposited away over its whole length where moisture is present to assist electrolysis. This remark has no application to lead-covered conductors on board ship, where the lead sheathing is

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throughout in intimate contact with the hull of the ship, nor to lead-covered concentric conductors. This liability to injury from moisture is the fatal weakness of the ordinary wood-cased system. It is of much greater consequence to obtain a moderately high insulation, which may be relied upon to be durable, than to have—as can easily be had in a dry building—an insulation resistance of many megohms, which will disappear on the approach of the char-woman and her wash-bucket, or is at the mercy of the first loose slate or leaky water pipe. What a common experience it is to discover wiring faults in the fungus-grown casings in damp and mouldy basements, or upon the "sweating" surfaces of cemented walls or ceilings! A fault which developed a few weeks ago in the writer's office is a good illustration of the weakness of the present double-wiring practice. The walls are covered with a light-green paper, which on one side of the room is pasted to a wooden partition, and through this partition and paper the conductors are led to a switch. Behind the base of this switch sparking was observed. On examination it was found that in our humid climate the paper had absorbed moisture from the atmosphere, and this moisture, charged with an acid held in the paper, had attacked and destroyed, first the insulation of the conductors, and then the copper, until of the latter only a green sulphate remained, and the circuit was interrupted. As only one lamp was in circuit the spark was small and the heating effect slight, but under other conditions the results might have been serious. This is an interesting example of a fault developing in an apparently dry and well-aired and warmed room, and under the eyes of one whose business it is to avoid such faults, and to whom a spark was the first intimation of anything being wrong.

After wood casing, with its perviousness to moisture and other attendant disadvantages, the biggest blot on existing practice is the indiscriminate use of fuses. Some insurance people, and wiring contractors too, imagine that the risk of fire varies inversely as the number of fuses. The contrary is more near the truth. Fuses are not only a nuisance, they are apt to be a positive source of danger. The smaller number of fuses used the better; but they must be absolutely reliable, well mounted, and well placed. Most of the leading wiring contractors have adopted the distributing box plan of wiring, in which the branch fuses are grouped at the distributing centres. This system should now be compulsory. The use of isolated fuses should be strictly prohibited. The only inducement to use them is a trifling saving in the cost of conductors. The number of fuses should be kept down by keeping up the section of conductors. The larger expenditure on branch conductors entailed is amply repaid by the simplicity and uniformity secured. The dangers of diminishing the section of conductors and scattering fuses through a building are that the crockery fuse bases and cases are liable to breakage; the terminal screws are liable to become loose and so cause heating; and last, but most important, the danger of a conductor of too large area being used by an inexperienced or careless person instead of a *bonâ-fide* fuse, in which case the "fuse" is a delusion. This last danger is so real and so imminent that the insurance companies ought long ago to have prohibited the use of such fuses. The writer was recently in competition with a firm of contractors of large experience who do a great amount of wiring, and were in this case estimating for wiring about 200 lamps of 16 c.p. each. Samples of the conductors, &c., quoted for were invited along with the estimates, and our double-wiring friends submitted a sample of each of the *nine* sizes of insulated cables and wires, with their corresponding wood casings, and of each of the several sizes of fuses which they proposed to use. Nine different sizes of cables and wires were certainly not essential to the double wiring of this building, but they were part of the method of a much-experienced contractor, and his method is common to many others.

Switches have been greatly improved during the last few years, both in mechanical design and in external form. The clumsy switches, with the ugliness of their porcelain covers embellished by gilt lines or floral decorations, have now nearly disappeared. They are superseded by switches of neat appearance, with suitable metal covers. The working parts of the switches are of a much more mechanical type than formerly, but there still remains ample room for improvement. There are far too many parts, too many screws, and too many contacts. The practice of dispensing with binding screws and soldering the wires directly to the contact plates should be highly commended. How often one sees the attempt made to secure the ends of conductors—frequently of considerable size—under paltry little cheese- or round-headed screws and washers absurdly too light and inadequate to the purpose! The ceiling rose is also a weak spot in double wiring. There are far too many contacts in it. To begin with, there is the usual crockery base, and upon this base are three little brass plates, with twice that number of brass screws. Each of these six little screws binds to a contact the end of a conductor or fuse, and every screw of them is liable to become loose, and every contact to become oxidised. Where vibration or moisture are present the development of trouble is only a question of time. Do those who so freely erect these little collections of screws and contacts ever consider the harvest of petty troubles and annoyances which will be reaped by-and-by?

We must now pursue our painful path of adverse criticism to the lamp holder. The double-contact lamp holder, especially when attached to flexible pendants, is the frequent seat of short-circuit and minor troubles. In this little piece of apparatus there are two contact plates, carrying the buffer springs and the inevitable binding screws. Each of these contact plates must be insulated from the other, and both from the surrounding metal tube. When this is done small space remains for further intrusion. But the flexible conductors are still to be brought in and pinched under the binding screws. Stray strands from these flexibles, where they are not most carefully soldered, are frequently responsible for short-circuits and the melting of many fuses. The risk would be reduced if here also binding screws were dispensed with and the wires brought straight through the insulating disc into holes in the plates and soldered therein.

It is with a sense of relief that one turns from double wiring and all its attendant ills to the simple mechanical and straightforward methods of concentric wiring with an uninsulated outer conductor. So far as the writer is aware, no system of concentric wiring in which both the inner and outer conductors are insulated has ever been used for indoor work. It appears probable that the difficulties in the way of designing junctions, switches, and other accessories which shall meet the electrical and mechanical requirements within moderate dimensions and at reasonable cost, will prevent the introduction of such a system. Two and three-wire concentric cables with each conductor insulated are largely used as mains in connection with two and three-wire systems, but in such cases there is no difficulty in providing junction boxes of adequate size. The only system of concentric wiring which has been adopted for internal use has an uninsulated outer conductor, and it is this system that is known as "Concentric Wiring." It is important that it be clearly understood that concentric wiring is not "single wiring," but is something essentially different. This distinction between concentric wiring and single wiring is necessary, because the two have been frequently confused. No method of wiring merits the title "concentric" which is not consistently concentric throughout. In a concentric system the central conductor must be everywhere surrounded over its insulation by a metallic sheathing of conductivity equal to or greater than the core. The switches and fuses should be in the central wire and enclosed in metal cases. These cases or boxes should be electrically and mechanically jointed to the outer conductor, and so form part of the continuous metallic envelope in which the central conductor is enclosed.

It must be pointed out here that, under the existing Board of Trade regulations referring to the insulation of electric light supply mains, concentric wiring is not admissible where connection has to be made to a source of public supply in this country. This is a matter to which we shall recur, and shall meanwhile consider the question of concentric wiring with regard to installations supplied with current from independent plants. The adoption of concentric wiring is the royal road out of the difficulties and dangers which beset double wiring. It seems to be difficult for those who have been accustomed to devote so much pains to attain good insulation of both conductors to realise that there is no necessity for doing so. The adoption of concentric wiring dispenses with this necessity, and abolishes risks which make a high standard of insulation of both conductors in a two-wire system so desirable. Much misunderstanding and prejudice, due to lack of information, exist with regard to concentric wiring; but there is complete absence of valid objections to its use, and prejudice against it is soon dissolved by an acquaintance with the system.

Some of the fire insurance companies were at one time rather suspicious of concentric wiring, probably because they feared its adoption would lead to the abolishing of their cherished rules regarding the width of fillets in wood casing, &c. The insurance companies are, however, now unanimous in their favourable verdict on the subject, and have recognised the advantages of concentric wiring from their point of view. More extended experience and appreciation of its fireproof qualities must confirm the preference many of them now have for concentric wiring.

It has been stated that, owing to one conductor being already earthed, the liability to complete breakdown of the insulation is doubled. This might be true of double wiring, but is certainly not true of concentric. The outer conductor being already at earth potential, there cannot be any risk whatever of shock or spark being experienced from it. There is thus only one vulnerable conductor, and this, with its insulation, being encased throughout its entire length in the metallic sheathing formed by the outer conductor, is well protected against injury. The consequences of injury to concentric and to double wiring are essentially different. In the case of the concentric conductor, if it should be crushed or a nail be driven into it, the instantaneous result is a dead short-circuit and the melting of the fuse. If the insulation should be punctured and moisture gain access, the distance across the insula-

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tion between the conductors is so small that the fault immediately develops into a short-circuit, and the spark passes from the centre conductor to the inner surface of the metallic sheathing, and being entirely within the sheathing it cannot communicate fire to its surroundings. Concentric conductors are thus self-testing. Faults cannot endure. They cut themselves out automatically. Or, rather, this is what they would do if faults were experienced; but we never have faults in lead-covered concentric conductors. How different is the case of ordinary double-wire conductors laid in the separate grooves of a wood casing! The casing which is provided for mechanical protection may become a positive source of danger, and may be ignited by leakage across the fillet—a danger which the fuse is powerless to prevent. In concentric wiring there is only one cable to handle instead of two, and this carrying its own protection the necessity for wood casing is abolished.

Perhaps the most conspicuous advantage of concentric wiring is that it may be so easily and so effectually made waterproof. The cables may be enclosed in lead sheathing laid under or over the outer conductor, and hermetically sealed to the various apparatus into which the cables are led. This must appeal to all those who have had a varied experience of wiring. If moisture—the arch enemy of good insulation—can be permanently excluded, it means the permanent maintenance of a high standard of insulation, and consequent freedom from trouble.

The next important advantage to be claimed is the large reduction in the number of fuses. The drastic method of abolishing fuses is to maintain the section of the conductors. This can readily be done in concentric wiring to an extent impracticable in double wiring. Conductors of much larger section may be conveniently and safely led into C.C. lampholders, ceiling roses, and wall sockets, than is possible in double wiring. And thus, by maintaining the section of conductors right into the lamp holders, many of the objectionable fuses are abolished. The fuses when reduced in number are more easily centralised and arranged in groups of standard size. It may be objected that if the number of fuses is diminished a larger number of lamps are affected in the event of a fuse being melted by a short-circuit. This is a very natural objection for one experienced in double wiring to offer. But it has no application to concentric wiring. We never have short-circuits. It is in double-contact lamp holders, and double-wire flexibles, ceiling roses, and the like, that short-circuits occur. Compare a central contact and a double-contact lamp holder. A 7/16 concentric cable may be led into the former more easily, and with greater safety, than two single No. 16 L.S.G. wires or their equivalent can be led into the latter. It is not necessary to lead 7/16 cables into concentric lamp holders, but the possibility suggests the large margin of safety in favour of the C.C. holders. The difficulty of avoiding mishaps in double-wire lamp holders will be emphasised by the introduction of 200-volt lamps. While on the subject of lamp holders, it may be noted that, there being only one buffer spring in the C.C. lamp holder, and that exactly in the centre, there is less risk of twisting lamps out of their collars while inserting or removing them. Concentric lamp holders, ceiling roses, and such fittings, having only one—and that a central—contact to be insulated, may be made of better mechanical design than where within the same space two contacts have to be insulated, each from the other, and both from the containing case. The benefit of the great reduction in the number of parts can hardly be exaggerated, the liability to derangement is so very greatly reduced.

In regard to fittings, the comparison is again in favour of concentric wiring. The flexible conductors of which the pendants are made are of such large section that they are mechanically strong. The pendant terminates at either end in a screwed brass nipple with insulating plug and central contact—an arrangement which is substantial without being clumsy. No loose strands are possible. The top nipple of the pendant is screwed into the junction or fitting base, and the nipple at the lower end is screwed into the lamp holder. The brackets are similarly wired to screwed nipples with central contacts. The erection of fittings is therefore an extremely simple operation, and the labour so employed is reduced to a minimum.

The method of concentric wiring is based upon a full recognition of the fact that electric light wiring, in order to be permanently durable and reliable, must be impervious to moisture. So far as the writer is aware, this is the only method of wiring which provides a continuously waterproof metallic sheathing over the insulation from the main switchboard to the lamp holders. The main switchboard has the usual single-pole switch and fuse arrangement, and the board is surrounded by the negative omnibus bar, which receives in sockets attached to it the outer conductors and sheathings of the concentric cables. The main cables—which are lead-sheathed throughout, and are generally armoured with galvanised iron wires laid over the lead on a cushion of jute—are carried without break or joint direct to their respective distributing boxes, where the central conductors are soldered to the omnibus bars, and the outer conductors terminate in gun-metal sockets secured to the boxes. The distributing boxes are of cast iron or cast brass, enamelled white inside, and fitted with fuses, or switches and fuses, as required. These boxes have close backs and hinged fronts closing upon an india-rubber ring, thus rendering them proof against dust or moisture. The concentric branch cables which radiate from these boxes are under all ordinary circumstances of uniform section, namely, 7/21½—equal in area to 0·005 sq. in. The outer conductor of the cable has the same section of copper as the core, and the whole is enclosed in a solid drawn tube of lead. Wherever a joint is to be made, or the cable led into a switch or fitting base, the centre wire is soldered to its contacts, and the outer conductor and its lead sheathing are received and terminate in a jointing pocket cast upon the switchbox or junction. The central wire and its insulation are thus enclosed throughout their length in a hermetically sealed metallic sheathing. The section of the branch conductor 0·005 sq. in. is carried into every switch and into every lamp-holder, no reduction being made. There is no necessity for any fuses other than those in the cast-iron fuse boxes. and these are all uniform and interchangeable. It is very rarely that occasion requires any departure from this plan. Many large installations have been carried out on the lines indicated, some of these amounting to several thousands of lamps, where only two sizes of fuses—main and branch, respectively uniform and interchangeable—have been used. The simplicity and reliability of such a system must be too obvious for emphasis.

The branch cables are led through buildings like flexible gas pipes, but they are not liable to damage as composition gas pipes are. The conductors and the insulation within the lead sheathing serve as a backing for the lead, so that it is not at all easily damaged. It has been the custom of the writer's firm for years to have their concentric conductors and joints embedded in the plaster of new buildings, and they have never known a single instance of a fault developing in conductors so treated. It is sometimes objected that where the conductors are so buried they are not accessible. They certainly are not. Why should they be? It is essential that wood casings carrying ordinary double wiring should be accessible; further, it is desirable that they should be visible wherever possible. But the conditions with regard to lead-covered concentric conductors are entirely different. Given a conductor and joint of imperishable materials, and impervious to moisture and the acids found in plaster and cement, and no reason remains for laying conductors on the surface, or for providing access to them where enclosed in plaster. This demand for accessibility, and the objection to cover conductors with plaster, is a relic of the times when india-rubber-covered conductors laid in wood casing were embedded in walls. The bitter experience which rapidly follows this practice results in the prejudice against covering any conductors with plaster. If anyone wishes to have his conductors laid on the surface of plastered walls, by all means let him do so, but there is no necessity either to lay them on the surface or to provide access to them where lead-covered concentric conductors are used. Access to the distributing boxes only is necessary.

Another bogey is the chance nail driven into the plaster. Consider how largely the practice of embedding composition gas pipes in plaster is in vogue, and how immeasurably greater is the danger resulting from the piercing of such a pipe than from piercing the insulation of a conductor. Yet how seldom one hears any objection to the practice! If a nail is driven into a concentric conductor the immediate result is an emphatic short-circuit, and the fuse melts; there is not the slightest danger. Two cases only of nails piercing embedded conductors have come under the writer's notice. Both of these were in the same building—a block wired for about 500 lights, where all the conductors were embedded in plaster. The faults—one behind a picture moulding, and the other behind a dado—were readily localised, and repaired before the work was completed.

The insulation resistance of the wiring in a new building is not a matter which causes any anxiety. The lead sheathings and brass junctions and switch boxes make one independent in this regard. In occupied buildings the lead-covered branch conductors may be led about under floors and behind plaster and linings with the greatest freedom and complete immunity from danger. The amount of lifting of flooring and disturbance to woodwork and plaster is only a fraction of that required for the carrying out of wood-cased double wiring. The junctions employed may be manipulated by any intelligent man who can use a soldering bolt. No careful lapping of insulating material around the joint is required. The insulation is air space, and there is none better. The branch conductors being of uniform size—so are the junctions—and men soon become expert in jointing. The operation is so very simple and easily performed that it may safely be done by unskilled labour. This feature specially adapts the system for export. As an illustration, it may be stated that a squad of Hindoos, chiefly tinsmiths, under the guidance of one European, carried out in the most satisfactory style the wiring for 3,000 lamps in 10 weeks. In mills or factories floored with wood the

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conductors are cleated to the woodwork with brass cleats; and where iron beams and concrete floors are met, the conductors, with junctions (tapped to receive the pendants) attached at the proper intervals, are secured by brass or copper cleats to stranded steel suspending wires strained between eye-bolts attached to the walls. The laborious plugging of the concrete ceilings, with the resulting dust and disturbance to the work of the factory and expense to the wiring contractor, is entirely abolished. In single-storey weaving sheds, ironworks, or other buildings with iron roofs divided into bays, the same method of suspending the conductors between the beams or tie-rods is adopted.

In support of the claim that this method of wiring is reliably waterproof, the case of Messrs. Nobel's Explosives Company's West Quarter Factory may be cited. The buildings to be lighted are isolated and scattered over a large area in order to reduce the risk and minimise the effect of explosions. The regulations issued by the Home Office regarding electric lighting were so very stringent that it was impracticable to comply with them except by the use of concentric wiring. With concentric wiring everything was made easy. Its waterproof and fireproof properties overcame all the difficulties. Every joint and every yard of the conductors is outside and exposed to the weather, cleated for the most part to the gangways. The switches, of cast brass, and distributing boxes, of cast iron, are also all outside, protected only by watersheds. The work of wiring was completed more than three years ago, and, notwithstanding three years' exposure to the elements in this climate, the insulation resistance is as high as ever. Monthly tests of the insulation are required by the Home Office, and on the 10th of last month the insulation resistance was two and a-half times higher than the most stringent of the fire-office rules require for *indoor* wiring. In the nitrating department of the same factory, which is a quarter of a mile distant from the other installation, the insulation is equally satisfactory, although the wiring is subjected to the profuse fumes of nitric acid. It is noteworthy that the insulation of the wiring at both these places is not india-rubber, but is fibrous. The exclusion of moisture is therefore solely due to the lead sheathing and waterproof nature of the joints.

The more difficult the wiring of a building appears to be, the more favourable is the comparison to concentric wiring. The iron roofs, concrete floors, moisture, and other ills that vex the spirit of the double wirer, have no terrors for his concentric friend. For wiring in any situation, from collieries to boudoirs, where difficulties of erection have to be faced, or in situations where the conductors, &c., after erection must endure excessive heat or cold, moisture, acid vapour, or inflammable dust, concentric wiring meets the case. Conviction of its immense superiority is immediately impressed by inspection of buildings so wired. The thing requires to be seen to be appreciated. Concentric wiring had this further advantage—that a very simple and easily followed set of rules can be framed which are applicable to wiring to be carried out under widely differing conditions.

Contractors who are unacquainted with concentric wiring are often ready, when they know it is in competition with their double-wire tenders, to pour into the ears of their prospective client a dismal tale of the woes which would follow the adoption of any system which would not embrace their precious wood casing and crockery ware. If those contractors were informed on the subject, they would learn how great is their error. Take a contractor who has had experience of concentric wiring into any building whatever, and he will show how to make a better, more mechanical, reliable, and durable job, and generally at less cost, than is possible with double wiring. Those who have used only double wiring, and know no other, are reluctant, and with reason, to depart from practice in which their patterns are systematised and standardised, and in which their staff are trained. But when the change proposed is all in the direction of simplicity and reduction of labour the chief objections to its adoption are removed. That fires or minor troubles are not more frequent in badly-wired buildings is a fine testimonial to the safety of electric light wiring, but is no excuse for the continuance of slipshod work or adherence to existing methods where improvements are possible.

For mining work concentric wiring is specially adapted. The mechanical nature of the fittings, and the ease with which they and the conductors may be made waterproof, are important features. A concentric cable for mining purposes is more safe than two separate cables. A fall of material from the roof may rupture one of two conductors, and if current is passing the inevitable result is a spark at the point of parting. In fiery mines this might have serious consequences. With a concentric conductor, however, the fall would crush the outer conductor in upon the core, and so cause a dead short-circuit and melt the fuse before the cable parted. The spark would thus take place at the fuse at the pit bank. In the only case of such accident within the writer's experience the fuse promptly melted. Several devices have been proposed for the purpose of preventing a spark at the point of rupture of cables used in pit work. There is room for doubt as to the likelihood of these devices performing their functions in case of need. There can be no question that the concentric cable is much more simple, and it is probably more reliable than any of them. Further, none of these arrangements afford to the miner the immunity from personal danger from shock which the concentric cable does. An E.M.F. of 500 volts is frequently used for such work, and it is usually considered that such a pressure, although sufficient to give a disagreeable shock, is not dangerous to life. That this feeling of security is not well founded is unfortunately proved by recent fatal accidents. For power transmission in mines an ideally safe system is furnished by concentric cables with earthed sheathing, and switches, fuses, and other appliances enclosed in cast-iron cases, also earthed, and, if need be, enclosed-type motors with their casings earthed.

With regard to the wiring of ships, it is well known that an essential condition of durable wiring is that it shall be waterproof throughout. The British Admiralty for years tried all that the best materials of the usual double wiring sort, and most careful workmanship, could do to secure the desired result. But the incessantly recurring faults and derangements drove them six years ago to abandon wood casing and the ordinary rubber insulated conductors, and no longer to attempt the impossible. At the time indicated they discarded wood casing, and adopted in lead sheathing of the conductors the most effectual means of rendering them permanently waterproof. It was not, however, till four years later that they fully faced the question of making the wiring systematically waterproof throughout. Cast-brass distributing fuse-boxes, and cast-brass switch-boxes, all of waterproof patterns, were then adopted, and means taken to make watertight joints between these boxes and the lead conductors. The present patterns of distributing boxes, &c., although they serve their purpose, are still capable of improvement, and their awkward styles admirably illustrate the difficulty of designing waterproof fittings for use in a double-wire system, where the two sides of the circuit must be insulated from each other, and both from metal of the containing boxes. The Admiralty still adhere to double wiring owing to fancied danger of compass disturbance from concentric wiring. In the early days of electric lighting some of Her Majesty's ships were single-wired, and had dynamos of unsuitable types injudiciously placed. The results were compass disturbances. (The risks of compass disturbance, even from single wiring, are as nothing when compared with those which may arise from the dynamos.) The navigating officers naturally become alarmed, and the alarm has not yet subsided. That well-arranged concentric wiring has no effect whatever upon the compasses of a ship has been proved by the most careful tests. The waterproof qualities of concentric wiring and the safety from fire which it ensures peculiarly adapt it for use on board ship. The history of the development of electric light wiring in our Navy is highly interesting and instructive. The conditions to be endured by wiring on board ship are admittedly severe, but it is under these circumstances that the inherent defects in a system will be most rapidly disclosed. We may profit by the experience of the Admiralty, and accept their progress as an index to the direction in which wiring practice on shore should be improved. The same defects which led to the abandonment of double wiring in wood casing in the Navy exist in this system when applied to land work. The conditions on shore are less trying, and severe treatment less frequent, but the same inherent defects are there, and only await opportunity to develop.

And now with regard to possible electrolysis due to difference of potential along the outer conductor. In isolated installations where the distances are short the question of electrolysis may be dismissed as having no bearing. In cases where the distances are considerable the risk of electrolysis may be entirely avoided by adopting very simple precautions. The first of these—suggested to the writer by Mr. T. B. Murray—is to so proportion the conductivities of the inner and outer conductors that the fall in volts shall be nearly all in the inner conductor; the copper saved from the inner conductor being added to the outer in order to reduce to a minimum the difference of potential between its ends. Another method adopted by the writer is to provide between the outer conductor and its lead sheathing a very light insulation, and to earth the outer conductor only at the distant end. The layer of braiding laid for manufacturing reasons over the strands of the outer conductor before it is passed through the lead press is sufficient for the purpose, as the maximum difference of potential between the outer conductor and the lead is only a few volts.

The risk of electrolysis is greatly over-estimated. The prejudice against earthing the return conductor is largely due to the results of the early American practice of using an earth return for street railway circuits, instead of providing an adequate return conductor. The consequence of this habit was serious damage by electrolysis to gas and water mains. But what where the conditions? In many cases the current was put to earth at the distant points at 50 volts to 100 volts above the E.M.F. of the dynamo negative, and the large currents, amounting sometimes to thousands of amperes, which had to find their way to the earth plates at the

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power house carried destruction in their path. But disappearance of these troubles has followed efficient bonding of the rails and the provision of complete metallic circuits of suitable conductivity—in other words, the substitution of a metallic *earthed* return for an *earth* return. In dealing with distribution for electric lighting purposes we do not have to contend with such large differences of potential at different points of the system, and the difficulties are not at all comparable with those encountered in street car work.

A three-wire system with the middle earthed, and concentric wiring on each side with the sheathing connected to the middle wire, is an ideally safe and reliable system of distribution. In a well-balanced three-wire system the fall of volts along the middle wire is negligible, and there is therefore no danger of electrolysis. No disturbance to telephones could take place. Stray currents passing between faults in the conductors would be impossible. The positive and negative conductors being each surrounded by an earthed sheathing, no current can escape from them. Leaks in concentric cables will not endure. The distance between the inner conductor and its sheathing being only the thickness of the insulation, a fault develops at once into a short-circuit which is internal to the sheathing of the cable, and the fuse at once comes into operation. But it must be repeated that faults are much less liable to occur in concentric cables than in double wiring. The importance and safety of the self-testing properties of concentric wiring must be obvious. As distributing networks are enlarged and extended, and the number of consumers increases, it becomes cumulatively more difficult to keep up the pretence of insulation. The present supposed insulation of the three wires is a sham, and the sooner we acknowledge it the better. Experience has proved that good insulation of all three conductors in an extensive network cannot be reliably maintained. Then why not face the difficulties, and end them by earthing the middle wire?

The initiation by Mr. Sidney Baynes of the use of 200-volt lamps and 400-volt distribution on the three-wire system has a significant bearing upon this question. That his policy from the supply engineer's point of view is a sound one is beyond doubt, and that it will be largely followed in the near future is certain. But what about the interior wiring? If the attempt is to be continued to maintain the insulation of all three wires, the possibility is introduced of having a difference of potential of 400 volts between one of the wires and earth. The danger from leakage across damp woodwork and the like is therefore much increased, and possible danger to life introduced.

Recent developments and experience demand the reconsideration of this question of earthing in its relation to electric light conductors. The Board of Trade have issued regulations referring to the use of uninsulated conductors for tramway and railway work. The time is ripe for the framing of regulations relating to an uninsulated middle wire in the three-wire system of distribution.

CORRESPONDENCE.

THE PRESIDENCY OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is desirable that the present question as regards the presidency of the Institution should be thoroughly understood by all. The feeling that the President, head as he is of the electrical profession during his tenure of office, should be either a thoroughly representative practising engineer or an electrical scientist who by solid work has gained real pre-eminence, is of no recent origin. It has been much discussed amongst members both in London and in the provinces for several years past. Many members of the Council themselves entertain it, and if others were until recently unaware of its existence and strength, this is only an instance of how greatly some are out of touch with the sentiments of those whom they are supposed to represent.

Except under special circumstances, when, as is at present the case, some species of organisation is arranged beforehand, the election of officers is a purely nominal proceeding and must be so according to the manner in which nominations and voting are at present conducted. The Council are in name elected by the members and associates, but in reality by themselves. New members of Council, as also the higher officers, are nominated entirely by the Council, of whom a yearly increasing majority are perpetual past-presidents. The Council's nominations are kept secret until the ballot papers are actually issued, a few days only before the voting takes place. There is then no time for members to take any combined action, and mere disagreement with the Council's list can have no effect. The Council have created a custom whereby the senior vice-president is always nominated for the presidency, while the ordinary members have no real voice as to the initial election of the men who thus eventually step by a purely automatic process into the presidential chair.

Everyone must agree that the existing arrangements are highly unsatisfactory. The president of a scientific or engineering institution should be the choice not of a minority, nor even of a majority, but should be acceptable to the whole of the members.

Sir David Salomons has been put in a most unfortunate and unenviable position by the Council of the Institution. He will, I am sure, give those who are opposing his election to the presidency credit for entirely impersonal and disinterested motives. They have only the interests of the profession and of the Institution itself at heart. The sacrifice that he is asked to make is not inconsiderable in itself. By making it he will be rescuing the Council, to whose actions he owes his present difficulties, from what promises to be a serious fall. Be his decision, as also the eventual result of the election, what it may, it is clear that similar difficulties will occur again in the future unless radical changes in the whole machinery by means of which the Council and its officers are elected are immediately carried out.—Yours, &c., A. A. C. SWINTON.

66, Victoria-street, Westminster.

BEHAVIOUR OF TRANSFORMERS AT INSTANT OF SWITCHING ON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the editorial comments on Dr. Roessler's Paper, the first part of which appears in your last week's issue, it is stated that "transformers under ordinary conditions of working are subjected to potentials of many times their usual value when the primary circuit is *made* or broken." Now, whatever rises of pressure may, under certain conditions, take place at the primary terminals on breaking the circuit (the secondary being open), it is highly improbable that the potential ever rises above its normal maximum at the instant of switching on the transformer. An experiment on this point is described by Dr. Fleming on p. 681, Vol. XXI., of the *Journal* of the Institution of Electrical Engineers, and as the result of this experiment a rise of pressure amounting to 67 per cent. of the normal pressure is recorded. But other experiments by Dr. Fleming failed to show any rise of pressure, and the same negative result has been obtained by other experimenters.

There appears to be some confusion between current rushes and *rises of pressure*. For the latter there seems to be no reliable experimental evidence, and it is highly doubtful whether they ever occur at the instant of switching on. It is absolutely certain, however, that enormous rushes of magnetising current may occur *without the slightest effect on the primary potential difference*. Hence devices whose object is to prevent such rushes of magnetising current are altogether unnecessary, the "rushes" being quite harmless.—Yours, &c.,

University College, Nottingham, November 25, 1895. ALFRED HAY.

STREET LIGHTING BY ARC LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The interesting criticisms of Mr. Trotter in *The Electrician* of November 22nd deal partly with my own work, partly with Mr. John Hesketh's translation.

It is for me very easy to answer to the first ones. Curves 4, 5, 6, 7, 8 cannot be inexact nor inaccurate, since they are not shown as examples of distribution of any source whatever, but as illustrating geometrical considerations and methods. The sharp peak of Fig. 15 (made perhaps a little too acute on the top by the draughtsman who copied it for photography) explains itself very easily by the choice of the *scales*, which may give to a curve a much sharper peak yet. In fact, *the same curve* drawn on another scale, such, for instance, as Fig. 52 of

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my second Paper, runs very smoothly. As to the superiority of observed plans over plans calculated from observed photometrical curves, I fail to see it, and may remark, after trying myself, that it is almost impossible to get observed plans accurate, since the arcs rotate continuously around the carbons of the various lamps, and the distribution of light suffers continual change much more difficult to take account of in a street with many lamps in position than in a laboratory with only one lamp. So I think the method of calculating contour lines *from experiments*, first introduced by M. Wybauw, is the best.

As to the criticisms relating to the translation, I can only regret that some errors referred to by Mr. Trotter, and not to be found in the original text, should have escaped Mr. Hesketh's notice as well as my own when hastily glancing at the proofs; but I do not think anybody reading the entire foot-note alluded to, in which the date of Mr. Trotter's valuable Paper is given at full length, could have misunderstood its meaning of justice and friendly courtesy. Moreover, I hope that nobody will contradict my opinion that, on the whole, Mr. John Hesketh has rendered the articles into English in a most clear, competent and elegant manner, and deserves praise far more than criticism.—Yours, &c.,

A. BLONDEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to Mr. Trotter's letter in your issue of last week, in which he rightly takes exception to the term *foyer* being rendered "lamp," or, still less correctly, "lantern," I may perhaps point out that, as applied to illumination, it is specifically a lighthouse term, and denotes, not so much the "source of light" as Mr. Trotter suggests, but the seat of light, while *feu* denotes "light" or "luminary." The exact equivalent of "source of light" is *source lumineuse* or *source de lumière*. It would hardly do to translate, *e.g.*, *lumière des foyers* by "light of sources of light," or *foyer-heure* by "source of light-hour." I think my friend Prof. Blondel, in the original of his masterly memoir in the *Génie Civil*, uses the very elastic term *foyer* almost throughout in the sense of "arc," or "arc-unit," and in respect of the height of arcs from the ground, in the sense of "focus" or "focal plane."—Yours, &c.,

C. S. DU RICHE PRELLER.

18, Margaret-street, Cavendish-square, W.,
November 25, 1895.

LEGAL INTELLIGENCE.

Fareham Electric Light Company (Limited) v. Fareham Urban District Council.

This action, which is brought for alleged breach of contract, and in which a claim is made for £5,000 as damages, came before the Lord Chief Justice and a special jury in the Queen's Bench Division on Wednesday. The plaintiffs allege a breach of the contract entered into between the Company and the Fareham Local Board (the predecessor of the District Council) in August, 1894, by which the Local Board agreed to purchase the whole of the Company's undertaking and plant at a valuation, and pay a sum of £1,000 in addition to the contract price, on condition that the Company should lay certain overhead wires underground, and should further purchase a new engine. The contract was to be subject to the consent of the Board of Trade and of the Local Government Board, the Company undertaking to use their best endeavours to get the consent of the former and the Local Board the consent of the latter. Valuers were in due course appointed, and the price of the undertaking fixed at £4,866. The defendants, it was alleged, subsequently refused to perform their agreement, whereby the plaintiffs were, it was claimed, considerably damnified. These damages were laid at £5,000.

The defendants, amongst other things, alleged that the resolution to purchase the undertaking was not properly passed, certain members interested in the plaintiff Company having voted, and that the consent of the Board of Trade and the Local Government Board had not been obtained, and that the contract was accordingly void; but in the alternative, in case it should be held that the defendants were liable to damages, they paid £5 into court as sufficient to meet the plaintiffs' claim.

Mr. Robson, Q.C., and Mr. R. M. Bray appeared for the plaintiffs; and Sir Edward Clarke, Q.C., M.P., Mr. Channell, Q.C., and Mr. Glen for the defendants.

Mr. ROBSON, in opening the plaintiffs' case, said that the Company was established in the year 1890 to supply electric light to Fareham in consequence of complaints, which were very general, both by private consumers and the public body, as to the unsatisfactory lighting of the place by gas. The plaintiffs had, he said, carried out their undertaking and obtained the consent of the Board of Trade, but the defendants did not use their best endeavours to obtain the consent of the Local Government Board. On the contrary, a change of members of the Local Board having taken place owing to an election in December, 1894, the new Board passed a resolution not to go on with the matter, and notice was actually given to the Local Government Board that they did not mean to go on with the purchase, and accordingly did not want the loan. It was set up as part of the defence that this consent was not given, but why was it not given? Surely the defendants could not take advantage of their own act.

His LORDSHIP asked whether the defendants were now ready to purchase, or was it a question of damages?

Sir EDWARD CLARKE: If we are liable, that is a question of contract. We have no desire to purchase.

Mr. ROBSON, continuing, said that another defence raised was that the two arbitrators did not sign the award jointly—that was to say, in each other's presence. That the learned counsel characterised as a wretched technicality, and said that if the defendants wished to avoid it they ought to have moved to set it aside within the proper time.

Mr. JAMES BLAKE, the Managing Director of the plaintiff Company, said about 800 shares of £1 each remained unissued, and the Company had issued two sets of debentures. The Company began by supplying electric light to the Fareham Local Board at 3d. per unit, which was 50 per cent. or 60 per cent. below the average price. In arriving at the amount of loss by the Company no allowance was made for depreciation of the plant. Witness was a member of the Fareham Local Board. In accordance with the requirements of the Local Government Board, steps were taken for putting certain of the wires underground, and the plaintiff Company awaited directions from the Local Government Board to proceed. The outgoing Board held office for 18 months. Capt. Ramsey, Admiral Townsend and Mr. Drewitt had all been Directors of the plaintiff Company, and they were all turned out at the election.

The LORD CHIEF JUSTICE asked what was the important point of the defence.

Sir EDWARD CLARKE said the important point was that the Local Government Board, in the discharge of its duty, considering the matters brought before it at the inquiry, could not have sanctioned the making of this loan when they had a definite expression of the opinion of the ratepayers against it.

The LORD CHIEF JUSTICE said he did not read the letter of the Local Government Board in that sense at all, but he should ask the opinion of the jury upon it. He read the letter as asking for an expression of the opinion of the District Council whether they desired the matter to go on or not. He could not doubt that if the District Council had said they wanted to go on, the Local Government Board would have consented. If a representative body entered into a contract its successors must bear the burden of it if lawfully and in good faith imposed upon them. The defendants had done their best to prevent the consent of the Local Government Board being given. Why should the Court look outside that?

Sir EDWARD CLARKE said his contention was that if the Local Board had laid all the facts before the Local Government Board there was no probability of the latter giving its consent to the contract. No doubt there had been a breach of the agreement on behalf of the Board to use its best endeavours, but that was a question of damages.

The LORD CHIEF JUSTICE said he proposed to ask the jury whether they believed that if the existing Council had represented to the Local Government Board that they wished the contract to be carried out, was there any doubt that the Local Government Board would have given its consent; or if they had told the Local Government Board that they thought that the contract was not an advantageous one, but if they broke the contract they would incur heavy damages, whether the Local Board would not in that state of circumstances have given effect to the contract. The carrying out of undertakings entered into in good faith by public bodies was a very important consideration.

Sir EDWARD CLARKE said the Board carried through the contract in known disobedience to the views of the ratepayers whom they were supposed to represent.

Captain Ramsey and Admiral Townsend were called, and gave evidence relative to their holdings in the Electric Light Company, both witnesses asserting that their connection with the Company in no way influenced their vote.

Sir EDWARD CLARKE, in opening the defence, said that undoubtedly there had been a breach of the obligation of the contract with regard to the Fareham Local Board using its best endeavours to induce the Local Government Board to sanction the contract and make the necessary loan to carry it out. It became, therefore, a question of what damages the defendants should pay in respect of this breach, having regard to the consideration of whether, in all the circumstances of the case, it was probable that the Local Government Board would have sanctioned such a loan upon terms which the Local Board would have accepted. It was the way in which Captain Ramsey, Admiral Townsend, and Mr. Drewitt had acted at the end of their term of office, which had induced the ratepayers of Fareham to turn them out of office and elect their opponents. This was a fact which the Local Government Board would have taken into consideration, and remembering that the ratepayers' meeting was adverse to the proposal to purchase, and that the resolution in favour of purchasing was carried by the vote of Captain Ramsey, who had disposed of his shares in the way that had been mentioned, he submitted that the defendants were justified in the course they had taken. It was perfectly clear that if the plaintiff Company had (as seemed probable) been unable to continue its business, the terms on which the District Council would have been able to acquire it would have been much less than under the contract which had been made with so much haste.

The first witness called for the defence was Thomas Robinson Johnson, an officer in the employment of the Local Government Board, who was

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asked to produce the report of Colonel Marsh, Inspector of the Local Government Board, in reference to the electric light undertaking. Witness objected on the ground that it would be contrary to the public interest, and in this objection he was sustained by his Lordship. He, however, produced all correspondence which had taken place previously.

Various witnesses were then called, and gave evidence as to the feeling of opposition to the proposed purchase which existed amongst the ratepayers of Fareham.

Sir EDWARD CLARKE replied on the defendants' case.

The verdict was for the plaintiff for £3,800. Judgment accordingly. Stay of execution was granted till January 15th, with the view to an appeal.

Edison and Swan United Electric Lighting Company v. Straus.

In the Chancery Division yesterday (Thursday) Mr. Justice Kekewich heard a motion by the defendant to have the action dismissed on the ground that it was frivolous and vexatious.

Mr. SMITH, counsel for the defendant, said the action was one to recover damages for an alleged infringement of the plaintiffs' patent. The claim was afterwards amended, the plaintiffs claiming an injunction to restrain the defendant from selling holders, &c., of electric lamps in connection with their patent. The defendant had undoubtedly been selling these holders and sockets, which were admittedly infringements. Thereupon the defendant's solicitor wrote saying that he would submit to an injunction. That offer was repeated before the Court when last the matter came up for hearing, and the order now before his Lordship was then made—viz., defendant was restrained from selling or otherwise infringing the plaintiff's patent; an inquiry as to damages was ordered, and the rest of the motion was to stand over. The next step was the delivery by the plaintiffs of a most extraordinary statement of claims which simply and solely contained the allegation of the infringement of the patent. Counsel furthermore stated that the costs had been taxed and paid by his client. The situation was hopelessly embarrassing. Counsel presumed that the plaintiffs must file particulars of the breaches. The plaintiffs had made the suggestion that the defendant, a retail dealer, who had bought and sold these things, could not sell them in the open market except on the terms that the plaintiffs had made with the original licencees. This, he supposed, was the cause of the action; but it was not complete.

Mr. J. C. GRAHAM (for the plaintiffs) said that the order of July 30th was to restrain the defendant from infringing two specific articles; but before that the plaintiffs found out that this gentleman was selling sockets in a way in which he was not allowed to sell them. They complained of that as an infringement, as to which they got an order, but there were other things which were in the claim; therefore this was a proper case to go to trial. The plaintiffs complained of a general infringement.

His LORDSHIP asked if it were the case that the defendant was selling the articles at a larger discount than was authorised.

Mr. GRAHAM said that was so. It was very similar to the incandescent case. It was a question of contract, and the plaintiffs complained of the threat by the defendant to continue to sell sockets and holders made according to letters patent. He submitted that there was no ground to support the motion to strike the case out as having no cause of action.

His LORDSHIP said he would not stop an action like this. He would, however, make no order in this motion, costs to be costs in the action.

Whiffen and others v. The Crompton Electric Supply Company of Australia (Limited).

This case came before Mr. Justice Kekewich in the Chancery Division on Tuesday last on a motion for judgment. Mr. Butcher said that he had to ask for judgment by consent in a Preferred Debenture-holders' action for some £10,000 out of total issues of about £20,000, interest on which was in arrear. The learned counsel stated that all parties to the suit were now legally represented, and that a receiver and manager had already been appointed under a declaration of charge, but his time having expired, it had temporarily been renewed by Mr. Justice Stirling. Negotiations were proceeding for the sale of the business, and he now asked that the receiver and managership should be continued. His Lordship assented to this, the arrangement to expire on the last day in April, unless further extended. It was agreed to adjourn further consideration on other matters in connection with the Company to Chambers.

Cohen v. The Electricity Supply Company for Spain (Limited).

This was an action heard in the City of London Court yesterday (Thursday), and was a claim made by Mr. Arthur Cohen, electrical engineer, of Old Broad-street, E.C., who sought to recover the sum of £96 from the defendant Company for 16 electrical transformers supplied to them at £6 each. For the plaintiff, it was said that Mr. Lowry, when in the service of Mr. Robert Hammond, consulting engineer to the defendant Company, went to the plaintiff and asked him if he could sell the defendants 16 transformers. The plaintiff placed the transformers in Lowry's hands for sale on commission, and Lowry succeeded in selling the goods to the defendants through Mr. Hammond. The latter insisted upon the transformers going through a test, which he prescribed at the Electrical Standardising Institute, Faraday House, W.C. Only 12 of the transformers would stand the test, and those were accepted by the defendants, who subsequently shipped them to Spain. The plaintiff afterwards sent in the invoice, and was then told that the defendants had paid Lowry £62 out of the £72 due for the 12. The defence was that the defendants bought the transformers from Lowry direct without any knowledge at all that they belonged to the plaintiff.

Mr. HAMMOND said he knew Lowry for some years, he having been in his (witness's) service, and after they parted company he made Lowry an allowance of £4 per week until he obtained work elsewhere. The defendants paid £62 to Lowry, and they deducted £10 to pay the Faraday House Institution for certain repairs which were executed to the transformers before the tests were made. They now paid £6. 14s. into Court, and admitted that a further 30s. was due.

The Jury, after further evidence, found for the plaintiff, and judgment was entered accordingly.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is in active preparation, and orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. The usual circulars, &c., are now being sent out. Full particulars post free on application.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES *can be obtained of the Booksellers or direct from the Publishing Offices:—*

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

'THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

A LARGE-SHEET TABLE, giving full particulars of the Electricity Supply Stations throughout the Kingdom, can now be supplied mounted on stout board, with cord for hanging. Price: Varnished, 3s. 6d.; Unvarnished, 3s.—each post free. A Map showing positions of Supply Stations throughout the country is mounted on the back of the Table, and a Coloured Map of Metropolitan Electric Lighting Areas and a large sheet of Electricity Supply Statistics are also mounted on some copies, the price of which complete, post free, is 5s.

A SHEET TABLE showing Total Capital Outlay and Receipts and Expenditure for the year 1894 of the Statutory Electric Supply Undertakings of the Metropolis is now ready, printed on thick paper. price 6d.

A SHEET TABLE giving similar particulars in relation to Provincia Statutory Electric Supply Undertakings is now ready, printed on thick paper, price 6d.

TENDERS INVITED.—The Great Northern Railway Company invite tenders for the supply of new and the purchase of old stores, including telegraph and electric lighting stores and material. Tenders by December 7th to the Secretary, King's Cross Station, London, N.

——— The Minister of Industry of the State of Pernambuco (Brazil) invites plans and schemes for the electric lighting of the town of Recife. Plans, &c., must be in by January 20th.

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TENDERS INVITED.—The Municipal Authorities of Betanzos (Galicia) are inviting tenders for the concession for the electric lighting of the town for 25 years. Tenders to El Ayuntamiento de Betanzos, Spain, by December 28th.

——— The Municipal Council of Alexandria (Egypt) invite offers for the concession of the tramways on the basis of an annual rental.

——— The Committee of the Ryhope and Silksworth Industrial and Provident Society invite tenders for supplying and fixing accumulators in connection with their Ryhope electric light installation. Tenders by 2 p.m. to-morrow, Saturday.

——— Tenders are invited for supplying and fixing electric lighting plant at Messrs. P. and F. M'Glade's stores, Belfast. Tenders to Messrs. George Combe and Co., consulting engineers, Castle Lane-place, Belfast.

TENDERS ACCEPTED.—At the meeting of the Metropolitan Asylums Board the Brook Hospital Committee reported that they had invited tenders from the firms agreed upon for the supply of the necessary plant for the electric light installation at the Brook Hospital, and that the following tenders had been received :—

	Engines, dynamos, &c.	Batteries, &c.	Switchboards, &c.
*Siemens Bros. and Co.	£2,004	£475	£527
*J. H. Holmes and Co.	2,100	475	350
Mather and Platt	2,605	465	415
Brush Company	2,428	378	480
T. Parker (Limited)	2,312	521	412
Johnson and Phillips	2,170	360	630
Electric Construction Company..	2,142	509	370
Crompton and Co., Chelmsford...	2,139	551	366
W. H. Allen, Son and Co.	2,060	—	—

* Accepted as shown in block figures.

The Committee recommended that subject to the sanction of the Local Government Board, the tenders of Messrs. Siemens Bros. and Co., for the supply of the engines, dynamos, &c., at £2,004, and batteries at £475, be accepted, and that the tender of Messrs. J. H. Holmes and Co. for the supply of the switchboards, &c., at £350 be accepted, and these recommendations were approved. The Committee further reported that they had received the following tenders for the wiring work and supply of fittings in connection with the installation of the electric light at the Brook Hospital and Ambulance station :—

	Ambulance Station.	Brook Hospital.
Julius Sax and Co. (*accepted*)	£213 9 11	£4,666 8 4
Slaters (Limited)	534 0 0	6,217 0 0
Hollingam and Saword	400 2 6	6,179 0 0
H. F. Joel and Co.	336 0 0	5,954 0 0
C. Nathan	630 0 0	5,063 0 0
Pritchetts and Gold	279 0 0	5,279 10 0
Strode and Co.	334 0 0	4,878 0 0
Edmundson's (Limited)	350 15 0	4,643 19 0
Fowler, Lancaster and Co.	228 0 0	4,685 12 6
Brush Company	192 0 0	4,547 0 0
Electrical and Gen. Engineering Co.	289 0 0	3,169 10 0

On the Committee's recommendation the tenders of Messrs. Julius Sax and Co. for the total sum of £4,879, 18s. 3d. were accepted.

——— The following tenders were received by the Bedford Urban Sanitary Authority for the supply of surface condenser and air pump and a centrifugal pump with engine for their electricity works :—

Robert Stephenson and Co. (Limited), Newcastle-upon-Tyne (*accepted*)	£467 0 0
Gwynne and Co., London	440 0 0
Wright's Patent Heater Condenser Company, 16, Great George-street, Westminster	541 0 0
Tangyes (Limited), Birmingham	546 0 0
W. H. Allen, Son and Co., Bedford	560 0 0
Humpidge, Holborow and Co. (Limited), Stroud	650 0 0
Thos. Metcalfe, Phœnix Foundry, Bradford	747 12 0
Stevenson and Co. (Limited), Canal Foundry, Preston	790 0 0

——— The Board of Control (Dublin) have accepted the tender of the Northern Counties Electric Construction Company for wiring and fitting up the Killarney District Lunatic Asylum for the electric light for the sum of £1,555.

——— The tender of Messrs. Westwood and Sons, Dundee, for fitting electric bells at the West Poorhouse, Dundee, has been accepted by the Guardians.

SALES BY AUCTION.—Our advertisement columns contain particulars of the sale by auction, by Messrs. Wheatley Kirk, Price and Goulty, on Thursday next, of the entire contents of the works premises at Broadway, Walham Green, S.W., in the occupation of Messrs. Russell and Co., who are giving up business. Catalogues are now ready and can be obtained from the auctioneers, and from Messrs. Russell and Co., 11, Queen Victoria-street, E.C.

——— The Reading Electric Supply Company having completed their new electricity station, Messrs. Wheatley Kirk, Price and Goulty give preliminary notice of the piecemeal sale by public auction, at an early date, of the entire contents of the Company's old station, the Island, Reading, comprising engines, boilers, combined lighting sets, dynamos, &c. Further information is given in our advertisement columns.

SALE BY TENDER.—Messrs. Percy Huddleston and Company announce a sale by tender of the surplus plant at the Woking (Surrey) Electric Light Station. Some particulars are given in our advertisement columns.

APPOINTMENT.—The Ealing District Council received 45 applications for the position of chief electrical engineer, and they have appointed Mr. Knight at an annual salary of £240, increasing to £300 by yearly increments of £30. Mr. Knight is at present in the employ of Messrs. Siemens Bros. and Co.

APPOINTMENT VACANT.—The Lighting Committee of the Wolverhampton Corporation require a clerk and canvasser in the office of the borough electrical engineer. Salary £100 per annum. Applications to Mr. F. Harman Lewis, Borough Electrical Engineer, Town Hall, Wolverhampton, by Saturday, December 7th next. Further particulars appear in our advertisement columns.

VACANCY.—The Woolwich District Electric Light Company have a vacancy for a pupil at their generating station. Some further particulars are given in an advertisement elsewhere.

DISSOLUTIONS OF PARTNERSHIP.—Messrs. Henry and Arthur Davis, carrying on business as electrical engineers and scientific instrument makers at All Saints' Works, Derby, and 118, Newgate-street, London, under the style of John Davis and Son, have dissolved partnership. Mr. Henry Davis will continue the business under the present title.

——— Messrs. J. S. Bolton and T. Harrison, carrying on business as electrical engineers at Collingwood-street, Newcastle-on-Tyne, under the style of Bolton, Harrison and Co., have dissolved partnership.

BANKRUPTCY.—Notice is given of the release of the trustee (the Official Receiver of the Halifax County Court) in the bankruptcy of John Henry Brown, electrical instrument case maker, South-street and Archer-street, Halifax.

PETITION FOR WINDING-UP.—A petition for the compulsory winding-up of the Herculite and Electrical Manufacturing Company (Limited) has been presented by the Harburg and Vienna India Rubber Company, and will be heard at the Royal Courts of Justice, Strand, London, on Wednesday next. Mr. W. H. Dale, 46, Finsbury-circus, London, E.C., is solicitor for the petitioner.

ADVANCE IN PRICES.—It will be remembered that in our issue of November 15th notice was given that the leading firms of electric wires and cable makers had decided, owing to the increase in the price of raw material, to advance the prices of their manufactures. We now have official intimation from the Brush Company that on and after January 1st next an advance of 10 per cent. will be made in their list prices for all Brush specialities excepting arc and incandescent lamps. Taking into account the complaints that have been made by the leading engineering firms as to the very narrow margin of profits on recent contracts, this seems a step in the right direction.

RECORDING INSTRUMENTS.—The recording instruments supplied to the Bristol and also to the Coventry Electric Tramways (an account of which was given in our last issue) were of the well-known make of Mr. J. Pitkin, of Red Lion-street, Clerkenwell, London. This firm has supplied instruments to the Aberdeen, Blackpool, Sheffield, Scarborough, Edinburgh, Shrewsbury, Finchley-road, and other lighting stations, and, we are informed, have orders in hand for Norwich, Sheffield, &c.——We have received from Mr. Pitkin, of Red Lion-street, a copy of his new price list of ammeters, voltmeters, &c., &c., in which Major Holden's well-known hot-wire recording instruments figure prominently. Owing to the fact that the indications of these instruments are not liable to be vitiated either by external magnetic disturbances or by the friction of the pen on the recording drum, they are specially suitable for central station switchboards, and we are not, therefore, surprised at their vogue in this connection.

"ADRESSBUCH DER DEUTSCHEN MASCHINEN-INDUSTRIE."—We have received a copy of this work, which is published in Dresden by Herrn. Friese and von Puttkamer, who are represented in this country by Messrs. Sampson Low, Marston and Co. The Address-book is published annually, this being the second publication. It is edited by Herr Holzt, and in addition to a very complete index of German electrical firms, contains as a frontispiece an excellent portrait of Dr. Werner von Siemens and a somewhat lengthy obituary notice. The original of the portrait is the same as that used for the recent steel-plate supplement to *The Electrician*. The book contains nearly 1,300 pages, is well printed, and the binding is a very fine example of German block making.

READY RECKONER.—There is of a certainty no limit to the number of publications of what may be termed the labour-saving

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kind, but certainly one of the most useful recently issued, is a handy ready reckoner for wages and costing purposes, compiled and published by Mr. K. Openshaw, of Wyke Regis, Weymouth. The tables are principally useful for wage-paying purposes, and are based on a 54-hour week—that is to say, if a workman is paid at the rate of 33s. per week, and works 60 hours, on that basis the table without trouble or calculation gives the figures. There are 300 sets of figures in all, which may be taken to cover the whole of the probable requirements of such a work.

ABERDEEN.—The work of installing the electric light at the Public Library has just been completed. About 180 16 c.p. incandescents are employed, and the installation has been carried out by Messrs. Shirras, Laing and Co.

BERMONDSEY (LONDON).—At the last meeting of the Vestry the Law and Parliamentary Committee's report, recommending that the application of the Capital and Counties Electricity Supply Company for a Provisional Order be opposed, was adopted.

BEXHILL (SUSSEX).—At the last meeting of the District Council the Highways Committee's report, recommending the Council to consent to the application recently received by them for a Provisional Electric Lighting Order for the district, was approved.

BRIGHTON.—At a meeting of the Lighting Committee, residents in Sillwood-street complained of the insufficient lighting of that thoroughfare. The Committee have decided not to do the extension work piecemeal. They are hopeful of being able early next year to light the remainder of the streets where the mains were laid by incandescent lamps to be affixed to the present gas standards, and with this object the borough electrical engineer (Mr. A. Wright) has been requested to prepare a scheme.

CAMBERWELL (LONDON).—At their last meeting the Vestry discussed the report of the General Purposes Committee, which recommended that sanction be given to the application of the County of London and Brush Provincial Company for a Provisional Order. After a long debate, an amendment by Mr. Phillips, "That the assignment of a monopoly for electric lighting in this parish to a private company for 42 years demands such grave consideration that the Vestry hereby appoints a Special Committee to consider and report upon the question of the lighting of the parish," was carried by 48 votes to 35.

CARDIFF.—At the last meeting of the Lighting and Electrical Committee the Chairman (Mr. Ald. Carey) stated that a Sub-committee had been appointed to confer with the Exhibition Committee on the subject of lighting the Exhibition by electricity. They would require extra plant capable of giving an additional 350 H.P. or 400 H.P. before they could undertake to supply the Exhibition authorities with current. It was proposed to employ 101 arcs and 539 incandescents. The matter would have to be taken up at once, as it involved an application to the Board of Trade. If they set to work at once everything ought to be in readiness to supply current to the Exhibition in May. The extra plant was really necessary for town purposes at the present moment, and it could be permanently utilised on the one expenditure for erecting. The matter was referred to the Sub-committee to report upon. A suggestion was made that the Town Hall and the square in the rear be lighted electrically, but the borough engineer (Mr. Harpur) stated that it would be impossible to do this until fresh plant was laid down.——The Corporation have received the formal sanction of the Local Government Board for borrowing £12,885 for electric lighting purposes, the loan to be repaid in 25 years.

CHELTENHAM.—The Corporation's electricity works are now running continuously day and night, and current is at all times available. Up till last week the machinery had been shut down during the day hours on Sunday, but owing to the increased popularity of the light by private consumers it has been decided that no break shall take place in the supply. The supply of current for power purposes is also making satisfactory progress. The Corporation have decided to proceed with their Bill before Parliament to acquire the gasworks for the town. This step is taken practically in opposition to an application to Parliament by the gas company.

CHURCH LIGHTING.—Canon Duckworth's church (St. Mark's, Hamilton-terrace, W.) is to be lighted electrically. The Canon was recently presented with a silver service and a cheque for 300 guineas, and in acknowledging the gift he stated that it would enable him to defray the cost of installing the electric light in his church.

DARWEN.—It has been decided to light the Technical School electrically, and several of the leading tradesmen and ratepayers are urging the Town Council to put down electric generating plant at the Schools (which are the property of the town) capable of supplying current for lighting the centre of the town.

EALING.—At the last meeting of the District Council the Surveyor reported that they had received applications for an equivalent of 6,234 8 c.p. lamps, and that 4,273 had already been connected.

ELECTRICITY AND SANITATION.—The Medical Officer of Health to the Corporation of the City of London (Dr. Sedgwick Saunders), in his annual report, recently issued, points out that the great extension of electric lighting installations within the City area has marked what he describes as a new era of sanitation, and he anticipates that much benefit must accrue to the moral and physical condition of the employés in the large commercial establishments which have adopted the electric light who had been condemned to work in badly lighted and overheated basements. A tendency also of the improved lighting is that attention is called to other sanitary weaknesses, leading to their abolition and the introduction of improvements all round.

ELECTRIC LOCOMOTIVES.—A Paper on this subject was read last week before the Manchester Association of Engineers. The author, Mr. T. Daniels, pointed out that there are now 81 electric railways constructed by European engineers, with a total length of about 440 miles. Of these the largest were in England—viz., the City and South London Railway and the Liverpool Overhead Railway. The author's claims for the electric railway and tramway were increased comfort to passengers, greater speed, cleanliness, ease of lighting, heating and ventilating, and the improved braking of the electric car. Finally, the author recommended the railway companies to set about developing electric feeding lines in thickly-populated districts in order to meet the opposition of competing electric railways which were likely to spring up and deprive the older companies of much of their local traffic.

ELECTRIC TRACTION NOTICES.—Some variety is observable in the traction notices appearing in the *London Gazette*. In some cases power is asked for the substitution of electric motive power throughout the systems, in other cases electric or other motive power. The Portsmouth Street Tramways Company are in the former category, while the Corporations of Sheffield, Swansea, Blackpool and Newcastle, and the Belfast Street Tramways Company, are amongst those bodies which seek for powers to introduce electric or other motive power. Notice is also given of intention to apply for powers for the incorporation of companies—(1) to construct an electric tramway between Kidderminster and Stourport; (2) to construct tramways in Halifax and neighbourhood (electric or other motive power to be employed); (3) to construct tramways in the boroughs of Ashton-under-Lyne and Hyde, the urban districts of Denton and Audenshaw, the rural district of Limehurst, and the districts of the Parish Councils of Waterloo and Bardsley (electric or other motive power to be employed); (4) to construct tramways in Sheffield and Rotherham (use of electric or other motive power); (5) to construct a light railway between Derby and Ashbourne (use of electric power); (6) to construct tramways in Blackpool and Fleetwood (use of electric or other motive power). In the applications for powers to construct tramways between Farnborough and Aldershot a clause for sanction to use electric or other motive power is also included. In Ireland official notice has been given by the Dublin and Southern Tramways Company and by the Dublin United Tramways Company of application being made for powers to construct electric tramways in Dublin. In addition to the above the *Gazette* notices include several applications for powers to construct light railways, the proposed motive power for which is not stated.

EXTENSIONS OF TIME.—Notice is given that the Baker-street and Waterloo Railway Company intend to apply to Parliament for an extension of time for the construction of the line authorised by the Baker-street and Waterloo Railway Act (1893). The City and South London Railway Company intend to apply for an extension of time for the completion of the works authorised by the City and South London Railway Act (1893). The Brighton and Rottingdean Seashore Electric Tramroad Company intend to apply for an extension of time for the construction of the works authorised by the Brighton and Rottingdean Seashore Electric Tramroad Act (1893). Application is also to be made for an extension of time for the construction of the Blackpool, St. Anne's and Lythen Tramways and for the use of electric or other motive power.

FOLKESTONE.—At a special meeting of the District Council last week it was decided to apply for a Provisional Electric Lighting Order, and it was also decided to oppose the Capital and Counties Electricity Supply Company's application for a similar Order.

GAS COMPANIES AND THE ELECTRIC LIGHT.—The Ilfracombe Gas Company gives official notice of its intention to apply for powers in the next session of Parliament to supply electric current for lighting, heating and motive power purposes.

GAS TO THE RESCUE.—At the meeting of the Edinburgh and Leith Gas Commission on Monday last, Bailie Kinloch Anderson, in commenting on the engineer's report for October, said that they were "combating very bravely the invasion of the electric light,

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Since May 15th there was an increased consumption of over 18,000,000 cubic ft. of gas, but that the influence of the electric light was now being seriously felt. In Edinburgh there was an increase of under 700,000 cubic ft., whereas in Leith they had an increase of over 4,000,000 cubic ft., which had been the proportionate increase for some time, only there the electric light was not in operation. So Leith was coming to the rescue again, and saving the Gas Commission from destruction. He had no doubt they would be able to hold their own in the future"—so long as the electric light held off.

HAMMERSMITH (LONDON).—The Electric Lighting Committee recently presented a report on the tenders and schemes sent in for lighting the compulsory area of the district electrically. The Committee recommend that they be empowered to obtain such expert advice as may be necessary, at a cost not exceeding 200 guineas, to enable them to make a complete report on the matter.

HAM (SURREY).—At the last meeting of the District Council it was decided to ask the Richmond Town Council to extend their electric fire-alarm system towards Ham.

KINGSWOOD (BRISTOL).—At the last meeting of the District Council it was reported that the Great Western Electric Light Company proposed to apply for a Provisional Electric Lighting Order for Kingswood and St. George.

LAMBETH (LONDON).—At a special meeting of the Vestry last week it was decided to appoint a special committee of eleven members "to consider carefully all the information obtainable on the electric lighting question, and to report thereon to the Vestry."

LIVERPOOL.—Mr. Charles Rettie, of Geraint-street, has recently completed the fitting and lighting of Dunthorne's Rembrandt Gallery, in Castle-street, for the electric light. The gallery extends from Castle-street to Back Castle-street, and is a portion of a new stone building, the front of which is of highly artistic design. The gallery is divided into three sections, front, centre and back, and these have 60 lights fitted, independent of the lights in the workshop in basement. Parquet flooring is used throughout the galleries, the pervading colour in which is green bronze, and, as will be readily understood, the electric light has proved most effective. There are eight complete circuits, which come down on a switchboard especially designed and containing one D.P. 50-ampere switch and four S.P. 25-ampere switches. The ornamental shell fittings in the windows facing front to the street have proved very attractive.

LIVERPOOL.—At the last meeting of the Lighting Committee of the City Council it was stated that the Liverpool Electric Supply Company had sealed the contract extending the time for the purchase of the Company's undertaking to six weeks after the Act for its acquisition shall have been passed.

LLANDUDNO.—At the last meeting of the District Council the Electric Lighting Committee's report recommending the appointment of Messrs Kincaid, Waller and Manville as consulting electrical engineers, was discussed, but it was eventually decided to invite schemes for a system of electric lighting, and to submit these to an electrical expert.

LONDON COUNTY COUNCIL.—At the weekly meeting on Tuesday it was agreed, on the recommendation of the Fire Brigade Committee, that agreements be entered into with the Post Office in respect of electric fire alarms in Islington and Poplar, and in respect of telephonic communication between several of the City and suburban fire stations. The Post Office asked permission to carry a wire across Nunhead Green, but the Council declined to allow this, as the Green is a recreation ground. Permission was given to place the wire underground.

MEVAGISSEY.—At the special meeting of the Parish Council it was announced that a company would be formed for lighting the district. A sufficient number of shares have been applied for to warrant them in proceeding with the matter.

NEWPORT.—It has been decided to make further electric lighting extensions at a cost of about £1,000. It was stated at the last meeting of the Council that the electric light scheme had proved to be a great success.

PETERBOROUGH.—The borough engineer (Mr. Gill) recently presented his amended report on the electric lighting question, and the matter was debated at great length at a meeting of the Town Council last week, but was again referred back for the purpose of further ascertaining the amount of support likely to be accorded to the scheme.

PROVISIONAL ELECTRIC LIGHTING ORDERS.—The Corporations of Bangor, Devonport, Gloucester, Liverpool, and Margate, the Bath Urban Authority, the Vestries of St. Mary, Newington, and St. Mary, Battersea (London), the Urban Councils of Colwyn Bay, Folkestone, Kettering, and Sale, and the Queenstown Commissioners give notice of their intention to apply to the Board of Trade for Provisional Orders under the Electric Lighting Acts 1882 and 1888. In their Improvement Bill the Corporation of Darlington also apply for powers to extend the provisions of the Darlington Electric Lighting Order (1890). The following companies also give notice of their intention to apply for Provisional Electric Lighting Orders: Bedford Electric Light Company (for Berkhamsted and Northchurch), Liverpool District Lighting Company (for Great Crosby and Waterloo, and for Allerton, Little Woolton, Much Woolton, Childwall and Garston, Lancs.), Newmarket Electric Light Company (for Newmarket), County of London and Brush Provincial Company (for the district of St. Saviour's District Board of Works, the parishes of St. Mary (Newington), St. Mary (Lambeth), St. Giles (Camberwell), St. Mary (Battersea), all in London; and also for Ipswich and Lincoln), British Insulated Wire Company (for Prescot), Windermere and District Electricity Supply Company (for Ambleside); J. C. Howell, Limited (for Merthyr Tydfil).

RHONDDA.—At the last meeting of the District Council the Electric Lighting Committee's report on the electric lighting of the Valley was presented. The Committee have had three schemes under consideration: (1) The erection of two independent generating stations in the Rhondda Fach and in the Rhondda Fawr Valley; (2) to avail themselves of the electrical installations at the collieries in the district, as offered by the colliery companies upon certain terms; and (3) a scheme by which they could utilise water-power for driving turbines. The Committee, as there is an abundance of available water in the valleys, recommend the adoption of the latter scheme. The consideration of the question was adjourned for a fortnight.

ROCHDALE.—At the last meeting of the Watch Committee of the Town Council it was resolved to erect a public police and fire-alarm system in the town. The Committee have decided to adopt Messrs. W. A. Shaw and Co.'s system of electric alarms.

ST. PANCRAS VESTRY (LONDON, N.W.)—The annual report of Mr. A. E. Pycraft, the chief clerk to the Vestry's Electricity Department, has just been issued, and shows that considerable progress has been made in the supply of current during the period under review, the increase being set out as under:—

Number of consumers	44	per cent.
Sale of current at 6d. per unit	17½	„
Sale of current at 3d. per unit	212	„
Supply to private houses (exclusive of trade premises, &c.)	49	„
Number of lamps connected (equiv. 16 c.p.)	22	„
Highest load point	23	„
Total sale of current (excluding public lighting)	33	„
Money value of current consumed	26	„

In May last the total number of consumers was 373, the total current supply representing 16,751 16 c.p. incandescents, 129 arcs and 27 motors. But the large increase in consumption is specially noticeable in the private supply, evidencing a considerable increase in popularity for the light. After all charges for repairs and maintenance, including rates and taxes, have been paid, the balance available to meet interest and payments of the instalments on loans, and including the interest on the bank overdraft (amounting in all to £5,379. 19s. 2d.) is £7,233. 1s. 4d., or, after making proper provision for all debts, &c., a net profit on the year's work of £1,753. 18s. 2d., which is equivalent to 6 per cent. on the total capital expenditure, and would, if the undertaking were the property of a company be available for distribution amongst the shareholders. A considerable reduction has been made in the charge for public lighting, although additional lamps have been erected. This is owing to the reduction in the charge per unit from 6d. to 5d. for public lighting and to other economies. The report is throughout of an extremely satisfactory character, and the outlook for the Vestry's electric lighting scheme is described as most promising.

THE FIRE AT CROMPTON'S.—It is gratifying to announce that in spite of the damage caused by the recent fire at their Chelmsford works, Messrs. Crompton and Co. are still able to ensure prompt deliveries of some of their special manufactures, especially arc lamps and arc lamp accessories. This department not having been damaged is in full working order. The Company's installation department is also unaffected by the fire, as is also the heating and cooking department at 35, Queen Victoria-street, E.C. Immediate steps have been taken to resume the manufacture of dynamos, a considerable portion of the stock having been saved. In a circular to hand Messrs. Crompton and Co. ask for copies of any orders remaining unexecuted, statements of account and invoices, sketches, &c., to be supplied to them owing to the fire having completely destroyed all trace of these documents.

THE SOUTH STAFFORDSHIRE TRAMWAYS.—Some excitement has been caused in the Handsworth, West Bromwich and Tipton districts, through which the South Staffordshire Tramways Company's line passes, owing to the fact that the licence granted by the Board of Trade for the use of steam on these sections of the system will expire at the end of the current year. It would appear that the local authorities in the districts are not disposed to assist

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in obtaining further concessions for the Company, and that the Board of Trade has intimated that the traffic will cease unless the Company is prepared to introduce a new system at once. At a meeting of the Tipton Urban District Council on Tuesday it was announced that a syndicate had come forward which was prepared to discharge the liabilities of the present South Staffordshire Tramways Company, and to equip a portion of the line with cable and the remainder (that between Handsworth and Carter's Green) with the overhead electric system. The districts through which these sections of the Company's lines pass are densely populated, and a cessation of traffic would cause great public inconvenience.

TOTTENHAM (MIDDLESEX).—The General Purposes Committee of the District Council have presented a report on the electric lighting question, which states that unless there is a large demand for electric current for private lighting the cost of street lighting would be greater than that of gas. The Committee recommended that, in case the Council decided to proceed further with the matter, an electrical expert be appointed to prepare a report and devise an electric lighting scheme for the district. After considerable discussion, this report was adopted, and notice of motion was given for the next meeting that schemes, reports and estimates be invited from electrical engineers, and that premiums of £50, £30 and £15 be offered for the three best schemes.

WAKEFIELD.—A Local Government Board inquiry is to be held to-day (Friday) into the application of the Town Council for sanction to borrow £25,000 for electric lighting purposes.

WELLS.—At their last meeting the City Council formally resolved to apply for an electric lighting Provisional Order, and voted £50 as a deposit with the Board of Trade. The Sanitary Committee reported that as a result of their negotiations with the gas company they had offered their works to the Council for £19,680, and the Committee had offered £12,700, which the Company had declined. A proposition to offer £15,000 was rejected, and the negotiations between the parties are consequently, at an end—at least for the present.

WILMSLOW (MANCHESTER).—At the last meeting of the District Council a letter was read from Mr. S. V. Clirehugh, stating that he was acting on behalf of a company which was anxious to obtain powers to supply electric current in the Wilmslow district, and asking for the Council's consent to its application for a Provisional Order. After discussion a committee was appointed to confer with Mr. Clirehugh on the subject.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

November 4, 1895.

20,164A. S. O. COWPER-COLES, M. ULCOQ, W. M. GUTHRIE, and C. R. G. SMYTHE. London. Improvements in or connected with cathodes for use in the electrolytic deposit of metals.

20,790. F. E. W. BOWEN. London. Improvements relating to filaments for electric incandescent lamps.

20,801. O. VON MORSTEIN. London. An improved means for electrically lighting gas jets from a distance.*

20,807. R. MAYER. London. Process for the production of electrotypes or galvanos with engraved or sunk drawings or designs.*

20,815. E. T. MIDDLEMASS. London. Improvements in coin-released machines which are electrically driven.

20,821. V. FABRIS. London. An improved reflector for electric arc lamps.

20,824. W. GRIMES. London. Improvements in or relating to electric batteries.

20,828. W. ROWBOTHAM. London. Improvements in or relating to primary electric batteries.

20,835. A. J. P. WITAKER and F. G. TREHARNE. London. Improvements in or relating to insulating conduits or tubing and connecting boxes for containing electrical conductors.

November 5, 1895.

20,843. C. P. SHREWSBURY, F. L. MARSHALL and J. L. DOBELL. London. Improvements in electric batteries.

20,883. P. M. JUSTICE. London. Improvements in electric systems. (W. H. Nixon, U.S.A.)*

20,904. J. DEVONSHIRE. London. Improvements in controlling electric motors by the three-wire system. (W. B. Potter, United States.)*

20,917. E. BULSTRODE. London. An improved form of electric candle fitting.

20,923. W. P. THOMPSON. Liverpool. Improvements in electrical annunciators. (H. Buckner Higgins, United States.)*

20,924. W. P. THOMPSON. Liverpool. Improvements in electrical annunciators. (H. Buckner Higgins, United States.)*

20,925. E. BURNETT. Liverpool. Improvements in batteries or compounds bells applicable for pocket electric lamps and for other purposes.

20,926. R. BELFIELD. London. Improvements in block systems for electric railways.

20,928. J. JEFFRIES and J. LEA. London. Improved means and appliances for regulating the feed of carbons in electric arc lamps.

20,940. J. Y. JOHNSON. London. Improvements in printing telegraphs. (J. E. Woodbridge, United States.)*

November 6, 1895.

20,986. J. LENDERYON, JUN., and J. WILLIAMS, JUN. London. Improvements in collecting brushes for dynamo electrical machines, electrical motors and other electrical machines and apparatus.

November 7, 1895.

21,045. J. BROWETT and H. A. HENDERSON. Manchester. Controlling electrical switches.

21,050. L. MARCHLEWSKI and M. HERTZ. Improvement on the preparation of hydrosulphite of sodium by the electric current.

21,090. H. A. BESSEMER. London. Improvements in or relating to welding or joining together metals by electricity.

November 8, 1895.

21,137. G. H. NISBETT. London. Electrical tramway and railway conductors.

21,146. F. BATHURST and G. BINSWANGER. London. Improvements in the construction of tubes or conduits for electrical conductors.

21,153. F. M. LEWIS. Leeds. Improvements in or in connection with arc lamps.

November 9, 1895.

21,283. A. S. ELMORE. London. Improvements in the electro-depositing of metals. (J. O. S. Elmore, India.)

November 11, 1895.

21,357. E. J. P. MERCADIER and H. R. J. PIERQUIN. Liverpool. Improvements in or connected with telegraphy and telephony, and in electric relays for use therewith.

21,367. R. J. C. WOOD and E. J. MAYES. London. Improvements in electrical indicating and recording meters.

21,370. S. ALLINGHAM and W. A. CLATWORTHY. London. Improvements in and relating to rotating brushes, applicable to moving electrical generators, motors or machinery.

21,381. J. ROUBAL. London. Improved manufacture of carbon rods for arc lights.*

November 12, 1895.

21,433. R. G. EVERED. London. Improvements in the holders or carriers of electrical incandescent or glow lamps.

21,460. W. H. MORGAN. London. Improvements in electric controllers and reversing switches for electric motors.*

November 13, 1895.

21,498. W. H. CLEGG. Birmingham. Improvements in cabons for electric arc lamps.

21,543. C. D. ABEL. London. Improvements in apparatus for transforming continuous electric currents into alternating currents. (La Société Anonyme pour la Transmission de la Force par l'Electricité, France.)

21,556. W. P. THOMPSON. Liverpool. Improvements in microphones or telephone transmitters. (The firm of Hammacher and Paetzold, Germany.)*

21,586. J. McL. MURPHY, W. J. DIXON, and A. F. PIERCE. London. Improvements in electrical railway systems.*

November 14, 1895.

21,601. L. WHITE. Manchester. Electrical apparatus for destroying rats and like animals.

21,623. W. J. FOX. Manchester. Improvements in the fittings of electric lamps.*

21,657. F. C. CRAWFORD. London. Improvements in or relating to submarine telegraph cables.

21,664. R. H. FOWLER and C. J. HALL. London. Improvements in or relating to the running of alternate-current dynamo machines in parallel.

21,679. H. EDMUNDS. London. Improved means for use with electric cables for diverting the current through adjacent cables when required for repairs or other purpose.

November 15, 1895.

21,752. G. CUTHBERT. London. Improved system of using electric lights and other means of illumination.

21,759. F. W. ALLAN, A. POWELL, and C. J. TIBBITS. London. Improvements in electric storage batteries or accumulators.

November 16, 1895.

21,763. J. FAIRCLOUGH. Liverpool. Improvements in electric tramway or railway systems.

21,798. J. NICOLSON. London. Improvements in and connected with telegraph and other signals.

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SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1894.

20,170. ZERENER. Electrical soldering and welding apparatus.
20,746. VILLIERS-STEAD. Electrical prepayment gas meter.
21,855. ADAMS and CROMPTON. Dynamo-electric machine cylinders, &c.
22,458. KING. Electrically propelled carriage, &c.
22,460. KING. Electrically propelled vehicles.
24,908. BLACKBURN. Indicating, &c., electric currents.
25,079. BOULT (Spiro). Telegraphic transmitters.
25,623. ROGG. Electric call bell.

1895.

2,816. KING. Secondary batteries.
14,031. BOSSARD. Electro-plating, &c., devices.
15,069. BIGGAR. Telephony.
16,910. REGAN. Electric, &c., motors.
17,436. COX. Thermo-electric generators.
17,603. BAIR. Electric batteries.

NEW COMPANIES, STATUTORY RETURNS, &c.

APOSTOLOPF AUTOMATIC TELEPHONE PARENT SYNDICATE, (LTD.).—This Company was registered on November 19th, with a capital of £10,000, in £1 shares, to acquire patents, licences concessions, &c., conferring an exclusive or non-exclusive or limited right to use any invention which may seem to the Company capable of being profitably dealt with in connection with telephony, and in particular the Apostoloff Automatic Telephone invention, to construct, erect, use, maintain, lay down, carry out, work, sell, let on hire, and deal in telephones, and all kinds of works, cables, wires, lines, stations, exchanges, reservoirs, accumulators, lamps, meters and engines, and to carry on the business of a telephone, telegraph, and electric light, heat and power supply Company in all or any of its branches. The subscribers are:—

	Shares
Max Margowski, merchant	2,913
Honduras Government Banking and Trading Co. (Limited)	500
T. S. Hopcraft, gentleman	25
S. B. A. Apostoloff, telephone expert	1
J. W. Cohen, gentleman	25
H. E. Monington, gentleman	25
Arthur W. Cohen, gentleman	10
J. Herbert Farmer, solicitor	25

The first Directors are: Max Margowski, Joseph W. Cohen and T. S. Hopcraft.

BRITISH MOTOR SYNDICATE (LIMITED).—This Company was registered on November 21st, with a nominal capital of £150,000, in £1 shares, to carry into effect an agreement referred to in the Articles of Association, to use, develop, grant licences in respect of or otherwise turn to account any patents, brevets d'invention, licences, concessions, &c.; to manufacture, sell, or otherwise deal in motors of every description, cycles, vehicles, and carriages of all kinds, and to carry on the business of electricians, mechanical engineers, machinists, wire drawers, metallurgists, &c. The first subscribers, with one share each, are: H. J. Lawson, engineer; J. D. Newton, G. G. Hay, E. R. Baines, W. H. Robson, J. P. Aldridge and E. W. Pidgeon.

DAVY ELECTRICAL CONSTRUCTION COMPANY (LIMITED).—This Company was registered on November 19th, with a capital of £10,000, in £1 shares, to carry into effect an agreement made between William J. Davy and the Company to work and develop all or any of the properties by the said agreement agreed to be sold, and any other property hereafter acquired by the Company, &c. The first subscribers, with one share each, are: Arthur Simmons, W. A. Pittman, Edward A. Leadam, E. M. Slaughter, Reginald Young, Herbert J. Wells and A. J. Wells. The first Directors are: William T. Douglas, Ernest Berthier and William J. Davy.

LONDON AND PROVINCIAL TRACTION COMPANY (LIMITED).—This Company was registered on November 25th, with a nominal capital of £100,100, divided into 10,000 £7 per cent. cumulative £10 Preference shares and 100 £1 Ordinary shares, to enter into and carry out contracts, concessions, or other grants in Great Britain or elsewhere, for constructing, purchasing, or working railways, tramways, telegraph and telephone lines, electric lighting, electric, hydraulic, and other works, and for the equipment of any such undertakings or works with electric or other plant, stock and apparatus, and to carry on the business of contractors. The subscribers, with one share each, are: D. Parrish, A. Parrish, engineer, T. Werner, F. R. Harris, S. Neumann, L. Hirch, and H. R. Butin.

EASTON, ANDERSON AND GOOLDEN (LIMITED).—The annual return to November 13th has been filed. The nominal capital is £200,000, in 10,000 Preference and a like number of Ordinary shares of £10 each; 5,986 of the former and all the latter have been taken up, and 2,886 Preference and 9,320 Ordinary have been issued as fully paid. The full amount has been called on the remaining 680 Ordinary and 3,100 Preference shares.

MATHER AND PLATT (LIMITED).—The annual return to November 13th has been filed. The nominal capital is £200,000, in £10 shares, and 15,000 have been allotted, upon each of which £9 has been paid.

ELECTRIC ORGAN COMPANY (LIMITED).—The statutory return has just been filed. The nominal capital is £110,000, in 55,000 £6 per cent. Cumulative Preference and 55,000 Ordinary £1 shares; 23,389 of the former and 2,225 of the latter class have been allotted, and 10s. per share has been called.

DUTTON AND CO. (LIMITED).—The annual return to November 11th has been filed. The capital of £60,000 is divided into 500 Preference and 5,500 Ordinary shares, of £10 each; 285 of the former and 2,810 of the latter have been taken up, and 2,200 Ordinary have been issued as fully paid to the vendors. The full amount has been called on the remaining 285 Preference and 610 Ordinary shares.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30 1/16d. per oz. (Nov. 28th). Consols (2¾ per cent.) 107—107⅛ for money, 107—107⅛ for account; 2½ per cent. 104½—104¾ (Nov. 28th). Stock Exchange Settling Days: Consols, Dec. 2nd; Stocks and Shares Continuation Day, Dec. 13th; Ticket Day, Dec. 14th; Pay Day, Dec. 15th. Mining Share Carry-over Day, Dec. 12th.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended November 24th were £946, against £957 in the corresponding week of 1894, a decrease of £11. The total receipts for the half-year amount to £18,562, against £18,648 for the corresponding period of 1894, a decrease of £86.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—On another page of our present issue will be found a prospectus of an issue of £100,000 Five per Cent. Debenture Stock of the above Company, at the price of £128 per cent. This is the balance of the authorised issue of £400,000, and is redeemable by the Company at £125 per cent. after December 31, 1910, by six months' notice. Subscriptions are payable on the present issue—£10 on application, £38 (including premium) on allotment, £40 on March 31st next, and £40 on June 30th next, interest on the stock (exclusive of premium) commencing from the date of allotment, and from the dates when the respective instalments become payable. Interest on this issue is payable half-yearly in July and January. Applications from existing debenture-holders will receive preferential consideration. The Debenture Stock of the Company "operates as a first charge by way of floating security upon the whole undertaking and property of the Company, exclusive of the uncalled capital for the time being, in respect of any shares hereafter created and issued, and subject as to certain tubes for telephonic purposes to a contract relating thereto with the New Telephone Company (Limited). In the event of purchase by the Local Authority the Debenture Stock and the premium payable on redemption (£25) will constitute a first charge on the purchase money received." The prospectus sets out in some detail the revenue and expenditure of the Company. Lists of subscriptions for this issue opened yesterday at 10 a.m., and closes this day (Friday), at 4 p.m., both for town and country.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The transfer books of this Company will be closed from December 13th to 19th inclusive, preparatory to the payment of an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended September 30th last. The dividend is payable on December 20th.

DORMAN, LONG AND CO. (LIMITED).—The annual report of the Directors of this Company, after referring to the unexampled depression through which trade has passed, states: "One decidedly encouraging feature in the year's working is the large reduction in the cost of manufacture, due to the improvements of the last few years having come into full operation. This is seen in the fact that nearly the whole of the profit has accrued during the last six months of the financial year, although the prices then realised were lower than over the first six months. The saving effected by the expenditure during 1894 in applying electrical power to the outlying machinery was found to be so satisfactory that your Directors felt justified in a further outlay in this direction, and hence the greater part of the capital expenditure this year is for electrical machinery. Up to the present time the total amount spent on this head is about £8,000, and the saving is at the rate of £3,000 to £4,000 a year, in addition to increased efficiency."

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 24th inst. amounted to £1,067. The amount for the corresponding week last year was £913; increase, £154.

MESSRS. R. HORNSBY AND SONS (LIMITED).—In addition to the usual payment for the half-year ended September 15th, on the Preference Stock of this Company, the Directors propose a division of 4s. per share on the Ordinary shares for the year ended September 30th.

ROYAL ELECTRIC COMPANY OF MONTREAL.—During the week Messrs. Coates, Son and Co., on behalf of this Company, invited applications for £34,000 sterling Four and a-Half per Cent. First Mortgage Debentures, being the balance of an authorised total issue of $750,000 (£154,000), the first portion of which was offered for subscription in November, 1894. The authorised capital of the Company is £1,500,000, and the paid-up capital $1,000,000. The present debentures were issued at 105, and are redeemable by annual drawings at 105, or on six months' notice at 110.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended November 22nd, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,049.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Nov. 20.	Price Wednesday, Nov. 27.	Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending Nov. 23. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	10/0	Anglo-American	43 45	44 46	4 17 10	Jan., Apr., July, Oct.	.. ..	.. ..
£2,993,560	Stock	20/0	Do. Preferred	82½ 83½	84½ 85½	5 5 2	" " "	83½	82½
£2,993,560	Stock	5/0	Do. Deferred	6 6½	6½ 7	..	" " "	6⅞	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	101 105	101 105	3 17 1	January and July	.. ..	.. ..
120,000	£10	5/0	Brazilian Submarine	12 13½	13 13½	5 3 8	Mar., June, Oct., Dec.	13½	13
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111 115	111 115	4 8 4	June and December	.. ..	.. ..
10,000,000	$100	$1½	Commercial Cable Capital Stock	164 168	164 168	4 3 10	Jan., Apr., July, Oct.	.. ..	.. ..
16,000	10	8/0	Cuba Submarine	13 14	13 14	5 14 4	February and August	13	⅛
6,000	10	10%	Do. Preference 10 per Cent.	21½ 21½	20½ 21½	4 13 0	" " "	.. ..	.. ..
12,931	5	2/0	Direct Spanish (fully paid)	3½ 4½	3½ 4½	4 8 11	April and October	.. ..	.. ..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 5 3	" " "	.. ..	.. ..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104% 107%	104% 107%	4 6 9	" " "	.. ..	.. ..
60,710	20	2/0	Direct United States Cable, 1877	8½ 8⅝	8½ 8⅝	4 11 5	Jan., Apr., July, Oct.	8 7/16	.. ..
400,000	10	2/6	Eastern	16 16½	16 16½	3 18 9	" " "	16⅝	16½
70,000	10	6%	Do. 6 per Cent. Preference	17⅛ 18	17⅛ 18	3 6 8	" " "	18	17⅛
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	125 128	125 128	3 2 6	May and November	127	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 12 2	February & August	.. ..	.. ..
250,000	10	2/6	Eastern Extension	17½ 17⅝	17 17⅛	4 0 0	Jan., Apr., July, Oct.	17⅛	17½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	124 129	126 129	3 2 6	February & August	.. ..	.. ..
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103 107	102 106	4 16 2	January and July	106	103
£80,630	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103 107	102 106	4 6 2	" " "	.. ..	.. ..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108 111	108 111	3 12 9	February & August	.. ..	.. ..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	113% 115%	113% 115%	3 9 7	May and November	.. ..	.. ..
180,227	10	1/8	Globe Telegraph and Trust	9½ 10	9½ 10	4 5 0	Jan., Apr., July, Oct.	9⅛	9½
180,042	10	6%	Do. 6 per Cent. Preference	16 17	16½ 17	3 10 7	" " "	16⅞	16½
150,000	10	5/0	Great Northern	21½ 22	21½ 22	3 17 3	Jan., April, and July	22⅛	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	104 107	104 107	4 14 4	March & September	104⅛	..
17,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	49½	48
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" " "	.. ..	.. ..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 110	106 110	5 10 10	March & September	.. ..	.. ..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	109 112	102 112	3 12 3	.. .. ..	.. ..	.. ..
11,639	8	4/0	Reuter's	5½ 6½	5 6	..	April and October	.. ..	.. ..
3,381	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	127 132	127 132	4 10 11	" " "	129½	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	..	January and July	.. ..	.. ..
£223,300	100	5%	* Do. 5 per Cent. Debentures (red.)	103 106	103 105	4 16 5	March & September	.. ..	.. ..
30,000	10	2/0	West Coast of America	1 2	1 2	..	January and July	.. ..	.. ..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	98 103	98 103	7 19 3	June and December	101½	..
88,321	10	1/8	West India and Panama	¾ 1	¾ 1½	..	.. .. ..	⅞	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	May and November	10 7/16	10⅛
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½ 9½	8½ 9½	6 6 4	" " "	.. ..	.. ..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	111 114	111 114	4 9 1	June and December	.. ..	.. ..
64,242	15	6/0	Western and Brazilian	9⅜ 10½	9⅜ 10½	4 17 0	May and November	9⅝	..
33,129	7½	4/6	Do. 5 per Cent. Cumulative Preferred	6½ 6⅞	6½ 6⅞	—	—	6⅞	6½
33,129	7½	1/6	Do. 5 per Cent. Deferred	3½ 3⅝	3½ 3⅝	—	—	.. ..	.. ..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 14 3	February & August	.. ..	.. ..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 14 3	" " "	.. ..	.. ..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	110 115	110 115	6 1 9	May and November	.. ..	.. ..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	160 163	160 163	5 18 10	March & September	.. ..	.. ..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3½ 3⅝	3½ 3⅝	..	—	.. ..	.. ..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16 1/8	1/16 1/8	..	May and November	.. ..	.. ..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	1/16 1/8	1/16 1/8	..	Yearly	.. ..	.. ..
£84,597	5	2/6	National	6 6½	5½ 6⅛	3 1 6	June and December	6⅛	5⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" " "	.. ..	.. ..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15 1/16 16 1/16	15⅛ 16⅛	3 12 9	" " "	.. ..	.. ..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6½ 6⅝	6½ 6⅝	3 16 11	—	6 7/16	6⅜
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	105 107	105 107	3 6 4	January and July	107	105
58,000	5	3/0	United River Plate	2⅜ 3⅛	2⅜ 3	..	" " "	2 7/16	..
£146,783	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	92 97	92 97	5 5 6	" " "	.. ..	.. ..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12⅝ 13⅛	13 13⅛	1 17 0	—	13⅛	13
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15⅝ 16⅛	15⅝ 16⅛	3 13 10	—	16⅛	15⅝
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	131 135	134 136	3 14 9	June and December	135	134
19,900	£5	..	Electricity Supply Co. for Spain	— —	.. ..	..	—	.. ..	.. ..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5⅛ 5⅜	5⅛ 5⅜	..	—	.. ..	.. ..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	— —	— —	..	—	.. ..	.. ..
8,322	£5	..	House-to-House Electric	— —	— —	..	—	.. ..	.. ..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	— —	— —	..	—	.. ..	.. ..
19,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July	.. ..	.. ..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 8⅛	7⅞ 8⅛	..	—	.. ..	.. ..
111,000	5	..	London Electric Supply	.. ..	.. ..	..	—	.. ..	.. ..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	10½ 11½	10½ 11½	2 12 2	—	11 7/16	10
150,000	Stock	4½%	* Do. 4½% Debs.	117 120	117 120	3 16 3	June and December	1.8½	..
6,452	£10	2/0	Notting Hill Electric	8½ 9½	8½ 9	..	—	.. ..	.. ..
..	..	..	Rand Electric	1/16 ¼ prem	¼ ⅜ prem	..	—	.. ..	.. ..
19,980	£5	2/0	St. James and Pall Mall	8 8½	8 8½	..	—	8⅝	8½
20,000	£5	7%	Do. 7 per Cent. Preference	9 10	9 10	3 10 0	—	9½	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8 8½	8 8½	3 2 10	—	8 7/16	8
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1½ 1⅝	1½ 1⅝	10 0 0	—	.. ..	.. ..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝ 2⅛	1⅝ 2⅛	5 12 11	—	.. ..	.. ..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 19 0	March & September	.. ..	.. ..
28,.80	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	1½ 2½	2 2½	..	January and July	.. ..	.. ..
89,261	5	1/6	Edison and Swan United	1⅝ 2⅛	1⅝ 2⅛	..	.. .. ..	⅛	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 5 9	.. .. ..	.. ..	.. ..
£10,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	— —	.. ..	..	.. .. ..	.. ..	.. ..
110,000	2	..	Electric Construction	⅝ ¾	⅝ ¾	..	.. .. ..	13/16	⅝
12,845	2	2/9½	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 11 0	.. .. ..	.. ..	.. ..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅝	⅜ ⅝	..	.. .. ..	.. ..	.. ..
20,000	5	..	Fowler-Waring Cables (fully paid)	⅛ ¼	⅛ ¼	..	.. .. ..	.. ..	.. ..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	18½ 19½	18 19	3 18 11	February & August	19	18½
£300,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101 103	101 103	4 8 0	March & September	.. ..	.. ..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	..	—	.. ..	.. ..
15,000	£10	..	Do. 8 per Cent. Preference	— —	.. ..	..	December and June	— —	— —
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	½ ½	½ ½	..	.. .. ..	.. ..	.. ..
37,350	12	12/0	Telegraph Construction and Maintenance	40 42	39 41	5 17 0	March and July	41½	40½
£150,000	100	5%	* Do. 5 per Cent. Bonds	104 107	104 107	4 15 6	January and July	.. ..	.. ..
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	..	.. .. ..	.. ..	.. ..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	.. .. ..	.. ..	.. ..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	14 14½	14 14½	4 2 9	—	14½	..
£30,000	10	7/0	Do. 7 per Cent. Preference	15½ 16½	15½ 16½	4 4 0	—	16½	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108 111	108 111	4 1 11	—	.. ..	.. ..
			RAILWAYS AND TRAMWAYS.						
£380,000	Stock	1½%	City and South London Railway	40 42	40 42	2 19 6	May and November	40	..
7,650	10	5%	Do. 5% Perpetual Preference	14½ 15½	14½ 15½	3 5 7	.. .. ..	14½	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	132 134	130 132	3 0 9	May and November	.. ..	.. ..
37,500	£10	2½%	Liverpool Overhead Railway	11⅛ 11½	10⅞ 11	2 0 11	—	— —	— —
10,000	10	5%	Do. 5% Preference	15½ 15⅝	15½ 15⅝	3 3 6	—	.. ..	.. ..
148,000	Stock	4%	Do. 4% Debenture	112 114	113 115	3 9 7	January and July	.. ..	.. ..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

THE Committee, consisting of Lord Kelvin, Mr. Preece and Major CARDEW, appointed by the Board of Trade to advise it in the matter of the definition of "low pressure" has reported, and the result may be expected to be made public in the course of next week. We believe the decision arrived at will be generally acceptable.

THE members and associates of the Institution of Electrical Engineers were made acquainted on Tuesday morning, by the receipt of the balloting list for Council and officers for the year 1896, with the withdrawal of Sir DAVID SALOMONS' candidature and the substitution therefor of that of Dr. JOHN HOPKINSON, our President in 1890. The avoidance, even at the eleventh hour, of a contested election is undoubtedly a matter for general congratulation; nevertheless, members of the Institution will do well not to rest and be thankful. Had not the so-called election of Council been converted into nomination by Council the recent Presidential crisis would not have arisen. It is within the power of the members of the Institution to remedy this state of things. A simple way out of the difficulty would be to give groups of members who may consider themselves under-represented or otherwise aggrieved ample time to formulate their grievance and nominate their champion. At present a week or ten days is all that intervenes between the receipt of the Council's List and the Annual General Meeting, a period within which it is quite impossible, as the Council know full well, to make any effective counter-proposals. The Council's List should be prepared and circulated not later than the date of the first autumn meeting. Members of the Institution are amused with the appearance of free choice, but carefully deprived of any real voice. No institution deserves to thrive under such a system. The argument that it works well, notwithstanding its theoretical defects, is no longer tenable.

IN another column we publish in full a valuable report on the comparative cost of gas and electric lighting, which has recently been prepared by Mr. A. P. TROTTER at the instance of the Hastings and St. Leonards Electric Light Company. The genesis of this report is somewhat interesting. A local critic was persuading the Hastings public that electric lighting cost three times as much as gas lighting. The Electric Lighting Company, although quite ready to admit that electricity might be somewhat more expensive than gas, declined to sit quiet under this absurd allegation, and decided to call in an expert to thoroughly sift the matter, with the result that the Company has not only rebutted a groundless charge, but has shown, in a manner to be understood of all people, that under practical working conditions and at average prices electric lighting is, to put the matter in its lowest terms, no more costly than gas lighting. In arriving at this conclusion the advantages arising from the lessened cost of re-decoration, from the absence of injury to delicate goods, and from the increased healthiness and coolness of the air, have not been taken into account; not but that it would be perfectly legitimate to do so, although it is exceedingly difficult to accurately assess the money value of such advantages.

ALTHOUGH the Hastings gasophiles have good reason to regret they ever made exaggerated charges against glow lamp lighting, they may perhaps seek consolation from Mr. TROTTER'S figures with regard to the Hastings sea-front arc lights. But on closer examination we do not think they will find much wherewith to console themselves, even here. Taking the Incandescent Gas Light Company's own figures for gas consumption, candle-power, and renewals, a *naked* 500 c.p. light for one hour would cost 1·43d., with gas at 3s. a thousand, *exclusive* of cost of lamp lighters, cleaners, damages by wind and water, repairs, interest on capital outlay. The alternating arcs at Hastings, which absorb 600 true watts and give a mean light of about 500 candles, cost 1·95 per hour, *including* carbons, trimming, cleaning, repairs, and interest on capital outlay. If a more impartial source than the Incandescent Gas Light Company could be found for figures relative to gas consumption, &c.; if the items included in the cost of the arc light were also included in the cost of the incandescent gas light; and if absorption by lanterns and diminution of the luminosity of the mantles with time were taken into account, the difference of 0·52d. in favour of the "Welsbach" light would assuredly disappear. It is evident from this that the relative cost of the two systems of street lighting when good continuous-current arcs are used would be in favour of electricity.

THE simple formula given by Mr. TROTTER will enable anyone knowing the facts of the case to compute for himself the comparative cost of gas and electric lighting. At present gas enthusiasts at one end of the scale talk of electric lighting

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being n times more expensive than gas lighting, n being, as a rule, an integer greater than three, and at the other end of the scale we have electrical engineers asserting that electricity is the poor man's light, implying thereby that electricity is cheaper than oil. Mr. TROTTER rightly insists on the immense importance, among the three factors that go to make up the total cost of electric lighting, of the watts per candle. We hear much about reductions in the price of the Board of Trade unit, and rejoice exceedingly thereat, little recking that a reduction from 8d. to 4d. may be, so far as the consumer is concerned, largely neutralised by the substitution of a batch of 4-watt lamps for a batch of 3-watt lamps. The careful control which many supply concerns exercise over the quality of the glow lamps used by their customers is quite to the interest of the consumer.

GAS-DRIVEN tramcars have proved such a failure in this country that the advocates of this mode of propulsion must find comfort in the fact of the Dessau gas tramcars having been run successfully for a whole year. The Dessau line was 2¾ miles in length when opened in November of last year; but it proved so popular that it was soon extended to nearly 4 miles. The present equipment includes nine 7 H.P. cars, four 10 H.P. cars and four trailers. The amount of gas actually consumed in the engines on the cars has averaged 26·6 cubic ft. per car mile, to which, however, must be added 4·46 cubic ft. used in the engines driving the gas compressors. The total consumption of gas, therefore, has averaged 31·06 cubic ft. per car mile. At 2s. 6d. per 1,000 cubic ft., this represents a cost of fuel equal to 0·932d. per car mile. If it can be shown that what has been done at Dessau can be done elsewhere and wherever there is cheap town gas, the battle between gas and electric cars will evidently have to be fought on other issues than the cost of fuel. There still remains, however, for electrical engineers the comforting fact that gas cars have had more than one genuine trial in this country, and that they have always turned out to be genuine failures.

MR. FERNANDO SANFORD is again to the fore with his hypothesis of a "Variation in Electrical Conductivity of Metallic Wires in Different Dielectrics"; and in the current number of the *Physical Review* he makes further advance in his theory. The notion that the resistance of a conductor depends on its dielectric environment has no more to do with the truth or otherwise of OHM's law than tinning the surface on copper wire has to do with the same principle of current flow. Mr. SANFORD'S hypothesis, which he conceives to involve a modification of this law, has been attacked, he says, on both theoretical and experimental grounds. We ourselves, in our issue of January 13, 1893, expressed our doubts on the latter ground. But, is it wise to attack any such hypothesis as this deductively? Are we, that is to say, so perfectly informed of the mechanism of the relationship between a conducting wire and its dielectric environment, that we can venture to deduce, without experiment, that no such variation as Mr. SANFORD supposes can take place? We prefer to believe that the existence of such a variation must stand or fall by a purely experimental test. In research work inductive evidence has always proved a safer instrument than abstract reasoning.

IN regard to our previous suggestion that the variations of resistance might have arisen from unrecognised changes in the temperature of the wire, Mr. SANFORD has prepared a table to show each observed change of resistance and the corresponding temperature variation which would account for it. The latter is of the order of 0·5 degree, and should be easily measured, so that the question narrows down to this: Do the changes of resistance, from whatever cause arising, actually take place to the extent tabulated by Mr. SANFORD? We are not prepared to pass judgment upon Mr. SANFORD'S experiments, as they stand at present; they are by no means convincing either way, but we think there is enough in them to justify further investigation of the matter. One thing seems pretty certain—namely, that if any effect there be it must be a skin effect. We would suggest, then, that the variation of resistance of conductors of equal section, but arranged to expose different amounts of surface to the dielectric, should be investigated.

AN article in a recent number of the *Electrical Engineer* of New York, from the pen of Mr. W. S. HORRY, describes a method of running arc lamps in series on an alternating-current system, to which the name of "reactance" system has been applied. We have here a modification of the old series transformer system, the transformers being replaced by choking coils, or as it is now more fashionable to call them, reactance coils, shunted by arc lamps. It will be seen at once that this loses the advantage possessed by the transformer method, of isolating each lamp from the high-pressure conductor. The simplest arrangement, in the reactance system, is a series of arc lamps with a choking coil in shunt with each lamp. In a modification, a portion of the choking coil is connected in series with the arc, the remaining portion serving as the regulating shunt. Choking coils are, and always have been, wonderfully efficient devices—on paper. "The efficiency of the device," says Mr. HORRY, "may be dismissed with a very few words. The amperes that flow through the coil are almost entirely wattless, and the whole device is exceedingly efficient." After this, it is somewhat curious to read that "the iron in the core of course gets hot, and for this reason only very little iron is employed—highly saturated." We commend this novel method of reducing iron losses to Prof. EWING!

Cable Interruptions and Repairs.—There are no cable interruptions or repairs to record.

The Coventry Electric Tramways.—As the result of the Board of Trade inspection on Friday last, a certificate has been issued, and a start has been made in running cars for general traffic.

Appointment.—We have great pleasure in announcing that the appointment of Electrician and Inspector to the Government of Cape Colony, a post which has been created by the Electric Lighting and Power Act of the present year, has been conferred on Mr. A. P. Trotter. Mr. Trotter will probably sail early in January.

Royal Society.—The following Papers were down for reading at the Royal Society yesterday:—H. C. Leake, R. Leventhorpe,

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and C. S. Whitehead: "The Measurement of High Potential Difference." Prof. Ayrton, F.R.S., and W. R. Cooper: "Variations in the Electromotive Force of Clark Cells with Temperature."

Damages for Injuries Caused by the Electric Current.—The New Jersey Court of Appeals has just confirmed the verdict of a lower court by which a lineman, who lost an eye and was terribly burned by the electric current while working for the Western Union Telegraph Company, was awarded £5,000 damages.

"Aluminium and Electrolysis."—This is the title of a new monthly technical and scientific journal intended for those interested in the development and manufacture of aluminium, and in electrolysis, electricity, civil and mechanical engineering chemistry and the electro-deposition of metals. The editor is Mr. A. H. Vesey.

Royal Institution.—The following are some of the lecture arrangements before Easter: Prof. John Gray McKendrick will give six lectures (adapted to a juvenile auditory), "On Sound, Hearing and Speech" (experimentally illustrated); Lord Rayleigh will deliver six lectures on "Light," The Friday evening meetings will begin on January 17th, when a discourse will be given by Lord Rayleigh on "Argon."

Chatham.—On Thursday last week two men, in passing along the High-street, at the bottom of Clover-street, Chatham, happened to step at the same time on the lid of one of the Electric Light Company's junction boxes. Both men received a severe shock and were knocked down. The men who were knocked down were so frightened that they got up and ran away. The employés of the Company were immediately at the spot, and remedied the defect.

Electric Traction on the Dublin Southern District Tramways.—The Dublin Southern District Tramways Company have almost completed their electric system from Haddington-road to Kingstown and Dalkey. On Saturday evening last, at the invitation of Mr. J. Clifton Robinson, Managing Director of the Southern District Tramways Company, a number of people made a trial trip from the power house at Ballsbridge to Kingstown on one of the new electric cars. All along the route to Kingstown and back the progress of the visitors was greeted with enthusiastic cheers from crowds of bystanders, and when Kingstown was reached quite a big gathering welcomed the appearance of the car. Now that the line has been completed as far as Kingstown it is proposed by the Managing Director to continue these series of trial trips until everything in connection with the work has been completed before announcing the formal opening for passenger traffic. In the meantime the members and officials of the local authorities have been invited to visit the power house and to participate in the experimental journeys between Haddington-road and Kingstown.

Overhead Trolley Work.—The *Builder*, speaking of the Coventry electric tramway, says:—"The overhead work is a very good object lesson to town councillors and others, as almost every variety of method is employed. For the first part of the route the trolley wire is supported by span wires, stretched between plain tubular posts situated on each side of the street, a primitive method long since discarded by every self-respecting town in America. Next it passes Grey Friars Green, and along here the wire is suspended from single bracket standards, which form part of the railings, the effect being not unpleasing. However, span wires are soon resorted to again, the wires in many cases being fixed to rosettes bolted to houses on opposite sides of the street, special precautions being necessary to prevent the vibration of the trolley wire being communicated to the houses. There seems to have been very little attempt at either uniformity or elegance, the methods of suspending the wire proving the ingenuity of engineers to whom economy and efficiency were the only considerations. The principal lesson to be learned from this tramway is that the 'overhead work' is the most important from the citizen's point of view, and that this part of the work should be supervised by someone who has some respect for the most elementary principles of art."

Obituary.—We greatly regret to have to announce the death of Mr. Denny Lane, which took place last Friday. Mr. Lane was for many years secretary of the Cork Gas Company and Chairman of the local School of Science. He had formerly been President both of the Cork Literary and Scientific Society and of the Gas Institute. He was a man of large intellectual interests and many parts; and his loss will be felt not only among his friends in the gas industry, but also among electrical engineers. He ever took an interest in the progress of electrical science and its applications, and more particularly in that happy union of gas and electrical interests which is to be found in the gas engine station, a type of station which Mr. Lane was the first to advocate (see *The Electrician*, Vol. XXVII., p. 578). The contributions, from time to time, to our correspondence columns, also served to show that his interest in electrical matters was an active one. Mr. Denny Lane was in his 77th year.——We also regret to announce the death of Mr. John Muirhead. A share may be claimed for him in the design and introduction of the duplex system of submarine telegraphy, with which the name of his distinguished brother, Dr. Alexander Muirhead, is also associated.

Lengths of 500-Volt Arcs.—The Chicago insurance companies have recently made some experiments with a view of fixing practical distances between different parts of 500-volt switches, cut-outs, &c., with the object of avoiding the production of an arc when the circuit is broken, and also to prevent the spontaneous development of arcs should two points be too close together. We give below the figures obtained:—

Current.	Maximum distance at which the arc is produced (spontaneously).	Minimum distance at which no arc is observed (on breaking circuit).	Working distance.
	Inch.	Inch.	Inch.
10	0·25	0·25	1·0
20	0·50	0·76	2·0
30	1·20	2·00	2·7
40	2·00	2·24	3·2
50	2·24	2·52	3·5
60	3·04	3·24	3·7
70	3·04	3·40	4·0
80	3·32	3·60	4·1
90	3·56	3·84	4·4
100	3·80	4·00	4·5

Conference on Light Railways.—On Thursday last week a large gathering of gentlemen interested in the subject of light railways and their promotion by means of legislation assembled at the Westminster Palace Hotel. The chair was taken by Sir A. Rollit, M.P. Major Rasch, M.P., moved: "That this Conference heartily approves the establishing of light railways under an improved system of procedure and regulations, and with State and local aid to private enterprise; and urges Her Majesty's Government to introduce proposals for legislation on the subject at the earliest possible opportunity during the ensuing Session of Parliament." Mr. Vaughan Davies, M.P., moved: "That those present form themselves into an association, with power to add to their number, to promote the object of the previous resolution, and that Mr. J. Wallis Davies be appointed secretary." Sir J. Szlumper moved and Sir M. Lloyd seconded the appointment of a committee to examine the report of the conference called by the late Government and the Bill subsequently introduced, to formulate general detailed proposals, and to report. Mr. Squarey moved: "That the Conference be again called to consider the report of the committee, and that at such adjourned meeting a deputation be appointed to wait upon the Government in order to urge the necessity of legislation on the lines approved."

Conduit Electric Traction System at Washington, U.S.A.—The Connett conduit system, adopted by the Metropolitan Company of Washington, has attracted a good deal of attention in America, and a short description may therefore be of interest. The system employed differs from the Budapest one in the following points: The conduit is placed in the centre of the track, instead of in one of the rails; T-shaped iron conductors fixed at the top of the conduit are employed instead of angle irons arranged at the sides of the conduit, and

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further a different contact mechanism has been adopted. The slot rails are Z-shaped and provided with a drip flange, which prevents the water from running down the sides of the conduit and reaching the insulators. They are braced to the grooved car rails by heavy tie rods above each yoke, and secured at the base to cast yokes placed 4½ft. apart. The conduit chamber is of concrete, and a drainage pit is provided every 300ft. to 400ft. The conductors are supported by rods screwed into porcelain insulators, which in turn are cemented on to iron cups firmly fastened to the base of the slot rails. Between the faces of the conductors a collecting plough passes. A pair of levers prevents a vertical play of the shoe, and a flat spring presses it well against the face of the T bars. A flexible conductor connects the shoe with the leads. There are four miles of double track put down at present, and though the power house is situated at one end of the line the maximum drop of potential is but 20 volts on the working pressure of 500 volts.

Engineering at Cambridge.—The report to the Senate of the Engineering Laboratory Syndicate, dated November 9, 1895, is, says *Nature*, a very satisfactory record of energetic work. The University was unable to provide more than £1,000 for the building and equipment of the laboratory, which was estimated to cost about £6,000. By steady and enthusiastic efforts Prof. Ewing and his colleagues succeeded in collecting from many sources, within and without the University, the £5,000 that were needed; and what is still more to their credit, have completed the work in hand with a small balance to the good. The continued growth of the department, in which there are now 85 students under instruction, makes a further extension of the buildings urgently necessary. A site has been provided for the purpose, but further funds are needed for construction. The workshops, never intended to be other than temporary, must soon be rebuilt and more lecture-room accommodation must be provided. The department has certainly justified its existence, and the Syndicate have proved themselves to be worthy stewards of the funds placed at their disposal. It is to be hoped that, with these guarantees that they will be well used, the needful moneys may ere long be forthcoming. The valuable services of Mr. Dalby and Mr. Lamb, the demonstrators of mechanism and engineering, in the work of organising the laboratory, are mentioned with cordial appreciation in the report. Among the donors of contributions of over £100 are the Duke of Devonshire, the late Earl of Derby, Mr. Frank McClean, and Dr. John Hopkinson, and eleven benefactors have given £100 each. Valuable donations of apparatus and of books have helped greatly towards the furnishing of the laboratory.

Glow Lamp Patent Litigation in the United States.—On November 11th the United States Supreme Court gave judgment in an action in which the fundamental Edison glow-lamp patent was challenged. The action was nominally the Consolidated Electric Light Company *v.* the McKeesport Light Company, but the real defendant was the General Electric Company and the real plaintiff the Westinghouse Electric and Manufacturing Company, which now owns the Sawyer-Man patents. The first claim of the Sawyer-Man patent, No. 317,076 of 1885 (U.S.A.) was for "an incandescing conductor for an electric lamp of carbonised *fibrous or textile material.* . . ." It was argued that the carbonised bamboo conductor used by Edison was an infringement of the claim for "carbonised fibrous or textile material." This contention did not meet with the approval of the Court of First Instance, and the Sawyer-Man patent was declared invalid; the plaintiffs thereupon appealed to the Supreme Court, which also decided against the validity of the patent. The argument of the Supreme Court was as follows:—Sawyer and Man supposed they had discovered in carbonised paper the best material for an incandescent conductor. Instead of confining themselves to carbonised paper, as they might properly have done, and in fact did in their third claim, they made a broad claim for every fibrous or textile material, when in fact an examination of over 6,000 vegetable growths showed that none of them possessed the peculiar qualities that fitted them for that purpose. Was everybody, then, precluded by this broad claim from making further investigations? Only if the patentees had discovered in fibrous and textile substances a common quality peculiarly fitting them for incandescent conductor purposes, would a broad claim such as they made have been sustainable.

Accumulator Tests in Germany.—At the laboratory of the Technical High School of Karlsruhe some tests were made a little time ago on behalf of the State Railway of Baden, with cells for a discharge rate of 1,000 amperes down to 1·8 volts, and with a guaranteed capacity of 3,000 ampere-hours. The competitors were the Accumulator Company of Hagen, Westphalia, Gottfried Hagen of Kalk, near Cologne, and the Electricitäts-Gesellschaft Gelnhausen. The tests lasted about two months, and the results are given in the following tables:—

Normal discharges at 1,000 amperes down to 1·8 volts. Guaranteed capacity 3,000 ampere-hours.

	Hagen. Amp.-hours.	Kalk. Amp.-hours.	Gelnhausen. Amp.-hours.
February 13th and 25th	3,900	2,000	3,500
March 16th	3,033	2,583	3,350
March 29th	2,500	2,333	3,250
April 20th.....	3,133	3,484	4,144
Discharge (March 15th) at 1,500 amperes.			
Potential fell to 1·8 volts in.....	88min.	72min.	100min.
Capacity (ampere-hours).....	2,175	1,800	2,500
Discharge (March 28th) at 2,000 amperes.			
After 82min. potential is.....	0·060 volt	0·280 volt	1·715 volt
Discharge (April 24th) at 4,000 amperes.			
Potential fell to 1·70 volts in ...	10min.	10min.	25min.
Capacity (ampere-hours).....	667	667	1,667
Discharge (April 25th) at 5,280 amperes.			
Potential fell to 1·66 volts in ...	5min.	5min.	15min.
Capacity (ampere-hours)	440	440	1,320
Discharge (March 19th) at 400 amperes.			
Potential fell to 1·8 volts in.....	11h. 40min.	9h. 30min.	14 hours.
Capacity (ampere-hours).....	4,667	3,800	5,600

It may be added that the "Hagen" cell is of the "Tudor" type and the "Kalk" cell is of the "grid" pattern, whilst the "Gelnhausen" are so-called "Bleistaub" (lead dust) accumulators.

Contemporary Electrical Science.—*Wiedemann's Beiblätter*, No. 10, contains a good selection of electrical abstracts from various remote sources.——M. Töpler has endeavoured to supply all the links connecting condenser oscillations with Tesla's experiments. The oscillations were transformed to lower and to higher pressures respectively. In the former case several new phenomena were observed which had not as yet been produced with electrostatic apparatus. In transforming up, all Tesla's experiments could be reproduced. Iron cores diminished the induction of these high-frequency currents.——K. A. Holmgren, of Lund, has studied the electrification of air issuing from water, and obtained differences of potential of 70 volts. He also obtained electrification by a rod dipping into water and thrown into oscillations. The vessel containing the water assumed a positive charge.——M. Reiner describes a new method of measuring the potential of a metal immersed in a liquid. The liquid is put to earth by a wet thread, and the metal connected with an electrometer. Copper in copper sulphate is positive.——A. Bartoli found that both methyl alcohol and sulphurous acid possess a certain conductivity which disappears at their critical temperature, but reappears on cooling.——Signor Majorana has investigated the formation of cuprite, Cu_2O, by the electrolysis of $CuSO_4$. When a small current is passed through dilute $CuSO_4$, acidulated with sulphuric acid, ruby-red crystals of cuprite are formed, especially when the solution is heated.——H. Luggin tested the capillary electric phenomena of molten lead covered with fused potassium and lithium bromides, and mercury covered with potassium and sodium nitrates. The capillary constants attain a maximum at lower differences of potential in iodides than in bromides, and lower in bromides than in chlorides. Helmholtz's and other theories do not agree with the facts.——E. Wiedemann describes a new kind of ray observed in spark discharges. He calls these rays discharge rays. They are not deflected by a magnet, and therein they differ from cathode rays. They more resemble the rays found in the positive light. They are characterised by the bright "thermo-luminescence" which they produce in $CaSO_4$ mixed with a little $MnSO_4$ or in the corresponding carbonates. They are absorbed by fluorspar, but not by air. Hence they are not extreme ultra-violet rays.

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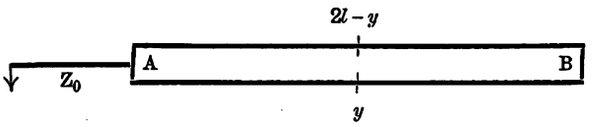
ELECTROMAGNETIC THEORY.—LXXIX.*

BY OLIVER HEAVISIDE.

(*Continued from page 113.*)

§ 313. The last examples sufficiently indicating the connection between the main solution for the cable itself and the terminal arbitraries, we may pass on to another minor matter. If the cable ends A and B are joined, either directly or through apparatus, with or without an earth connection at the same place, the two conditions expressing V/C at the terminals independently of one another are replaced by two conditions of a different kind. Some difference in the treatment is, therefore, needed. It is not great, and may be readily inferred from the preceding.

Take an explicit example. Let the length of the cable be $2l$. At B, where $x=l$, there is simple continuity, without imposed condition. At A, where $x=0$ or $2l$, there is a shunt or leak to earth. It is any sort of leak, defined by a resistance



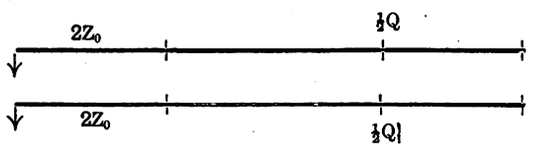
operator Z_0. We have to see how this arrangement will behave. We may consider three sorts of problems: the diffusion of a point charge initially at y, which will give, by integration, the effect of any initial state of the cable; the effect of an impressed force anywhere; and the effect of terminal energisation, when Z_0 is of a suitable kind. The last, however, may be inferred from the solution for an initial state in the cable, so we need not consider it specially.

As regards Q at y. By inspection of the above diagram, and a little thought, we may split the problem into two, of which the solutions are already known. Split Q into halves. Pair one of them with an equal charge at the corresponding point $2l-y$. Pair the other with an equal charge of the opposite sign at the corresponding point. The sum of the four charges is simply Q at y, so the solution is the same for the four as for the original Q.

Consider the positive pair alone, that is, $\frac{1}{2}$Q at y and $\frac{1}{2}$Q at $2l-y$. By symmetry they cause no current at B, and behave similarly in the upper and lower cables. At A the currents going to Z_0 are equal. They therefore unite and leak out through Z_0. Thus, each member of the positive pair discharges in its own cable in the same way as if it were insulated at B, and were earthed at A through the arrangement whose resistance operator is $2Z_0$. This case has been already considered. $2Z_0$ may be constructed by putting Z_0 in sequence with another Z_0, or in other ways.

The positive and negative pair, on the other hand, produce no potential at either A or B. There is no leakage current in Z_0, and consequently continuity of current between the upper and lower cables. So the $\frac{1}{2}$Q in the lower cable discharges as if it were earthed at A and B, and so does the $-\frac{1}{2}$Q in the upper cable. This part of the complete solution is also known. Putting these together, we obtain the complete result, and can use previous formulæ without more work.

In the case of the positive pair we have this arrangement

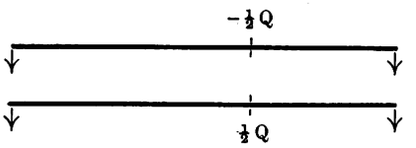


diagrammatically. Use (85), § 294. Put $Z_1=\infty$, and $2Z_0$ for Z_0, and $\frac{1}{2}$Q for Q. Then

$$v_1=\frac{(2Z_0s\cos+R\sin)sy}{(2Z_0s\sin-R\cos)sl}\cos s(l-x)\cdot\frac{sQ}{2S} \qquad (1)$$

expresses the potential at x, on the right of y, in the lower cable. Interchange x and y when $x<y$.

In the case of the positive and negative pair we have this arrangement,



and we may use the quoted formula with $Z_1=0=Z_0$, or the special formula (18), § 267. The result is that

$$w_1=-\frac{\sin sy}{\sin sl}\sin s(l-x)\cdot\frac{sQ}{2S} \qquad (2)$$

expresses the potential at x on the right of y in the lower cable.

In the upper cables the potentials are the same at corresponding points in the first case, and their negatives in the second. Uniting the two formulæ, we see that

$$V_1=v_1+w_1 \qquad (3)$$

is the potential at x in the lower cable, when greater than y, and the same with x and y interchanged when x is less than y. The same formula is valid all the way from y to $x=2l$, as we may see by altering x to $2l-x$, and observing that v_1 is unchanged, whilst v_2 is negatived.

The conversion to Fourier series is to be done as usual by the expansion theorem. Doing it in the most simple case of $Z_0=R_0$, a constant, we obtain

$$V=\frac{Q}{Sl}\Sigma\sin sy\sin sx\,\epsilon^{pt}+\frac{Q}{Sl}\Sigma\frac{(2R_0s\cos+R\sin)sy\cdot\cos s(l-x)}{2R_0s\cos sl+(R+2R_0/l)\sin sl}\epsilon^{pt}, \qquad (4)$$

which is now valid on both sides of y. In the first summation $\sin sl=0$. In the second, we have

$$\tan sl=R/2R_0s \qquad (5)$$

for determinantal equation. The result for the upper line need not be written separately, being the same formula.

When we make $R_0=\infty$, we have the two cables connected together without external constraint. We then reduce the above to Fourier's periodic formula. Notice the way the constant term arises. The last equation has a very small root when R_0 is big, and the corresponding p is very small. In the limit the root is zero, and the result is a constant term showing that the final effect is a uniform state of potential in the complete cable.

§ 314. If we should not notice that the problem admitted of splitting into two in the above way, we would proceed thus. Start with Q at y. This is an impulsive external source of current $pQ=h$, as explained before. Then let

$$V_1=\epsilon^{qx}F+\epsilon^{-qx}G, \qquad V_2=\epsilon^{qx}H+\epsilon^{-qx}I, \qquad (6)$$

where V_1 is the potential at x when on the right side of Q, and V_2 when on the left side. There are four time functions to be determined, and four conditions which find them.

(1) Continuity of potential at A makes

$$H+I=\epsilon^{2ql}F+\epsilon^{-2ql}G. \qquad (7)$$

(2) Continuity of potential at y makes

$$\epsilon^{qy}F+\epsilon^{-qy}G=\epsilon^{qy}H+\epsilon^{-qy}I. \qquad (8)$$

(3) Discontinuity in the current at A makes

$$V=Z_0(C_1-C_2), \qquad (9)$$

at $x=0$. Or

$$\frac{H+I}{Z_0}=-\frac{q}{R}\left\{\epsilon^{2ql}F-\epsilon^{-2ql}G-H+I\right\}. \qquad (10)$$

(4) Discontinuity in the current at y (regarding h as any function of the time) makes

$$h=C_1-C_2=pQ, \qquad (11)$$

at $x=y$. Or

$$pQ=-\frac{q}{R}\left\{\epsilon^{qy}F-\epsilon^{-qy}G-\epsilon^{qy}H+\epsilon^{-qy}I\right\}. \qquad (12)$$

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These four conditions determine the time functions and make, finally,

$$V_2 = \frac{\frac{R}{2Z_0}\sin s(2l-y)\sin sx + s\sin sl\cos s(l+x-y)}{\sin sl\left(\sin sl - \frac{R}{2Z_0 s}\cos sl\right)}\,\frac{Q}{2S}, \quad (13)$$

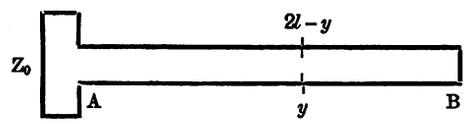
$$V_1 = V_2 + \sin s(x-y)\,.\,sQ/S. \quad (14)$$

That the determinantal equation splits into two distinct equations is shown by the denominator in (13), and it may be readily shown that the operator in (13) may be represented as the sum of two operators, one having the denominator $\sin sl$, the other the bracketed part of the denominator in (13). One of these partial operators produces v_1 and v_2, the other w_1 and w_2. The expanded solution in Fourier series is the same as before got, of course.

The difference between V_1 and V_2 is operationally exhibited in equation (14). It is equivalent to exchanging y and x in the preceding formula, and taking the difference. But this difference has no existence in the Fourier series. We can see that by putting the extra part of (14) in the numerator, when it becomes multiplied by the denominator, and therefore gives zero terms when the expansion theorem is applied. We also see the same by observing that only even powers of p are involved in the extra operator in (14). But this extra operator is not of no moment in general. If, instead of the impulsive source of current pQ, we have h, any function of the time, the solutions to right and left of the source are got by writing h/p for Q in (13), (14), and the difference between the forms of V_1 and V_2 cannot be neglected in general; for example, when h is simply periodic, and the algebrisation is effected by $p^2 = -n^2$.

When we have an impressed force e at y instead of h or pQ, we can treat the matter similarly by either of the above ways, noting now that C is continuous and V discontinuous at y. Since $\frac{1}{2}e$ at y, together with $\pm\frac{1}{2}e$ at the corresponding point in the upper cable, produce zero current at B, or else zero potential, with similar effects at A, we see that the problem splits into two connected simpler cases.

§ 315. In the above, Z_0 produced a discontinuity in the current, though none in the potential. But if we introduce Z_0 in circuit with the double cable, and have no earth connection, it is the current that is continuous, and the potential discontinuous at A. The question arises whether the problem



admits of splitting. It clearly does when Z_0 is a resistance, because equal similar charges at y and $2l-y$ will produce no current either at B or A, that is, in Z_0; whilst equal unlike charges will produce no potential at B or in the middle of Z_0. So the problem splits into two, in one of which there is insulation at both A and B, whilst in the other there is earth at B, and earth through resistance $\frac{1}{2}R_0$ at A.

That a similar split takes place when Z_0 is a condenser is also evident on consideration. The same may be said of any simple electrical arrangement which is divisible into similar halves. But it is not immediately evident that a split is possible when Z_0 is any electrical arrangement, which may have no sort of symmetry with respect to the cable terminals. It is sufficient to think of a coil and a condenser in sequence. Given a charge at y, and an equal charge at the corresponding point. If it be said that if the charges are unlike there is zero potential in the middle of Z_0, it may be asked, Where is the middle? The condenser and coil are not comparable in the way suggested. At the same time, the property must be true in a certain sense, because the combination of condenser and coil behaves to external voltage as a single whole. The same is true of any regular combination. It may be symbolised by an operator, without entering into its detailed structure in the form of coils and condensers.

The proper interpretation is to substitute for the combination symbolised by Z_0 two combinations in sequence, each symbolised by $\frac{1}{2}Z_0$. This is easily done. The condenser and coil may be replaced by two condensers and two coils, all in sequence. Then one of the new condensers and one of the new coils in sequence makes $\frac{1}{2}Z_0$, provided the resistance, inductance, and elastance of the original coil and condenser are all halved. Similarly as regards the remaining new condenser and coil. Z_0 has now a middle in reality, as well as in imagination. A similar process is applicable to any combination. So, without actually doing it in detail, we may say that equal unlike charges at y and the corresponding point redistribute themselves in the same way as if earth were on at B, and earth on in the middle of Z_0; or, without speaking of the middle, as if we substitute for Z_0 two arrangements each equivalent to $\frac{1}{2}Z_0$, and then put on earth between them.

So let there be a charge $\frac{1}{2}Q$ at y and $\frac{1}{2}Q$ at $2l-y$. They move as if the ends A, B were insulated. If v_1 is the resulting potential at x on the right of y, we have

$$v_1 = \frac{\cos sy}{\sin sl}\cos s(l-x)\,.\,\frac{sQ}{2S}, \quad (15)$$

either by (85), § 294, with $Z_0 = \infty = Z_1$ and $\frac{1}{2}Q$ instead of Q; or by the elementary theory in § 269.

Also, if w_1 is the potential at x on the right of y due to $\frac{1}{2}Q$ at y and $-\frac{1}{2}Q$ at $2l-y$, we have

$$w_1 = -\frac{(2R\sin + Z_0 s\cos)sy}{(2R\sin + Z_0 s\cos)sl}\sin s(l-x).\frac{sQ}{2S}, \quad (16)$$

by the same formula (85), with $Z_1 = 0$, $\frac{1}{2}Z_0$ instead of Z_0, and $\frac{1}{2}Q$ instead of Q.

It follows that if there is initially only Q at y, the resulting potential V_1 at x on the right of y is

$$V_1 = v_1 + w_1. \quad (17)$$

The expansions of v_1 and w_1 are to be effected as usual. I have given so many examples that it is unnecessary to exhibit the special expansions required here. The expansion theorem (30) is very easy to remember and to apply when required. On the other hand, the operational formulæ are much easier to manipulate. Note in the present case that there is a constant term in V_1. It arises from v_1, and its value is $Q/2Sl$, the mean potential which is finally existent because there is no leak anywhere.

§ 316. But as the above reasoning about the splitting of Z_0 may not be wholly convincing, we may justify its accuracy by a direct investigation. Say there is initially Q at y. Let

$$V_1 = \cos sx\,.\,F + \sin sx\,.\,G \quad (18)$$

at x on the right of y, that is, from y up to $x = 2l$. Also, let

$$V_2 = V_1 + \sin s(x-y)\,.\,K \quad (19)$$

on the left of y, V_1 meaning the expression in the previous equation.

The condition of continuity of the potential at y is already satisfied. We also require

$$pQ = C_1 - C_2 \quad (20)$$

at y, C_1 and C_2 being the currents corresponding to V_1 and V_2, obtained by the operation $-(d/dx)/R$. Doing this, we get

$$pQ = sK/R, \quad (21)$$

making
$$C_2 = C_1 - \cos s(x-y)\,.\,pQ, \quad (22)$$

and
$$V_2 = V_1 - \sin s(x-y)\,.\,\frac{sQ}{S}. \quad (23)$$

There are now only the two time functions F, G to be found. The condition of continuity of current at the ends of Z_0 gives

$$\frac{s}{R}(\sin 2sl\,.\,F - \cos 2sl\,.\,G) = -\frac{Gs}{R} - \cos syp\,.\,Q; \quad (24)$$

and the condition

$$V_1 - V_2 = Z_0 C, \quad (25)$$

which is the equation of voltage for Z_0, gives

$$\cos 2sl\,.\,F + \sin 2sl\,.\,G - F - \sin sy\,.\,\frac{sQ}{S} = Z_0\left(-\frac{Gs}{R} - \cos sy\,.\,pQ\right). \quad (26)$$

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These equations find F and G by the usual algebraical work. Using the results in (18) and (23), we obtain

$$V_1 = \frac{2\sin sl\cos s(l-x+y)+(Z_0 s/R)\cos sy\cos s(2l-x)}{\sin sl(2\sin sl+\cos sl\ .\ Z_0 s/R)}\ \frac{sQ}{2S} \quad (27)$$

$$V_2 = V_1 - \sin s(x-y)\ .\ sQ/S. \quad (28)$$

These are the complete operational solutions without initial splitting. We see that the determinantal equation does split into two, giving

$$\sin sl = 0, \quad \text{and} \quad \tan sl = -Z_0 s/2R, \quad (29)$$

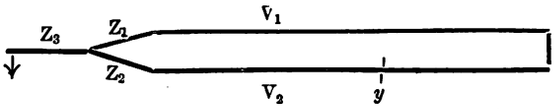
proving definitely the validity of the previous reasoning.

Now, if we expand the above V_1 by the expansion theorem, attending only to $\sin sl = 0$, we shall obtain the expansion of the v_1 in (15). And if we expand according to the other condition in (29) we shall obtain the expansion of w_1 in (16). Thus $V_1 = v_1 + w_1$, when in the fully expanded form.

But the equivalence is also true in the operational form. To prove this, add together the v_1 and w_1 of (15) and (16), uniting the two fractions to make one with a denominator which is the product of the former ones. The result is (27), as required.

The expanded formula for V_2 is the same as for V_1. The complete solution for the whole cable from $x=0$ to $2l$ is therefore given by a single Fourier series, although it is separable into two of different types. The same is therefore true for any initial state of the cable. The reason is that there is not (except at the initial moment of the instantaneous introduction of the charge) any sort of constraint all the way from $x=0$ to $2l$. If there were, say a constraint at $x=z$, we should want two distinct Fourier series, one for each side of z. The determinantal equation would be the same, but there would be a break in the normal systems.

§ 317. We have done one case involving a discontinuity in the current, and another involving a discontinuity in the potential. But in general both will be discontinuous. Let, for example, the connection between $x=0$ and $x=2l$ be made through $Z_1 + Z_2$ in sequence, with a shunt to earth put on at



their junction. Let V_0 be the potential at the junction. Then we have these voltage equations to satisfy:—

$$V_1 - V_0 = Z_1 C_1, \quad V_0 - V_2 = Z_2 C_2, \quad V_0 = Z_3(C_1 - C_2); \quad (30)$$

and therefore have the two terminal conditions

$$V_1 = (Z_1 + Z_3)C_1 - Z_3 C_2, \quad (31)$$

$$V_2 = Z_3 C_1 - (Z_2 + Z_3)C_2. \quad (32)$$

In these equations V_1 and C_1 mean the potential and current at $x=2l$; V_2 and C_2 those at $x=0$.

If, then, there is an initial charge Q at y, we can obtain the operational solution by means of equations (18) and (23) above, applied to (31), (32), to determine F and G. The result is, as before, a single Fourier series to represent both V_1 and V_2. It sometimes divides into two sets. For example, if Z_1 and Z_2 are equivalent, we get symmetry.

(To be continued.)

LIQUID FUEL.

From time to time we have had occasion to call the attention of our readers to the utilisation of petroleum residue, creosote, tar, and other heavy liquids, as fuel. The value of these combustibles for steam raising has long been recognised in countries where they are cheap and where coal is dear; but their application to this use in this country was not made prominent until the adoption of locomotives burning liquid fuel, by the Great Eastern Railway Company; and the attention of electrical engineers in particular was called to this mode of raising steam by Mr. R. E. Crompton, in his Paper on "The Cost of Electric Energy" (*Proc. Inst. E. E.*, Vol. XXIII.). The accompanying illustrations show the construction of the latest pattern of liquid fuel injector, as used for boiler firing on the Holden system. Fig. 1 shows the general arrangement of the injectors in a Babcock-Wilcox boiler; and Figs. 2 and 3 give details of the injector itself. Before we describe these particularly it will be well to summarise the main facts connected with the use of liquid fuel.

In this country liquid fuels are either the by-products of industrial processes, and therefore liable to considerable fluctuation of price, or they have to be imported from considerable distances, usually Southern Russia or America, and are therefore expensive. To the former class belong creosote, green oil, paraffin refuse, tar, &c.; to the latter, astatki and petroleum residuum, the one the Russian and the other the American petroleum refuse. After having occasion to go into the matter very carefully, we have no hesitation in saying that, as a main source of heat for steam raising in stationary boilers, in this country, none of these fuels can compete with coal. Petroleum refuse in bulk costs from 2d. to 3½d. per gallon; creosote about the same, or slightly less; tar about half this figure. The theoretical evaporative power of astatki is about 17·5lb. of water from and at 212°F.; good coal will readily give a *practical* evaporative efficiency of 9lb. or 10lb. of water from and at 212°F. Therefore, if astatki be only twice as dear as coal, per ton, even perfect evaporation, with no loss of heat of combustion, would not make astatki pay. In the majority of places in this country astatki would be more than twice the price of coal, per ton. It must not be forgotten, however, that besides the relative costs of the fuels, other elements of expense are affected. The handling of liquid fuel is cheaper than the handling of coal by human stokers, though it is doubtful if it is cheaper than the mechanical handling of coal. And on the other hand, liquid fuel requires generally an expenditure of steam in a heating coil, to keep it sufficiently fluid, as well as an even larger consumption of steam in the fuel injector.

We have made these remarks, not from any desire to deprecate the use of liquid fuel in electric supply stations, but to give force to the statement we are now about to make, that the proper function of this class of fuel is to act as an auxiliary in coal-fired boilers. The use of liquid fuel is susceptible of a much finer and more regular adjustment than even the best automatic coal stoker. The gentlest readjustment of the throttle valve actuating the injector suffices to raise or lower the boiler pressure a pound or so, and to keep it steadily at the altered figure. That is one advantage. Another point in its favour is the astonishing rapidity with which the steaming rate of a boiler may be increased a very considerable amount. With coal firing there will always be an appreciable interval between the extra firing and the extra steaming; and in that interval the sudden rise in the load may fatigue the boilers and drop the pressure to a serious extent. It may be that a fog has suddenly taken lodging over the area of supply. With oil firing by means of spray injectors no such lag or interval of delay exists; andwhen the regulator valves are turned on full, the firebox is simultaneously filled with flame capable of making enough steam to take on the extra duty at once. Thus its ease and fineness of adjustment, and its promptness, are the chief merits of liquid fuel firing which commend it to the central station engineer. And to obtain these things it is often worth while to burn a little more expensive fuel on occasion, keeping to coal for the main work. To cite one or two actual examples: Mr. Crompton has made practical trial of oil fuel for the boilers of the Kensington and Knightsbridge supply station, as well as in the Chelmsford supply station; and the system has also been in use at the Sardinia-street station of the Metropolitan Electric Supply Company. Oil firing is only used for forcing the boilers over the heaviest load. In the case of a Root's boiler, from which 700 H.P. was obtained by coal firing, an extra 300 H.P. could quickly be obtained by turning on the oil-fuel injectors.

Mr. Crompton has tried every available form of liquid fuel. He condemns the use of coal tar; but is satisfied with astatki, provided it can be obtained for 2d. a gallon, the price he pays for it at present. Naturally, the fuel purchased will depend on the state of the market; and very often it will pay to mix several liquid fuels and burn them together. At the present

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time, at the Kensington and Knightsbridge Station, oil gas tar, a by-product in the manufacture of Pintch's oil gas, is largely used, at a cost of about 2d. per gallon.

A glance at Fig. 1 will enable the reader to see that the Holden injector can be fitted to a boiler front with very little trouble or expense. Where oil alone is to be burned, the grate will be covered with firebrick, chalk or other refractory material; but where coal is to be burned as well, the furnace will not be altered. An aperture about 4in. diameter is cut above each fire door, in such a manner as not to interfere with the coal firing; and an injector is fitted in an inclined position so as to direct the blast away from the furnace crown. Fuel is fed to the injectors from a tank, which should be placed in such a position that the injectors have to lift the fuel a few feet. The fuel in this tank is usually kept sufficiently fluid by means of a steam coil. Overhead tanks have been found to

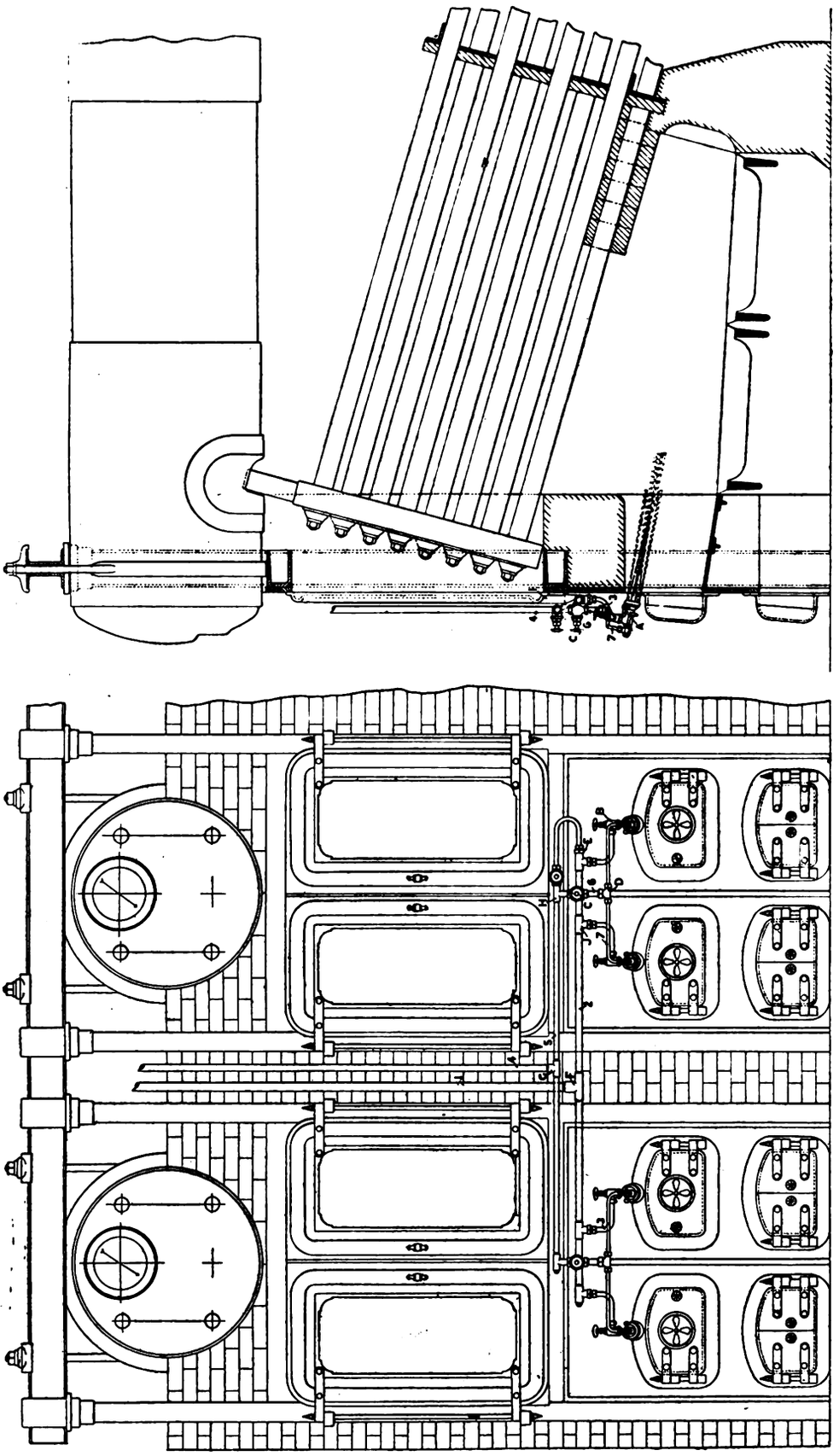

FIG. 1.—Holden System of Liquid Fuel Firing, adapted to Babcock-Wilcox Boilers.

A, Injectors. B, Regulating Valves. C, Steam Valves. D, Tee Pieces. E, Unions.

PIPES.—1. Iron Fuel Pipe, 1¼in. outside diameter. 2. Iron Fuel Pipe, 1in. outside diameter. 3. Copper Fuel Pipe, ⅞in. outside diameter. 4. Iron Steam Pipe, 1in. outside diameter. 5. Iron Steam Pipes, ¾in. outside diameter. 6. Copper Steam Pipes, ¾in. outside diameter. 7. Copper Steam Pipes, ¾in. outside diameter.

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work with less satisfaction than tanks below the boiler level. The injector, A, in Fig. 2, receives fuel through the regulator valve, B, and live steam through the pipe immediately behind it (to the left, in the drawing). In the furnace side of the injector, there are three orifices, set in horizontal line, in the middle of a circular steam ring jet. The two outer orifices form the fuel jets; and from the inner orifice, as well as from the ring jet, blasts of steam are projected against the liquid fuel, the ring jet directing the steam convergently upon the fuel. Thus is the liquid fuel completely "atomised" or sprayed into very finely-divided particles, the combustion of which takes place readily. The effect of this mode of combustion is beneficial in every way. It is unaccompanied by the formation of residual matter or smoke; and, owing to the fact that the furnace is completely filled with flame, while no flame impinges locally on the heating surfaces, no injury is done to the boiler plates by the rapid rate of steaming.

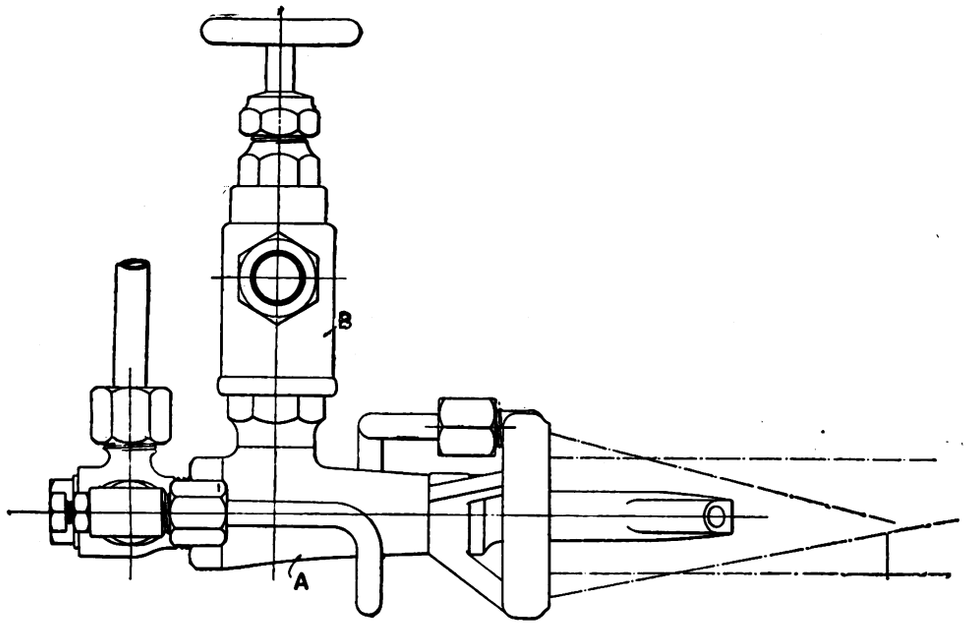

FIG. 2.

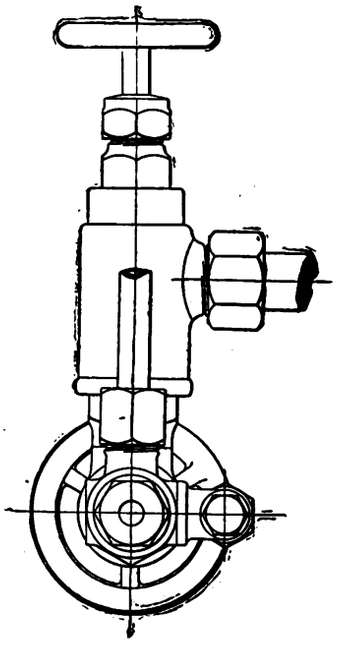

FIG. 3.

The Holden system of liquid fuel firing is adapted to boilers by Messrs. Taite and Carlton, to which firm we are indebted for the illustrations accompanying this article.

POWER DEVELOPMENT AT NIAGARA.

The electrical development of the power available at Niagara Falls still continues. The oldest power project at the Falls is the hydraulic canal, an open waterway which diverts a portion of the water of the upper river from its natural channel and conducts it to a basin situated a short distance, 300ft., back from the high bank of the lower river, from which basin it is conducted by flumes to the penstocks of the turbines of the mills now operated there. For the past few years the owners of this canal, the Niagara Falls Hydraulic Power and Manufacturing Company, have been expending large amounts of money in widening their possession in order to obtain a greater water supply and thus increase their power facilities. The work of enlarging the canal is now practically completed, and the Company have prepared plans and commenced work on what is destined to be a power house and plant of considerable magnitude.

This new power house is to be located on the sloping bank, at the edge of the water, in the river below the Falls. To prepare for the construction of the building it was necessary to clear the site of broken rock boulders. In some places the mass was from 75ft. to 100ft. deep. When the *débris* was all removed a substantial stratum of sandstone was found, and on this the new power house will be erected.

The building will be of stone, 60ft. long and 100ft. wide, but ultimately, as demand for power makes it necessary, the length of the building will be extended. For this plant water will be carried in an open canal from the basin before referred to to a forebay 30ft. wide and 22ft. deep, which is now in process of construction between the edge of the high bank and the basin. From this forebay, penstocks of flange steel, 8ft. in diameter, will conduct the water down the slope, a distance of 210ft., to the power house at the edge of the water in the lower river. These penstocks will lead from the forebay vertically about 135ft. to the top of the bank slope, thence down this slope to the side of the power station next to the bank, thus making the total length of the 8ft. pipes about 240ft. Pipes 10ft. in diameter will run horizontally into the building and be suspended over the tail race leading from the station. The thickness of the steel in these pipes will be $\frac{15}{16}$ths of an inch. All horizontal joints will be butt-strapped and held with three rows of rivets on each side. The cross seams will all be double riveted.

At the start, four turbine wheels of the horizontal type, having a capacity of about 7,000 H.P., will be located on the first floor of the station. Each turbine will be fed from a separate penstock, and will work under a head of 210ft. From the horizontal portion of the penstock the water will pass up through 60in. valves to the water wheels, which will be supported upon iron beams stiffened by braces built into the side of the tail race. The turbines will be mounted on horizontal shafts of the double-discharge design. They will be fitted with runners 74in. in diameter, made of bronze metal, and equipped with balanced gates. They will be so designed that the wheel runners are balanced by the equal discharge of water on each side, thus avoiding the use of end thrusts on the shafts. They will set in cases 11ft. in diameter, made of the best heavy plate steel and double riveted. The feeder pipe connections to these large cases will be on the bottoms of the same, being riveted directly to the 5ft. hydraulic cylinder valve, all of which valves will be connected to the main feeder pipe, which will be 10ft. in diameter, and will occupy space under the turbines between the foundation walls. Down each side of the main feeder pipe draft tubes from the turbines will pass, connecting with the tail water, which will be set at a distance of 27ft. from the centre of the turbine shaft. The shaft will be of wrought iron, carried in adjustable ring oiling bearings and mounted on heavy cast-iron bridge trees.

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The first four wheels for this station will be built by James Leffel and Co., of Springfield, O. Three of them are guaranteed to develop 1,700 H.P., under a head of 205ft., which is the minimum head estimated as obtainable, and to run at a speed of 250 revolutions per minute. As the ordinary head used will be from 210ft. to 215ft., the power from these wheels, it is expected, will be from 1,800 H.P. to 2,000 H.P. each. These three wheels will be connected to six electrical generators, two to each wheel, the electrical power to be used by the Pittsburg Reduction Company, manufacturers of aluminium, in a new factory to be built on the top of the high bank. The fourth wheel will be connected to two 560-kilowatt generators, and will make 300 revolutions a minute. By this means a 500-volt current for street railway or general power purposes will be obtained. The work is in charge of W. C. Johnson, chief engineer of the Company.

THE BEHAVIOUR OF TRANSFORMERS UNDER THE INFLUENCE OF ALTERNATING CURRENTS OF DIFFERENT WAVE FORMS.*

BY DR. G. ROESSLER.

(Continued from page 153.)

The variation of the potential and current curves with the loaded transformer is given in Figs. 14 to 17. In these curves the absolute values of the ordinates are not given; they may be obtained from the tables given at the end.

Each of the Figs. 14 to 17 shows the variation of the primary current J_1, and potential difference Ep_1, and of the secondary potential difference Ep_2. Since the load on the transformer is absorbed by glow lamps, the curve of the secondary current J_2 is of the same character as that of Ep_2. The curve of J_2 is therefore not separately drawn. Figs. 16 and 17 give the curves, with both machines, for the fully-loaded transformer $J_2=4$ A, Figs. 14 and 15 those for a load of $J_2=\frac{1}{2}$ A.

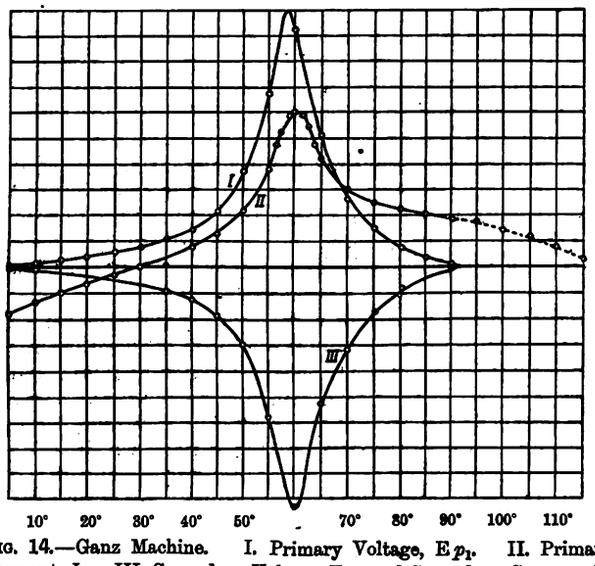

FIG. 14.—Ganz Machine. I. Primary Voltage, Ep_1. II. Primary Current, J_1. III. Secondary Voltage, Ep_2, and Secondary Current, J_2. $\sqrt{M(J_2^2)}=\frac{1}{2}$ A.

The figures show that the Ep_1 and Ep_2 curves are nearly the same shape for all loads of the transformer, and are symmetrical about the axis, and that the curve of J_1, for increasing transformer loads, approximates more nearly in shape and phase to Ep_1. The first effect is due to the small potential drop on the winding of the transformer, hence Ep_1 approaches equality to $n_1 \frac{dN}{dt}$, and $Ep_2 = n_2 \frac{dN}{dt}$, hence $\frac{Ep_1}{Ep_2}$ is constant. These calculations hold with equal accuracy, whatever the form of the primary potential difference curve.

* "Das Verhalten von Transformatoren unter den Einflusse von Wechselströmen verschiedenen periodischen Verlaufs." A Paper read at the third annual meeting of the Verband Deutscher Electrotechniker, Munich July 6, 1895.

The observed variation in J_1 can be explained as follows:—If, as here, $\sqrt{M(Ep_1^2)}$, and thus also $M(Ep_1)$, are kept constant, the mean value of the magnetisation of the iron must remain constant

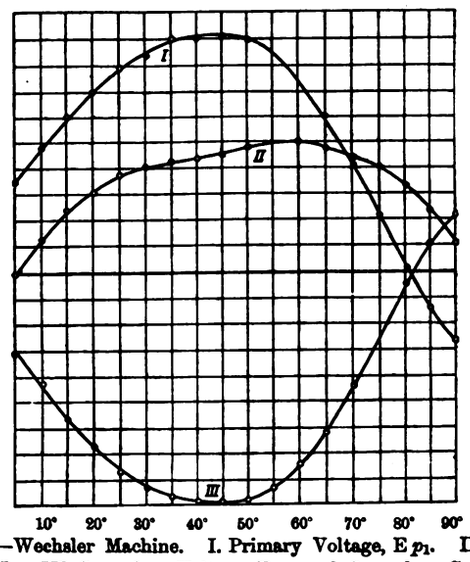

FIG. 15.—Wechsler Machine. I. Primary Voltage, Ep_1. II. Primary Current, J_1. III. Secondary Voltage, Ep_2, and Secondary Current, J_2. $\sqrt{M(J_2^2)}=\frac{1}{2}$ A.

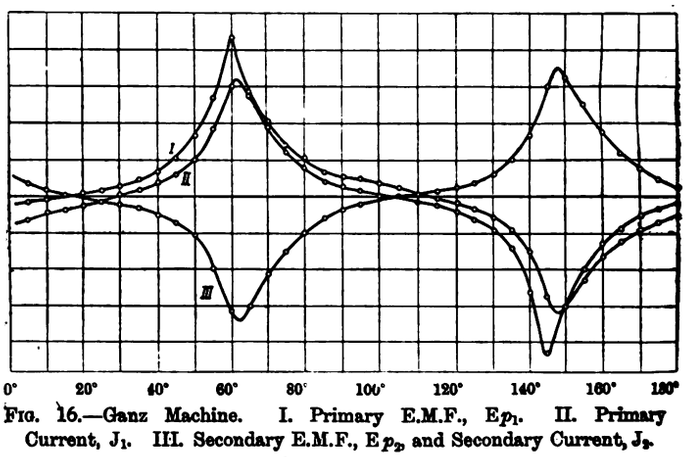

FIG. 16.—Ganz Machine. I. Primary E.M.F., Ep_1. II. Primary Current, J_1. III. Secondary E.M.F., Ep_2, and Secondary Current, J_2. $\sqrt{M(J_2^2)}=4$ A.

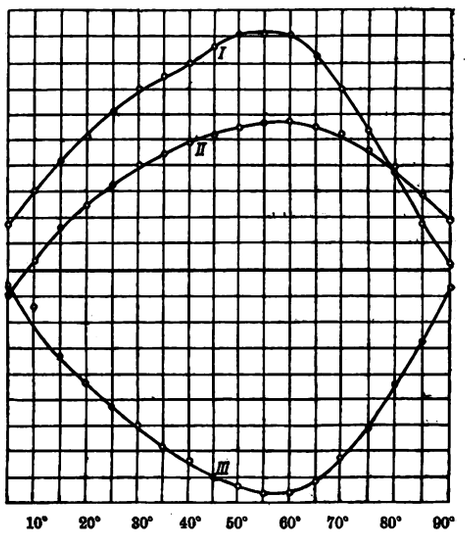

FIG. 17.—Wechsler Machine. I. Primary Voltage, Ep_1. II. Primary Current, J_1. III. Secondary Voltage, Ep_2, and Secondary Current, J_2. $\sqrt{M(J_2^2)}=4$ A.

for all loads on the transformer. Hence the total magnetising force, which is the algebraic sum of the magnetising forces due to both windings, must remain the same. For increasing

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values of J_2, this is only possible if the curves J_1 and J_2 have the same form and opposite phase, so that their magnetising forces must be subtracted at each instant, and if J_1 increases simultaneously with J_2. But since also J_2 has the same form and phase as $E p_2$, and $E p_2$ is in opposite phase to $E p_1$, J_1 must approximate more nearly to $E p_1$ in shape and phase as the load increases. If the curves J_1 and J_2 were always of the same shape and in opposite phase, and also of the same shape as the primary current curve for no-load J_0, then the conditions for constant magnetising force for all loads would be given by the equation

$$n_1 \sqrt{M(J_1^2)} - n_2 \sqrt{M(J_2^2)} = n \sqrt{M(J_0^2)},$$

$$\text{or } \sqrt{M(J_1^2)} = \sqrt{M(J_0^2)} + \frac{n_2}{n_1} \sqrt{M(J_2^2)}.^*$$

As Fig. 7 shows, the relation between the primary current and the secondary current is almost linear. Only at small loads does $\sqrt{M(J_1^2)}$ increase more slowly than $\sqrt{M(J_2^2)}$, this would be explained by J_1 approaching opposite phase to J_2, since the decrease of magnetisation is effected by increasing J_2, without $\sqrt{M(J_1^2)}$ increasing in the same proportion as at high loads.

These remarks concerning the shapes of the curves assist in explaining the great difference found in the primary power, current, efficiency and regulation.

Differences in Power Taken Up and Efficiency.

The primary power A_1 of a loaded transformer is divided into the secondary output A_2, and the power lost. These quantities are independent of the shapes of the potential difference and current curves in two points, the loss in the copper winding $J_1^2 w_1 + J_2^2 w_2$, and the iron loss, which is composed of hysteresis and eddy currents. The power lost in hysteresis per cycle per cubic centimetre of iron is given by the factor $\frac{1}{4\pi}$ times an area of the closed hysteresis curve having B_{max} as the highest induction in the iron. If V is the volume of iron, ν the periodicity of the current, and f the area of the hysteresis curve, the loss in the iron $= V \nu \frac{1}{4\pi} f$ and the total power lost in the transformer, neglecting eddy-current loss

$$A_1 - A_2 = J_1^2 w_1 + J_2^2 w_2 + V \nu \frac{1}{4\pi} f.$$

The determination of the power lost in hysteresis is very difficult if it has to be obtained by planimetering the hysteresis curve. It is well known that Steinmetz, from a large number of hysteresis measurements in iron, has obtained the result that the area of the curve can be given by the formula

$$f = \eta B^{1.6}_{max},$$

where η is a constant depending on the material, whose value for average soft iron is 0·002. This result is confirmed by the measurements of Ewing and others; they do not put it forward as a natural law, but as an empirical rule of sufficient accuracy for technical purposes.

To the power lost through hysteresis must be added the loss by eddies. If, in a closed circuit of resistance w_1, an E.M.F. E is induced, the power lost is $\frac{E^2}{w}$. Here E equals the secondary alteration of the lines of force cut by the circuit, and this is dependent on the quantities $+B_{max}$ and $-B_{max}$, between which the magnetisation alters. Hence the power lost in eddies is proportional to $\nu^2 B^2_{max}$, and can be expressed in the form $V \xi \nu^2 B^2_{max}$, where ξ is a constant which depends on the material, and the thickness of the plates and wire. On this account, Steinmetz gives as the expression for the total loss in the iron

$$\mathfrak{C} = V (\nu \eta B^{1.6}_{max} + \nu^2 \xi B^2_{max}).$$

In this formula it is shown that the iron loss only depends on the shape of the curve so far as this affects the value of B_{max}, and that the loss is smaller, the smaller B_{max}.

In the present case it is found that the peaked curve gives smaller iron loss than flat. The conclusion that this difference is typical for all peaked and flat curves is then settled if it is shown that flat curves for the same R.M.S. of the primary potential difference always have greater values of B_{max} than pointed curves.

Relations between B_{max} and the Shape of the Curve $E p_1$.

The simple mean of the potential difference $M(E p_1)$, which is found by planimetering the potential difference curve, and finding the height of a rectangle of equal area, stands in constant relation to B_{max}, since it is given by the equation

$$E p_1 = J_1 w_1 + n_1 \frac{dN}{dt},$$

the quantity $J_1 w_1$ being small in comparison with the other, so that one can take for the mean, with close approximation,

$$M(E p_1) = M\left(\frac{dN}{dt} n_1\right).$$

But, from the principles of induction, the mean E.M.F. induced in either winding equals the mean variation of the flux; hence we have the following: During each period the flux increases from $-N_{max}$ to $+N_{max}$, and falls from $+N_{max}$ to $-N_{max}$, the total variation is thus $4 N_{max}$; for ν periods per second, the mean variation in induction $= \nu 4 N_{max}$, and in the n_1 turns the mean induced E.M.F. $= 4 n_1 \nu N_{max}$.

Hence we have the equation

$$M(E p_1) = 4 n_1 \nu N_{max} = 4 n_1 \nu s B_{max}^*$$

as the expression for the relation between B_{max} and $M(E p_1)$. From this we are enabled to calculate from the R.M.S. of the potential difference, $\sqrt{M(E p_1^2)}$, the value of B_{max}, if we know the ratio,

$$\frac{M(E p_1)}{\sqrt{M(E p_1^2)}} = c.$$

By comparison of these ratios

$$\sqrt{M(E p_1^2)} = \frac{4 n_1 \nu s B_{max}}{c},$$

and

$$B_{max} = \frac{c \sqrt{M(E p_1^2)}}{4 n_1 \nu s}.$$

From these relations we can easily find the power lost in the iron for different values of the primary potential difference $\sqrt{M(E p_1^2)}$, and can calculate the curve $\mathfrak{C} = f(B_{max})$. *If it is correct that the iron loss only depends upon B_{max}, we ought to get the same curve $\mathfrak{C} = f(B_{max})$ from the most different potential difference curves.* This conclusion was proved in the present case. The measurements were so conducted that varying pressures were supplied to the transformer, from both machines, and measured with a Cardew voltmeter, the secondary of the transformer being open. At the same time, the power A_0 of the transformer was measured by a wattmeter, and the current by a dynamometer. If A_0 and J_0 are the corrected values, the loss by hysteresis in the transformer core

$$\mathfrak{C} = A_0 - J_0^2 w_1.$$

From $\sqrt{M(E p_1^2)}$, B_{max} was calculated from the above equation where, for the Ganz machine, $c = 0{\cdot}590$ and, for the Wechsler machine, $c = 0{\cdot}841$, from former researches. The periodicity was, during this investigation, 40·57. For the Ganz machine

$$B_{max} = \frac{c \sqrt{M(E p_1^2)}}{4 n_1 \nu s} = \frac{0{\cdot}590 \sqrt{M(E p_1^2)}}{4 \times 132 \times 40{\cdot}57 \times 20{\cdot}19},$$

and for the Wechsler machine

$$B_{max} = \frac{0{\cdot}841}{4 \times 132 \times 40{\cdot}57 \times 20{\cdot}19} \sqrt{M(E p_1^2)}.$$

The results were the following:—

Table VI.

—	No.	$\sqrt{M(E p_1^2)}$.	J_0.	A_0.	B_{max}.	C.	$\frac{C}{V}$
Ganz machine.	1	20·8	0·607	5·14	2,839	5·07	0·00485
	2	29·17	0·777	10·37	3,982	10·26	0·00981
	3	38·22	0·945	16·86	5,217	16·70	0·01597
	4	49·39	1·155	24·66	6,742	54·42	0·02334
	5	59·41	1·383	32·76	8,109	32·42	0·03100
	6	69·43	1·746	43·83	9,477	43·28	0·04137
	7	80·17	2·297	55·82	10,940	54·87	0·05245
	8	90·25	2·990	67·98	12,320	66·38	0·06346
	9	103·7	4·985	88·05	14,150	83·60	0·08000
Wechsler machine.	1	19·83	0·650	7·65	3,855	7·48	0·00745
	2	30·21	0·892	16·53	5,873	16·39	0·01567
	3	40·30	1·167	27·32	7,830	27·07	0·02588
	4	48·45	1·458	36·74	9,410	36·36	0·03476
	5	59·76	2·103	53·13	11,620	52·34	0·05004
	6	†68·30	2·881	65·16	13,280	63·68	0·06088

In Fig. 18 the two curves of iron loss as a function of B_{max} are given, the upper curve for the Ganz machine, the lower for the Wechsler machine. The two curves lie near each other but never come quite together; the iron loss when using the Ganz machine is 13 per cent. greater than with the Wechsler machine. This difference can be understood by supposing that Steinmetz's formula does not explain the variations with sufficient accuracy. On closer consideration one finds that the loss by eddies can be arrived at in another way. If the instantaneous value of the E.M.F. in a circuit in the iron core be at any moment E, the power lost

* For good modern transformers with closed magnetic circuit this equation holds with greater accuracy than for the old one under consideration.

* This formula holds generally for all curves with single maximum.

† The potential difference in this case could not be increased, since the maximum allowable excitation of the machine was attained.

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by eddies is proportional to $M(E^2)$. But the R.M.S. of the induced E.M.F. in the primary $=\frac{4\,n_1\,s\,\nu\,B_{max}}{c}$; hence $M(E^2)$ is proportional to $\frac{\nu^2 B^2_{max}}{c^2}$, and the loss by eddy current is thus $\xi'\frac{\nu^2 B^2_{max}}{c^2}$.

This formula differs from Steinmetz's in the introduction of the factor $\frac{1}{c^2}$, which is absent in Steinmetz's. Since c depends on the form of the potential difference curve, it cannot be included in the constant ξ.

If we put $\nu=40$, $\eta=0{\cdot}002$, and $\xi=2\times10^{-7}$ in Steinmetz's formula, we find that for values of B_{max} between 0 and 10,000 the loss by eddies is about the one-seventh part, or 14·3 per cent. of the hysteresis loss. For an alteration of c from 0·59 to 0·84, c^2 alters from 0·35 to 0·7. Thus the eddy-current loss in the transformer, with the Ganz measurements, would be twice as great, or about 14 per cent. more than when using the Wechsler machine. The observed difference of 13 per cent. is, therefore, completely explained.

The practical calculation of the power lost in the core of a transformer is given most exactly by the formula

$$C=\nu\eta B^{1\cdot6}_{max}+\frac{\xi'\nu^2 B^2_{max}}{c^2}.$$

If an extreme case is considered, large errors may arise by the use of the simple formula of Steinmetz, or of a curve $T=f(\mathfrak{E}_{max})$, which neglects the influence of the form of the potential-difference curve on the eddy-current loss.

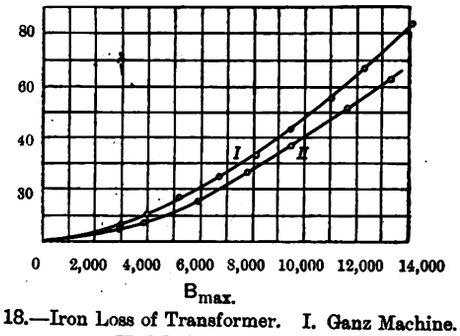

FIG. 18.—Iron Loss of Transformer. I. Ganz Machine. II. Wechsler Machine.

Theoretically it is interesting to note that the true eddy-current loss

$$C_2=\xi'\frac{\nu^2 B^2_{max}}{c^2},$$

and also

$$\sqrt{M(E p_1^2)}=\frac{4\,n_1\,\nu\,s B^2_{max}}{c};$$

hence

$$\mathfrak{E}_2=\frac{\xi'}{16\,n_1{}^2}M(E p_1)^2,$$

which only depends on the R.M.S of the primary potential difference and for constant values of this, is independent of the form of the curve, since the last equation does not contain c.

The loss by hysteresis thus becomes

$$=\nu\eta\left(\frac{c\sqrt{M(E p_1)^2}}{4\,n_1\,\nu\,s}\right)^{1\cdot6},$$

which contains c.

The differences in the total iron loss for different potential difference curves arise simply from variations in the hysteresis loss, which arise from the alteration of c.

In the case where the eddy current loss is much greater than the hysteresis loss, no great alteration of iron loss would result from variation of the shape of the potential difference curve. In all practical cases, however, the loss in the iron is always smaller, if c decreases. The general explanation of the observed fact that peaked potential difference curves give smaller iron losses reduces to the statement that peaked curves have a smaller value of c than flat curves.

Influence of the Curve Shape on the Value of "c."

The quantity c is known, entirely, from the geometrical form of the potential difference curve; for the sine curve, it is well known $c=0{\cdot}9$. In general it is clear that if a part of the ordinates of a curve are much greater than the rest, these greater ordinates increase the R.M.S. more than the simple mean. This is illustrated by the following example: Let there be (Fig. 19) the nth part of the abscissa a_1 representing a half-period, having ordinates of a height h. Then the simple mean is $\frac{h}{n}$, the mean of the square $\frac{h^2}{n}$, and the R.M.S. $\frac{h}{\sqrt{n}}$; therefore $c=\frac{1}{\sqrt{n}}$, *i.e.*, the smaller the part of the whole abscissæ upon which the ordinates stand, the smaller the value of c. This conclusion holds when the remaining ordinates are not vanishingly small, and shows that for peaked curves c is smaller than with flat curves. How c varies with increasing acuteness of the curve is shown in the following example. In Fig. 20 let the parabolas A_1, A_2, A_3 be parts of the potential difference curve, symmetrical about the axis. If the equations to the parabolas

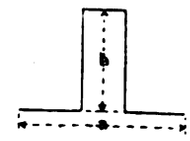

FIG. 19.

are in general $y=x^n$, the most pointed are those in which n is greatest. In general the simple mean is found thus:—

$$\frac{1}{a}\int_0^a y\,dx=\frac{1}{a}\int_0^a x^n dx=\frac{a^{n+1}}{(n+1)a}=\frac{a^n}{n+1}.$$

The mean of the square

$$=\frac{1}{a}\int_0^a y^2\,dx=\frac{1}{a}\int_0^a x^{2n}\,dx=\frac{a^{2n+1}}{(2n+1)a}=\frac{a^{2n}}{2n+1},$$

and the root of the last

$$=\frac{a^n}{\sqrt{2n+1}};$$

hence $c=\frac{\sqrt{2n+1}}{n+1}$, which is smaller as n increases. For $n=1$, $c=0{\cdot}865$; $n=2$, $c=0{\cdot}745$; $n=3$, $c=0{\cdot}660$.

Thus, for an unloaded transformer, it is easily seen that the iron loss for peaked potential curves is the smallest. This result

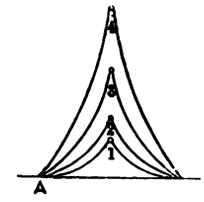

FIG. 20.

also holds for the loaded transformer, if the R.M.S. potential difference is kept constant for all loads, since the loss only depends on the value of the primary potential. The results of the above measurements are also generally applicable.

The frequently-made statement that the form of the potential difference curve has no influence on the efficiency of a transformer, becomes explicable, since where these observations have been made

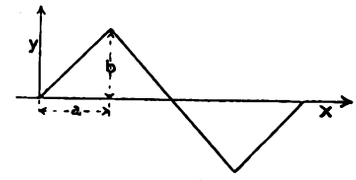

FIG. 21.

with different machines the quantity c had almost the same value. In fact, a sine curve can be very greatly distorted without perceptibly affecting the value of c. If the curve, for example, is made like Fig. 21, then, if $y=cx$ is the equation to the line,

$$M(y)=\frac{c\,a}{2}.$$

$$M(y^2)=\frac{1}{a}\int_0^a y^2\,dx=\frac{1}{a}\int_0^a c^2 x^2\,dx=\frac{c^2 a^2}{3}.$$

$$\sqrt{M\,y^2}=\frac{c\,a}{\sqrt{3}},$$

$$c=\frac{M(y)}{\sqrt{M(y^2)}}=\frac{\sqrt{3}}{2}=0{\cdot}866.$$

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If the curve has the form shown in Fig. 22, we have

$$M\,y = \frac{\frac{b}{2} + b}{2} = \frac{3}{4}\,b\,;$$

$$M\,(y^2) = \frac{\frac{b^2}{3} + b^2}{2} = \frac{2}{3}\,b^2,$$

$$\sqrt{M\,(y^2)} = \sqrt{\tfrac{2}{3}}\,b,$$

$$c = \frac{M\,(y)}{\sqrt{M\,(y^2)}} = \frac{3}{8}\sqrt{6} = 0{\cdot}919.$$

These values of c differ very little from 0 9. The alternators which are used in practice with transformers always give potential

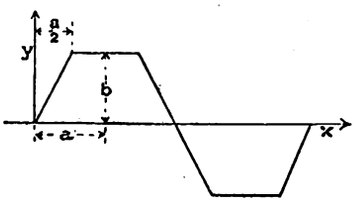

Fig. 22.

difference curves which lie between the curves given in Figs. 21 and 22, so that it is obvious that the calculations assuming $c = 0{\cdot}9$ would yield results very near the truth.

(To be concluded).

NOTE ON TINFOIL GRATING AS A DETECTOR FOR ELECTRIC WAVES.*

BY PROF. T. MIZUNO.

Much interested by Herr E. Aschkinass' experiments described in his Paper read before the Physical Society of Berlin, I have been induced to repeat them. How far my results confirm his and how far they differ from them, will be seen from this Note, in which I also give a few tests of the sensibility of tinfoil grating as a detector of electric waves, and an account of some experiments to determine the nature of its action.

I prepared by gratings by first coating a flat wooden block with tinfoil and then cutting on it a number of fine parallel slits with a sharp knife (*see* Fig. 1). A and B are binding screws which are fixed in the block and facilitate the connection of the grating with a Wheatstone's bridge.

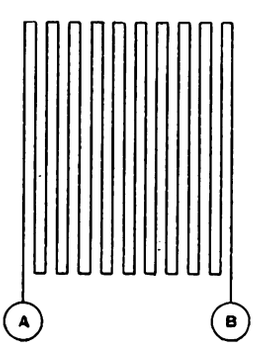

Fig. 1.

The particulars of the two gratings chiefly used in my experiments were as follows:—(1) Rectangular in form, 3·5cm. by 5·1cm., total number of lines 97, and the resistance nearly 130 ohms. (2) Also rectangular, 3 5cm. by 4·4cm., the number of lines 118, and the resistance nearly 232 ohms.

My primary vibrator was a brass cylinder 3cm. in diameter and 26cm. in length, its surface interrupted midway along its length by a spark gap, and its ends furnished with brass spheres 4cm. in diameter forming the poles. The wave length of the electric waves produced was ascertained to be about 60cm. The vibrator was placed in the focal line of a wooden parabolic cylinder coated inside with tinfoil, whose height was 76cm., depth 21cm., and focal length 12cm. My resonator is very simple in construction and has been found very convenient in my other researches on electric waves. It is merely a rectangular strip of tinfoil, 0·8cm. in breadth and 60cm. (30cm. in some case) in length, with a gap in the middle, which is so fine that resonance sparks can easily pass across.

I will now describe some experiments with the view of showing to what extent metallic gratings can screen the action of electric waves.

Experiment 1.

A wooden board, on which were pasted two parallel tinfoil strips, 33cm. in length and at a distance of 9·7cm. from one another, was set up vertically in front of the parabolic cylinder at a distance of about 30cm. from the vibrator. The grating No. 1 was brought behind the board, and after exposure for about half a minute to electric waves, its resistance was examined by a Wheatstone's bridge. The results obtained were as follows:—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	129·7 ohms.	123·5 ohms.	6·2 ohms.
2	129·7 „	123·4 „	6·3 „
3	129·9 „	123·6 „	6·3 „

As Herr Aschkinass mentions, the resistance of the grating once diminished by the action of electric waves could be restored almost to its original value by tapping it. In this experiment, resonance sparks could be discovered behind the board by means of my tinfoil resonator.

Experiment 2.

Next, a third strip was pasted on the board, half-way between the other two and the experiment repeated. The results were:—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	129·7	123·7	6·0
2	129·8	123·8	6·0
3	130·0	123·5	6·5

Here, the resonance sparks behind the board were very feeble.

Experiment 3.

Two more strips were then added bisecting the spaces between those in the previous experiment.

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	129·8	125·8	4·0
2	129·8	125·6	4·2
3	130·1	125·7	4·4

The resonator behind the board gave no sparks in this case.

Experiment 4.

Next, a grating, rectangular in form, 27cm. in length and 22cm. in breadth, was made, the average distance between two consecutive strips being about 0·6cm. Placing this grating in a vertical position in front of the parabola and bringing the grating just behind it, the following changes in resistance were observed:—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	129·7	123·7	6·0
2	129·1	124·1	5·0
3	129·2	123·5	5 7

Experiment 5.

Substituting for the above grating a large wire grating, 1·7 metres in the side and with consecutive wires 3cm. apart, I have found the changes of resistance as follows:—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	129·9	126·5	3·4 ∥
2	129·9	123·4	6·5 ⊥
3	129 9	126·7	3·2 ∥
4	130·2	124·5	5·7 ⊥
5	130·4	127·0	3·4 ∥
6	130·3	124·1	6·2 ⊥

* From the *Journal* of the College of Science, Imperial University, Tokio, Japan, Vol. IX., Part I., 1895.

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The signs in the last column of the above table denote the orientations of the wire grating according as the wires were placed parallel or perpendicular to the primary vibrator. The results show how different are the effects of polarised waves on my tinfoil grating. The experiments have shown also how sensitive the tinfoil grating is to the action of electric waves in comparison with my rectilinear tinfoil resonator, because I have found that whereas the former has shown a large amount of change in resistance the latter gave no perceptible resonance spark.

Experiment 6.

I now placed my tinfoil grating within a glass bell-jar which was covered with tinfoil strips. I found that even in this case the change of resistance was distinctly perceptible. Thus :—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	129·7	125·0	4·7
2	129·9	125·7	4·2
3	129·9	125·6	4·3

This result may be taken to indicate how imperfect would be the protection of an ordinary metallic gauze against powerful electric oscillations.

Experiment 7.

A circular copper plate 30cm. in diameter was vertically suspended in front of the vibrator. My tinfoil grating placed behind the plate at a distance of about 12cm. from it, showed the following changes in resistance :—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	129·1	121·0	8·1
2	129·3	122·3	7·0
3	129·4	122·0	7·4

Next, the distance between the plate and the grating was diminished to 2·5cm. The changes were as follows :—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	129·3	123·0	6·3
2	129·0	123·2	5·8
3	129·5	123·0	6·5

The difference between the results of this and those of the last experiment I am inclined to ascribe to the diffraction effects of electric waves caused by the plate.

Experiment 8.

A rectangular wooden board, 69cm. in length and 14cm. in breadth, was coated all over with tinfoil. When it was held vertically with the longer edges parallel to the primary oscillations, the resistance of my tinfoil grating placed behind it showed no change, but when the edges were placed perpendicular to the primary oscillations, I found :—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	130·0	127·0	3·0
2	130·8	127·7	3·1
3	131·4	127·8	3·6

This shows that the intensity of the diffraction effect depends on the extension of the tinfoil board with respect to the direction of of the primary oscillations.

Experiment 9.

A parabolic cylinder exactly similar to the one mentioned before was placed against the latter, at a distance of about 1·5 metre. So that their focal lines should be parallel. My tinfoil grating No. 2 was held in the focal line of the second parabolic cylinder and tested, thus :—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	229·9	219·0	10·9
2	229·9	219·7	10·2
3	229·9	219·6	10·3

Taking away the cylinder, I found :—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	230·0	227·6	2·4
2	230·0	228·0	2·0

Experiment 10.

In this experiment, my tinfoil grating No. 2 was placed just in front of a metallic plate—that is to say, near the node of the stationary electric waves produced by the plate, with the following results :—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	222·0	200·0	22·0
2	227·0	206·0	21·0
3	228·0	206·5	21·5

Taking away the plate, I found :—

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	227·2	184·7	42·5
2	225·7	184·5	41·2

Experiment 11.

In order to examine whether the orientation of the tinfoil grating with respect to the primary oscillations has an influence or none on the change of its resistance, the following observations were carried out.

(1) With the grating No. 1.

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	132·4	125·0	7·4 ⊥
2	132·2	125·5	6·7 ∥
3	132·4	125·2	7·2 ⊥
4	132·4	126·4	6·0 ∥
5	132·5	125·5	7·0 ⊥
6	132·7	126·5	6·2 ∥

(2) With the grating No. 2.

Experiment.	Initial resistance.	Final resistance.	Decrease of resistance.
1	232·0	189·9	42·1 ⊥
2	232·0	193·0	39·0 ∥
3	232·0	187·0	45·0 ⊥
4	232·0	196·0	36·0 ∥
5	232·4	183·2	49·2 ⊥
6	232·2	194·5	37·7 ∥

The signs in the last column indicate the direction of the tinfoil strips of the gratings with respect to that of the primary oscillations. Thus, the answer may be taken as positive.

Experiment 12.

Lastly I performed some experiments to decide the question whether the change of resistance under consideration is a molecular change as in a selenium cell or simply a mechanical one. For this purpose I prepared very carefully another tinfoil grating with a much wider space between the strips. It was rectangular, 7cm. in length and 6cm. in breadth, the total number of fine strips being 51 (*see* Fig. 2). The resistance of the grating thus prepared was 209 ohms. Now exposing this grating to the action of electric waves, I did not find the least sign of change in its resistance, except a very small one due perhaps to the heating effect. The experiment was, of course, tried several times and also on different occasions, but never with positive result. Here I wish also to notice that although I tried the experiment with fine German-silver wire and also fine iron-wire gratings, I could never find any decided effect due to the action of electric waves on them.

Conclusions.

1. It is certain that the change of resistance of the tinfoil grating is due to the action of electric waves. So far as the electric discharges in the primary spark-gap are oscillatory, they have an effect on the grating, but if not oscillatory, none.

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2. Inasmuch as where my rectilinear tinfoil resonator fails the tinfoil grating shows the presence of electric waves, the latter must be regarded as far more efficient than the former as a detector of electric waves. Even a single spark, if oscillatory, is sufficient to produce a large effect on the grating. I would here call attention to the fact that the change in resistance of one and the same grating observed on different days during the course of my research differed in amount. This is certainly due to the conditions of the spark-gap, and consequently the intensity of the primary oscillations, and also somewhat to the time of exposure.

3. The sensibility of gratings may, up to certain limits, be increased by increasing the fineness and closeness of the strips. For, of my two gratings which are nearly equal in their dimensions but greatly different in the number of strips, the first gave the maximum change of about 6 per cent., while the second gave about 19 per cent.

4. The phenomenon under consideration may not be molecular, and so far as my experiments go, seems to be purely mechanical. Slits cut in tinfoil with a knife, however sharp they may be, surely have margins which are zigzag. I imagine that the action of

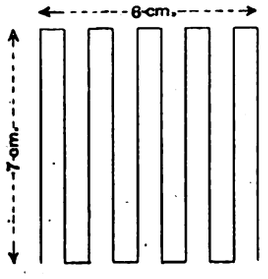

FIG. 2.

electric waves may consist in giving impulses to several strips of tinfoil so as to let the leaflets on the margins come in contact with one another and thus cause a diminution of the total resistance of the grating. Especially the fact that the spacing of the strips should have so large an influence as to reduce the effect almost to nothing seems to me to favour the above supposition. Also the fact that the change of resistance depends upon the orientation of the strips seems to point in the same direction. Still another fact which is equally important from the above point of view is that the resistance of the tinfoil grating once diminished by an exposure to the action of electric waves can be restored nearly to the original va'ue by tapping the grating. It may be pointed out that Prof. Minchin's experiment * on the action of electromagnetic radiation on films containing metallic powders may stand in close connection with the present subject.

PHYSICAL SOCIETY.

At a special meeting held on November 22, 1895, Capt. W. de W. Abney (President) in the chair, the following resolution, with reference to the Articles of Association, was passed :—In Article 33 to strike out the words "by the payment of £10 in one sum," and in place of this to insert the words "the composition fee shall be, for every member who shall not have paid 10 annual subscriptions, 15 times the amount of the annual subscription payable by such member, and for any member who shall have already paid 10 or more annual subscriptions, 10 times the amount of the annual subscription payable by such member."

The ordinary meeting then took place.

Dr. G. JOHNSTONE STONEY exhibited a print of Profs. Runge and Paschen's photograph of the spectrum of the gas obtained from clevite, together with a diagram illustrating the manner in which these observers have arranged *all* the lines obtained in two sets, each set containing three series of lines. Dr. Stoney also drew attention to the resemblance between each of these sets of three series of lines and the similar triple series obtained in the case of the metals of Mendelejeff's first group.

Mr. R. APPLEYARD read a Note on

"The Action of Sulphur Vapour on Copper."

When a copper wire is exposed for some time to the action of sulphur vapour it becomes entirely converted into sulphide of copper, and it is found that there is a fine axial hole running down the rod of sulphide formed. Rods of copper of square section cut from a block of copper after exposure to the action of sulphur vapour also exhibited the axial hole, the rod of sulphide formed being of circular cross-section. In every case the diameter of the rod of sulphide formed is about twice that of the original rod of copper. Delta metal was found to be unacted upon by the sulphur vapour.

* *Phil. Mag.*, p. 90, 1894.

Mr. APPLEYARD then read a Paper on

"A Direct-Reading Platinum Thermometer."

This form of platinum thermometer has been devised with the view of determining the temperature of the dielectrics employed in some experiments on the variation of the electrical resistance of dielectrics with temperature. The thermometers consist of six platinum coils, each of about 7 ohms resistance, attached to thick copper leads. A slide-wire Wheatstone's bridge is employed to measure the resistance. The stretched wire is 3 metres long, and the moving contact so arranged that it is impossible to damage the wire. The auxiliary coils used in connection with the bridge are immersed in a bath of paraffin oil, the temperature of which is maintained constant, and a little above that of the air, by means of a glow lamp immersed in the oil.

Mr. APPLEYARD also read a historical Note on

"Resistance and its Change with Temperature,"

in which he showed that the earliest measurements of the variation of resistance with temperature were made by Leutz in 1833. Some experiments on this subject made by Davy are also referred to, and some of these experiments were repeated before the Society.

Mr. TROTTER said he agreed with the author, that the "reserve of precision" at our disposal on account of the delicacy of some of the modern instruments ought to be made use of to facilitate the rapid performance of many measurements where the utmost accuracy is not necessary. He had the impression that platinum-silver was not now considered the best material for use as the bridge wire.

Mr. H. F. BURSTALL explained the differences between the temperature as measured on the mercury, air and platinum thermometers. At a temperature of about 40deg. the platinum thermometer read about 0·4deg. and the mercury thermometer about 0·1deg. below the air thermometer. Prof. Callendar had obtained measurements of temperature correct to within 0·1deg. by using a Weston voltmeter and an ordinary Wheatstone bridge, the variations of resistance, and hence the temperature being read directly from the deflections on the voltmeter.

Mr. RHODES thought that, except where extreme accuracy was necessary, the mercury thermometer was very much more convenient than the platinum thermometer.

Mr. BURSTALL said the great convenience of the platinum thermometer lay in the fact that the scale would be read at a distance of many yards from the point where the temperature was being measured, and hence it could be used in many places where it would be impossible to read a mercury thermometer.

Mr. BLAKESLEY considered that the author was somewhat bold to state that it was for general purposes never necessary to measure temperature to nearer than one-tenth of a degree.

The author having replied, the Society adjourned till the 13th of December.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, December 6th.

INSTITUTION OF JUNIOR ENGINEERS.

8 p.m. Meeting at the Westminster Palace Hotel. Paper to be read: "Considerations with respect to Water, Gas, and Electric Mains, &c., in connection with the Formation of Urban Roads and Footways," by J. Julian.

MONDAY, December 9th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture II.: "Mechanical Road Carriages," by W. Worby Beaumont.

TUESDAY, December 10th.

SELF-PROPELLED TRAFFIC ASSOCIATION.

3 p.m. Meeting at Cannon-street Hotel to consider the advisability of forming an Association. Sir David Salomons, Bart., will preside.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion on Messrs. Arnold and Wrightson's Paper on "The Physical Properties of Iron and Steel."

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting at the Palatine Hotel, Hunt's Bank, Manchester. Paper to be read: "Test of a Colliery Hauling, Pumping and Lighting Installation," by C. H. Lees.

WEDNESDAY, December 11th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Adjourned Discussion on Mr. Cunynghame's Paper on "Locomotive Carriages for Common Roads."

THURSDAY, December 12th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Annual General Meeting, to be followed by a Discussion on the following Papers: (1) "The Electric Wiring Question," by F. Bathurst; (2) "Concentric Wiring," by Sam. Mavor.

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MODERN ELECTROLYTIC ALKALI PROCESSES.

The development of most enterprises takes place by a series of advances and retreats, the former predominating to give a nett onward pace, and the history of industrial electrolysis shows no exception to this rule. Just now a period of advance is in prospect, if reports and other indications may be believed. The character of that advance may be judged by the accounts of the meetings of two companies recorded in a recent issue. Seeing that the processes used by these two associations are, in a sense, rivals, something may be learnt as to the standing of the infant industry, which they both hope to extend and make profitable, by instituting a comparison between their respective methods and progress, actual and probable.

The Electro-Chemical Company (Limited), which held its second annual meeting on November 5th at St. Helens, is stated to be now at work producing caustic soda and bleaching powder, although the output of these commodities is not announced. It is reasonable to suppose that the quantity is small at present, as no drop in price has taken place, and indeed it is the happy position of the Company to be able to obtain the highest rates fixed by the United Alkali Company, which controls the market. When the make approaches the 20,000 tons said to represent the capacity of the plant, a distinct influence on the ruling price may be reasonably anticipated. The Aluminium Company (Limited), which is interested in the Castner-Kellner process, had more to say of patent sales and negotiations than of the production of alkali and chlorine. The Castner-Kellner process, formed by the amalgamation of cognate patents, is, however, of such recent date that it can scarcely be expected to begin a manufacturing and dividend-earning existence yet awhile. The news that Continental and American manufacturers have bought certain of the foreign patents, and are about to work them, is good and encouraging, having regard to the status of the firms concerned; but the fact that the two largest producers of alkali in this country have held aloof is not without significance.

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Regarding the technical advantages and drawbacks of the two processes, much might be said did space permit of a detailed criticism. A few salient points may, however, be touched upon without unduly exceeding our customary bounds. Thus it is interesting to note that in the case of these two latter-day manifestations of electro-chemical invention, the interest (and conflict) centres round the cathode, once the negelected and despised Cinderella of every electrolytic cell. In the Electro-Chemical Company's apparatus the use of an iron cathode, such as has generally been employed in similar cases, has been retained, and its simplicity and cheapness are justly extolled. Parenthetically it may be remarked that the use of oxide of copper to oxidise hydrogen at the cathode appears to be abandoned, or, at least, there is little mention of it now. For the Castner-Kellner cell, mercury, functioning at once as a cathode and as a means of transmitting one of the products of decomposition (sodium) outside the cell proper, has been chosen, and its advantages have been fully impressed upon the receptive. A few years ago no one pretended to have the smallest interest in the cathode of a cell for making chlorine and caustic soda; it was either a new diaphragm or an artfully-contrived anode which claimed the public notice and the public's money. All that is for the moment changed; it is the anode which is neglected, and as for the diaphragm, it is as often as not absorbed by the triumphant cathode—a veritable pluralist. We should be, perhaps, too sanguine were we to hope that the difficulties which in early days constantly arose from the behaviour of the anode and diaphragm, have become mere obsolete traditional bogies; nevertheless, it may be reasonably deduced that such difficulties are not so pressing and importunate as they used to be, and that consequently some time and inventiveness are set free for the solving of less vital, but still important, problems. Given a cathode of mercury, as in the Castner-Kellner process, plentiful fault may be found with it. That it is heavy and costly is not to be denied; that, to secure the mobility on which its effectiveness as cathode and carrier depends, the use of rocking cells is requisite, cannot be gainsaid; but to brand it as a deadly insidious poison, when employed in this manner, seems to us a little far-fetched. Lives spent in an atmosphere of mercury vapour are neither pleasant nor healthy, but deplorable consequences need not be predicted for those whose occupations lead them to work in rooms wherein any necessary number of tons of the liquid metal are reposing in well-covered tanks. Leakages of chlorine, relatively inconsiderable, are far more likely to be troublesome and dangerous, though even under the worst conceivable working conditions the neighbourhood of a number of decomposing cells would be paradisiacal in comparison with the vicinity of a bleaching-powder chamber undergoing the process of emptying. The gallant Chairman of the Electro-Chemical Company remarked, with much justice, that the impressionable character of mercury was well shown by the use of the metal for barometers and thermometers; but, unhappily, he failed to trace a connection between this circumstance and the subtle toxic effects which he seemed to expect from the cathodes of the Castner-Kellner cell. Excogitation of the matter has failed to help us, for it leads irresistibly to the conclusion that if such a connection exists, then glycerine and air are poisonous in the extreme, and this view is difficult of reconciliation with recorded observations apparently authentic and reliable. Notwithstanding this confusion of ideas, however, the Chairman of the Electro-Chemical Company certainly made one good point when he alluded to the necessity of machinery for driving the oscillating tanks, as an undesirable feature of the Castner-Kellner process. Assuredly it is undesirable, the more so that the cost of plant per unit of product is inevitably high in all electrolytic processes for making alkali and chlorine which have been hitherto worked out. To justify extra expenditure on this item, some great gain in efficiency must be shown, and then choice between two processes, otherwise similar, becomes a mere matter of arithmetic. Reverting a moment to the question of the mercury cathode, it may be mentioned that figures are cited, appearing elsewhere in these pages, which effectually dispose of the belief that any tangible quantity of the metal can find its way into the systems of the operatives.

But the anode, though temporarily neglected, is not a negligible quantity. In most processes that have made any headway their devisers have adopted the use of carbon, in some form, for the anode. But one carbon differeth from another in refractoriness, and the ultimate method of selection must be a happy blend of experiment and experience. Information, if not considered too valuable to publish, as to the result of the trials on a considerable scale which have taken place freely within the last three or four years, would be in the highest degree interesting and important. Some data must now exist for determining the probable life of an anode of a given class of carbon, and calculation of the expenditure involved in renewals should have become possible. Again, the feasibility of using graphitic carbon prepared by the aid of the electric furnace is worthy of careful consideration. In fine, the anode is yet to be improved, and its amelioration should afford at least as much scope for ingenuity as does the devising of novel forms of cathode. Whatever the direction in which inventors may for the moment be working, one thing is certain, namely, that never before have two or more schemes, all possessing certain elements of advantage, if not of success, been brought to a point where there is excellent reason to think they may be tried thoroughly and on a scale which can leave no doubt as to their ultimate status. The present epoch is in this respect noteworthy.

REVIEW.

Cavi Telegrafici Sottomarini—Costruzione, Posa, Riparazione. Dall Ing. E. Jona. (Submarine Telegraph Cables—Construction, Laying, and Repairing. By E. Jona, Electrical Engineer.) (Milan: Ulrico Hoepli.)

A long-felt want has been supplied to telegraphists and students of electrical science in Italy by the publication of Signor Jona's work. An occasional spasmodic effort has indeed been made to enrich the very meagre scientific literature of that country dealing with the subject in question, but no regular attempt has hitherto been made to fill up the hiatus between the various text-books—all following the same beaten track—and the principles evolved out of modern practice. The handy little volume before us contains a collection of facts regarding submarine cables which, we may almost say, are not to be found in any two separate works, even in English. In a short preface the author acknowledges that he has drawn a great deal of his information from all the handbooks and treatises of electrical science extant, but in the compilation of such a work this necessity becomes self-evident.

The volume consists of 338 pages of closely-written matter, 188 clearly-drawn cuts, a map, and an index. It is divided into eight parts, the first of which is devoted to a review of the earliest attempts to lay submarine cables until the successful completion of the first Atlantic cable in 1866, and to the industry of submarine cable manufacture in Italy. In 1886 the firm of Pirelli and Co., of Milan, which for some years previously had been engaged in the manufacture of insulated telegraph wire, opened a large establishment in the naval

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seaport town of Spezia, especially devoted to the manufacture of submarine telegraph cables, and shortly afterwards obtained an order for some dozen short cables to connect certain islands with the continent, and also a proposal for renewing and maintaining the old Otranto-Valona cable laid in 1864 by Henley and Co. Before, however, the firm could execute this order, it was necessary to procure a properly-equipped cable-ship, eventually supplied by Messrs. Thompson of Sunderland. This vessel, now the "Città di Milano," closely resembles the "Electra" belonging to the Eastern Telegraph Company, and although owned by Pirelli, she practically forms part of the Italian Navy. Since 1887 the firm has made and laid some 900 knots of cable for Italy, and about 400 knots for the Spanish Government. The chapter closes with a table of all the cables of the world.

Part II. is entirely devoted to the construction of cables, and is very complete. Part III., extending over 70 pages, deals exhaustively with the theory and practice of cable-laying, the whole being amply illustrated. Part IV. explains some of the principal causes of faults in cables, and it is interesting to note that the very latest theory of geological evolution on the sea's bottom (one of the most frequent causes of interruption in cables) has been included by the author under this heading. The fifth and sixth sections constitute the principal and most valuable part of Signor Jona's work. Special attention has been given in considering laws which regulate the manufacture of an electrically perfect cable from the moment the bare wires pass through their first process of insulation until the whole is completed ready for submersion. A full description is given of all the apparatus in use for testing purposes, and the various tables and calculations in reference to the same have been carefully and accurately compiled. Testing for faults, both before and after the cables are laid, completes these sections; this part, however, is obviously only a translation of all the known methods for localising faults, but it is quite up to date and very correct. Parts VII. and VIII. treat of the theory of submarine telephony, as well as telegraphy, and a list of the usual tables and notes, without which no work on telegraphy is complete, brings us to the end of the book.

Although the type is rather small, it is perfectly clear, and there are remarkably few typographical errors considering the number of equations, calculations, and tables, &c. The map at the end shows fairly well all the cables of the world. We strongly recommend Signor Jonas's book to all electrical students who understand the language, whilst to the Italian telegraphist we say: "Ogni impiegato telegrafico, che tiene a cuore la sua professione, dovrebbe acquistarlo studiarlo e tenerlo sempre àdosso."

THE CROMPTON POTENTIOMETER: ITS USE AND CAPABILITIES.—II.*

BY W. C. FISHER, ASSOC.MEM.INST.C.E.

Up to the present the writer has been content to describe, in as diagrammatic and simple a manner as possible, the general outline of the potentiometer system of measurement; all side issues and questions of error and expediency have been avoided, so that those who may not have the time or patience to wade through the whole may, by a cursory glance, as it were, obtain a sufficient grasp of the subject to allow of their understanding and so putting to efficient use the apparatus under their control.

Before proceeding with the details attendant upon the different tests, and a study of the different points of interest, it is perhaps necessary to give a description of the latest type of instrument, and as much as possible the reasons for the adoption of this particular form and the design of its fittings, later on to be followed by the outlines of an ideal instrument.

Fig. 7 shows in plan the instrument as constructed up to date, and which is best described by following the main and galvanometer circuits in conjunction with the diagram of same shown in Fig. 8.

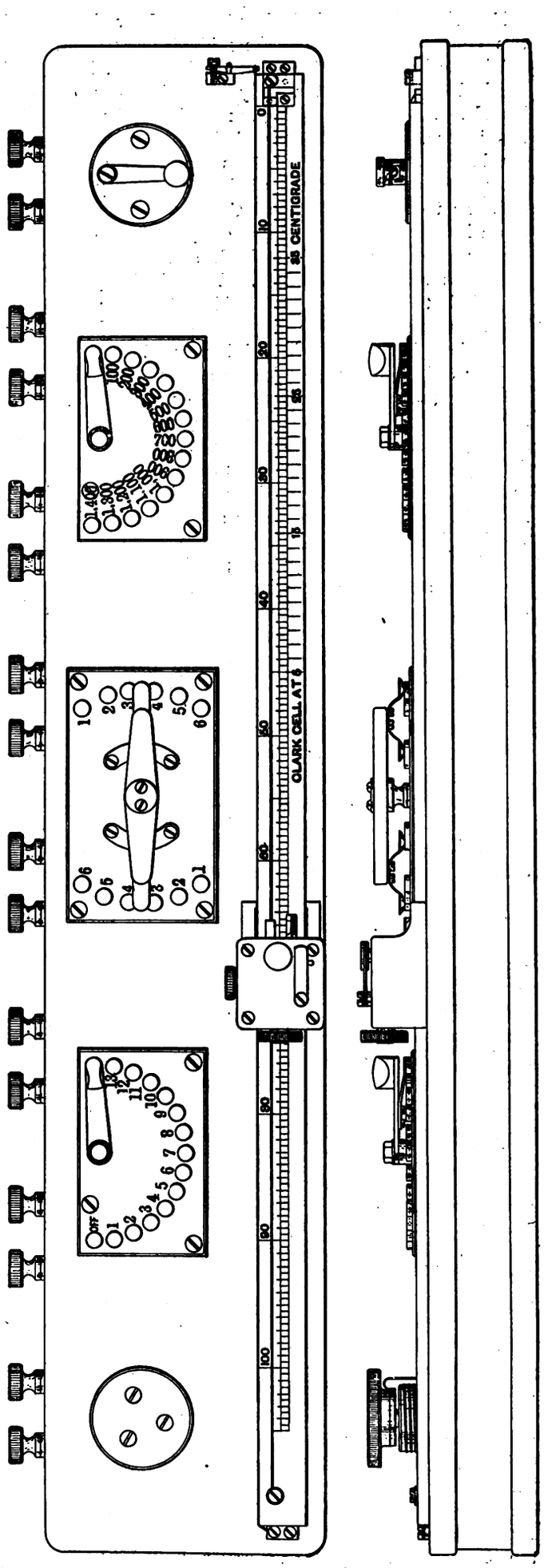

FIG. 7.

* All rights reserved. For Article I. see *The Electrician* of Nov. 29, p. 158.

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Commencing with the battery terminals, the left hand or positive is connected direct to the end of the slide wire by means of which we pass along to the 14 sections shown (each equal in resistance to the slide wire and placed inside the instrument), thence by means of a connection to the main rheostat R, thence to the small or fine adjustment rheostat *r*, and so to the negative terminal. (It will be noticed that the connections are so arranged that *all* positive terminals are to the left.) It is easily seen that the E.M.F. at the ends of the potentiometer proper, *i.e.*, the 15 sections, is controlled by the rheostats R, *r*, and may by them be readily adjusted to any value.

The galvanometer circuit from the negative of the right-hand pair of terminals is connected to the galvanometer contact wire (G.W.), which is placed in connection with the desired point of the slide wire by means of the sliding key.

The left-hand or positive terminal of the galvanometer pair is connected to the left-hand segment of the multiple switch (M.S.) through the contact spring upon the lever of which, it passes to either of the contact pins 1, 2, 3, 4, 5 or 6, and thence by a connection to the positive of either pair of the corresponding terminals, which, duly externally connected, returns us by way of the negative terminal and corresponding contacts to the multiple switch, from which, by means of the right-hand segment and connection, we get to the lever of potential switch (P.S.), and thence by either of its contacts to any desired section of the 15 sections, the circuit being completed by way of such sections and portion of the slide wire as may happen to be in circuit. The galvanometer may, if necessary, be short-circuited by means of the key (G.K.) connected to the galvanometer terminals as shown.

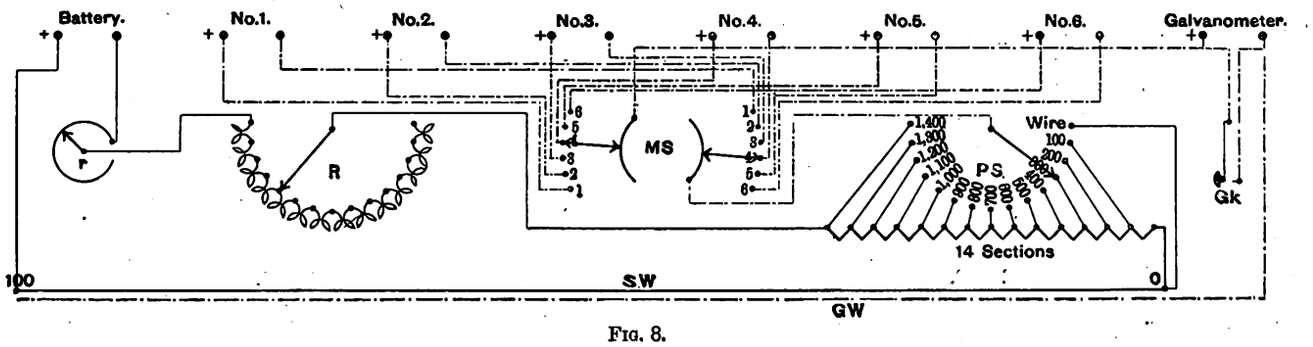

FIG. 8.

The matter of measuring or comparing any unknown value in E.M.F. is made as simple as possible, it being merely attached to either of the pairs of terminals 1, 2, 3, 4, 5 or 6, the multiple switch lever is placed upon the corresponding contacts, and the lever of the potential switch (P.S.) and sliding key (S.K.) moved and depressed until there is no deflection produced in the galvanometer, the position of the lever (P.S.) and key (S.K.) indicating the value direct, a process very much akin to accurate chemical weighing and purely that of potential balance, in which resistance of leads, compensation for temperature, thermo effects, &c., need not for all practical purposes be taken into account.

The calibration of the instrument is equally simple, and is effected and checked in the following manner: The standard is attached to, say, No. 1 pair of terminals, M.S. lever is put on to contact No. 1, the switch lever (P.S.) and sliding key are depressed at the numbers corresponding to the value of the standard, the rheostats R*r* are then adjusted until there is no deflection of the galvanometer upon the depression of the key (S.K.), indicating that the E.M.F. produced by the secondary battery in the main circuit of the instrument is now equal to that of the standard, and the instrument is ready for other comparisons.

With reference to the form and other details of the instrument, all have passed through endless alteration until the present may truly be said to be the survival of the fittest. As at present designed, the instrument is adapted for quick and straightforward working, and may be said to be very compact. Originally the scale was 4 metres long and left much to be desired, inasmuch as the weary tramping to and fro, whilst affording some slight relaxation by constant change in scenery, tended, at the end of a day's hard testing, to the impression that one had been engaged in a walking match of no short distance, to say nothing of the awful labour of calibrating unit length for unit length 4 metres of wire (work which might very well be recommended to the prison authorities as a species of refined hard labour). Certainly when done such a wire became invaluable, and the writer knows of but two in existence. The first deviation from this continuous calibration occurred when the 4 metres were split up into two lengths of 2 metres, then four of 1 metre; in each case one section only undergoing complete calibration, a radical change came about. Abandoning the metre (to the horror of many even to this day) the length of the slide wire was reduced to the prosaic 25in., and the number of its sections increased to 15, in some instances 30 and in one special case 100. It is likely to remain at 25in., for the very simple reason that when that length is divided into 1,000 parts the width of the divisions appear to be the limit that with continued testing and without artificial assistance does not unduly strain the eyes. By the introduction of a lens the scale might be still further shortened, but it is doubtful whether the slight advantage gained in weight and compactness would be worth while.

As shown and described, the scale is straight and divided into 1,000 parts duly numbered upon one side, whilst upon the other side, for convenience and in order to save time, the temperature in degrees Centigrade is engraved opposite the corresponding value of the Clark cell at such temperatures. The question as to whether the scale should be of plain boxwood or celluloid faced is purely a personal one; to some the boxwood is the more pleasing to the eyes, whilst the white celluloid tries them, whether this is due to the glare or to the finer dividing it is difficult to say—probably both have something to do with it. The celluloid has one chief advantage, and that is when dirty it may readily be cleaned with a moist rag without injury, and it certainly wears longest and best.

The straight form of scale has been retained for several reasons. Four years ago the writer designed a circular type of instrument, which was, however, abandoned for several reasons not the least of which was that unless in habitual use the unusual compound crank action of the wrist and elbow, and the figuring at all angles, is irritating and certainly not conducive to quick working, being to anyone but an expert much what a typewriter or A B C telegraph instrument is to a novice; the sweet simplicity and easy working of the straight line movement is entirely lacking, as is also the due alignment of figures, to say nothing of the general mixing up of the hands which it is almost impossible to avoid in the circular form. This opinion has been fully borne out by an instrument recently roughly constructed for trial.

The width of the dividing of the scale has been made as narrow as possible in order to avoid what Lord Kelvin has so aptly termed the pallisading effect.

In order to eliminate all soldered joints as much as possible the 14 sections, each equivalent to the slide wire, are wound in one continuous length, potential points being taken off at fixed distances, having as small a surface contact as is conducive to mechanical strength. The only joint in the whole is at that point where the slide wire joins the remaining sections, and this is made as perfect mechanically and electrically as possible. The sec-

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tions are of bare wire, wound on a tube the convolutions being as close together as the insulation, mechanical and calibrating reasons will permit; this is done to avoid temperature errors, the whole being as compact as possible. Any alteration in temperature affects the whole equally, so that the possible error from this cause, section for section, is very slight. The insulation employed is paper, and is made as perfect as possible. The whole is aged artificially and literally, being in the majority of cases, under test for quite six months, certainly until no change is perceptible in the value of the sections day by day. Up to a recent date the alloy employed, since the rejection of platinum alloys, has been manganin, but owing to the difficulty in obtaining two samples alike, the alteration of resistance with strain, and from atmospheric causes, it was thought advisable after trial to adopt a nickel-steel alloy. This, up to the present, has given every satisfaction, not the least valuable of its attributes being the fact that it remains untarnished for any length of time, especially if there is the slightest film of oil upon its surface; even in an atmosphere periodically charged with sulphuric acid fumes as emitted from fully-charged accumulators, it has stood for two years without any perceptible oxidation. Its temperature coefficient is, of course, higher than manganin, but on account of the precautions taken above this is negligible for practical work.

As forming no small element in the success and age of an accurate slide wire, it might be here advisable to consider the sliding key (S.K.) at this stage. To those accustomed to the old-fashioned form of metre bridge, and for that matter also the old form of potentiometer, with their brutal type of key, the dinting and denting of the wire and scale indiscriminately by careless hands is often put forward as an argument against the potentiometer. "It is so liable to injury by dents to the wire, either by the key being pressed too hard or something

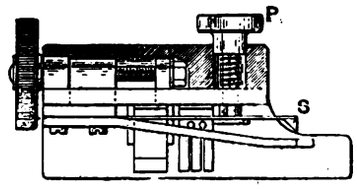

Fig. 9.

falling upon it." The former objection may be put on one side, as the form of key adopted renders it impossible. The design was the outcome of noticing a pupil filled with a more than usual quantity of superabundant energy playing a "tattoo" with both hands upon the key of an old-type instrument. With reference to the second objection, it is not, of course, usual to handle carelessly things approximating in weight to the proverbial "half brick" in a test room. If, moreover, an accident does happen and if in falling the object collides with an instrument, be it galvanometer, slide rule, or Kelvin balance, injury is likely to ensue, in which case one is not likely to condemn the injured, but rather the unfortunate cause of the accident. Besides the slide wire is so easily replaced that the injury to a potentiometer of this description is likely to be far less than to either of the instruments mentioned or those of a similar nature.

The key devised and adopted (Fig. 9) consists of a weak spring, S, having a suitable tip. Normally, if allowed to do so, this spring would make contact with the wire, but it is prevented from doing so by the plunger P with its stronger spring, it is only allowed to come in contact when the plunger is depressed, and then only to the extent of its own weak resiliency. Therefore the energy of the operator is expended upon the plunger spring, and not upon the wire, as in the older form. As seen in the figure, the whole is mounted upon an ebonite carriage for insulation purposes; there are several details shown, such as a micrometer movement, set screw for clamping carriage in fixed position if necessary, and spring for contact with galvanometer wire (G.W.), which runs alongside scale, and is attached to a binding post, as shown, and kept taut by means of an adjustable lever. The lever post is duly connected inside with the galvanometer terminals, as described.

A constant source of annoyance in the earlier form of instrument was the small or fine adjustment rheostat r; all manner of devices and designs were tried without effect in an endeavour to eliminate for ever that irritable source of annoyance, an intermittent or very variable contact. The form shown in Fig. 10 was finally adopted as the most serviceable and nearest to fulfilling the above requirement. It consists of an ebonite turntable T, having a milled edge, and attached to the same by a flange is a screw shank, S S, revolving in a thread cut in the sleeve S, and having a split pin, S P, projecting into a hole bored in the direction of its axis. The sleeve is secured concentrically in an ebonite cylinder, C, having cut upon its exterior a thread of the same pitch as that of the sleeve and screw shank. In this thread is wound a wire, W, suitably secured at each end, and insulated off the metal sleeve. Attached to the flange of the screw shank is a spring, H, which rests upon the wire as shown in figure, making contact therewith. The resistance in circuit is varied by revolving the turntable, together with the spring H, which, riding upon the wire and following it convolution for convolution, puts into circuit more or less of the same. As first designed, after a time, owing to possible wear, the contact between the surfaces of the screw and sleeve became somewhat irregular, and caused trouble; the split pin was therefore introduced as an auxiliary means of contact to take up whatever inequality there might be in that respect between the screw and sleeve, so affording a factor of safety of 3 to 1.

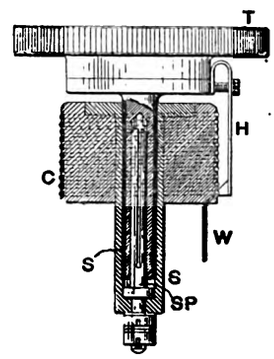

Fig. 10.

The multiple switch shown in the centre of the instrument (Fig. 7) is also the outcome of many devised, and has been definitely adopted as being the best both from a mechanical and insulation point of view. Its mechanical construction is simple, and, as shown, consists of a lever pivoted in its centre and carrying two springs which connect the inner segments with the outer contacts; the lever and standard are solidly built, and form no part of the circuit; the springs are made of just sufficient strength to make effective contact, the whole being therefore of a nature to admit of certain and definite movement, together with ease and smoothness of working—all points of the greatest importance where readings have to be taken in rapid succession. With reference to insulation it will be seen that the design admits of the longest possible paths of surface leakage, the contacts themselves being as far apart as possible, whilst the distance between contacts and segments, or segment and segment, is the maximum possible. In this manner surface leakage is reduced to a minimum at the points where the numerous electromotive forces to be measured are foregathered.

Gas Engine Stations.—The electric railway at Lausanne is operated from a power house in which the dynamos are driven by two gas engines of 130 H.P. each. These engines are by Messrs. Crossley, and use producer gas. The dynamos are belted to the flywheels. The working is said to be very economical, and the best result obtained has been an expenditure of 1·2lb. of anthracite coal per horse-power-hour in ordinary service. The engines are run on an average 18 to 20 hours per day. A careful calculation has shown that the amount of fuel used is 4·5lb. of anthracite per car-mile.

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INDUSTRIAL ELECTROLYSIS.

The Hargreaves-Bird process for the preparation of alkali and bleach by electrolysis has lately been cursorily dealt with in these columns, and those points which appeared open to criticism have been duly indicated. On Monday last a further opportunity was afforded of arriving at an opinion of the advantages of the method on the occasion of a meeting of the London Section of the Society of Chemical Industry, when Mr. Hargreaves read a Paper upon the invention in question, and invited criticism from the experts present. We cannot say that this communication added much to what is already public knowledge, for much of the author's attention was directed to the discussion, in a somewhat depreciating sense, of processes professing to accomplish similar ends. Seeing that several of those present were directly or indirectly interested in the processes attacked, somewhat lively rejoinders resulted, and the outcome was rather of dialectical than educational value. It is, however, practicable to compress certain of the contributions to the discussion, and to eliminate the unduly polemical, and thus arrive at the consensus of opinion, not only on the Hargreaves method, but on certain others now prominently before the public. Two of these other processes are dealt with comparatively in our leading article this week, and their relation to the Hargreaves process may be conveniently elaborated here.

It is significant of the need for allaying a vulgar scare which may do harm to a promising industry that Sir Henry Roscoe, with considerable sagacity, confined his remarks to a destructive criticism of the allegations which Mr. Hargreaves had made to the effect that mercury used in the Castner-Kellner process was a potential source of danger to the workmen. In our leading article already referred to, which was written before the present Paper was read, we have already endeavoured to relegate to limbo what is, on the face of it, a fallacy Sir Henry Roscoe added the weight of his testimony to the same excellent end. He stated that the notion that hydrogen was liberated from the surface of the mercury was a mistake, as it was actually evolved from an iron grid placed above the liquid metal. Thus the hypothesis that mercury vapour may accompany the escaping hydrogen goes by the board. Further, he brought forward the results of experience gained during $2\frac{1}{2}$ years' working of the process at Oldbury, which went to show that no mercurial poisoning whatever had occurred among the men employed. A comparison between the Castner-Kellner process and the old mercury method of "silvering" mirrors (in contradistinction to the modern process of depositing silver upon glass to form a reflecting surface) cannot reasonably be made; there is not even an analogy between the two operations. It is particularly necessary, when considering the possible causes o : loss of mercury used industrially, to remember that the metal in its liquid state is most mobile and penetrative, and that small quantities unaccounted for are not necessarily vaporised. The major part of such unrecoverable mercury has escaped through joints and even through bodies (*e.g.*, wood) of apparent solidity. In spite of this tendency, which is well known by all who have to use mercury in the laboratory, the amount lost from 2,782lb. of mercury during eleven weeks of working the Castner-Kellner process was only 7·27lb., or well under 2 per cent. per annum. By taking special care to collect the small quantity of dust and dirt from the floor of the shop as much as 3·3lb. out of the 7·27lb. missing was recovered, reducing the annual loss to something under 1 per cent. We do not think that anyone would hesitate to affirm that the greater part of this residual deficit was due to mechanical loss and not to volatilisation.

For the reason which has been stated above, viz., that Mr. Hargreaves' Paper necessited much controversial discussion, Dr. Hurter's contribution to the matter in hand was mainly taken up with a defence of his own views and statements. He gave an interesting exposition of the relation of working results with modern electro-chemical theory, and pointed out that an electrolytic cell designed for the production of alkali and bleach from common salt must not be considered as one in which the electrolyte is simply sodium chloride, but as a cell containing several substances each capable of acting as an electrolyte—to wit, sodium hydroxide, sodium hypochlorite and sodium chlorate, as well as sodium chloride; further, the distribution of the current in the electrolyte and consequently the amount of electrolysis is directly governed by the relative conductivity of the salts present. By taking advantage of a knowledge of these facts the current efficiency of a given cell can be calculated. It is proper to remark that this is only one factor in the true efficiency of a given cell; the volts must also be taken into account, and, in short, the output must be referred to watts as a standard of comparison.

In Mr. Swinburne's remarks the highly practical statement was made that after all the difference in efficiency of one process from another was not necessarily the largest item in deciding the cost of the processes. Certain fixed, or nearly fixed, charges make themselves apparent in any electrolytic process, and an economy in the electrolytic part of the preparation of commercial alkali and bleach does not necessarily greatly influence the ultimate monetary return of comparable methods. Mr. Blount, arguing on similar lines, spoke of the prevailing trouble of all electrolytic processes—viz, the small output per unit of plant. As not only interest on the capital sunk in the plant has to be paid, but the depreciation of the plant—often a serious item—has to be provided for, a given process, perhaps failing in actual economy of energy, may have the advantage over one in which the capital expenditure or upkeep is heavy. It may further be noted that most of the requirements arising from an adherence to modern dissociation theories are amply covered by older chemical principles, *e.g.*, such as insist on the necessity for the removal of the products for a given reaction from the sphere of the reaction if the continuance of the reaction under the same conditions and with the same expenditure of energy is required. A warning must be issued against the unqualified acceptance of Mr. Hargreaves' figure for the voltage necessary to effect electrolytic decomposition in his cell, inasmuch as the comparatively low value obtained by him—3·4 volts—applies to the production of sodium carbonate and not to caustic soda, the latter substance needing a greater outlay of energy for its formation, and consequently requiring a higher voltage. It is in any case clear that the critical voltage for the decomposition of common salt (about 2 volts) has not yet been approached in any commercial cell.

It will be seen from the foregoing statements that the Paper and the subsequent discussion were useful as leading to the interchange of opinions rather than to the promulgation of ascertained facts. Well-grounded opinions (and some were certainly well-grounded) are fully as useful as facts, and the occasion will not be without fruit, even though some of the processes will suffice to inaugurate an industrial millennium.

ELECTRIC LIGHTING CURVES.

Historians, we understand, find it exceedingly difficult as a rule to obtain an accurate idea of the domestic habits of nations upon whose forms of government or social customs they ponderously discourse. This difficulty ought in the future to be largely mitigated by an intelligent inspection of typical central station load curves. No doubt their peaks and plateaus will be liable to be variously, possibly erroneously, interpreted, but at any rate they should form an excellent basis upon which to build. For instance, armed with a Bankside, a Kensington-court, and a Carnaby-street load curve, a future Froude might easily deduce therefrom that an appreciable portion of the work of the City of London was carried on more or less subterraneously, and that by about eight o'clock the City became for the most part like unto a city of the dead. The Kensington-court curve would tell a true tale as to the average time taken in that quarter to dress for, consume and digest a dinner. A Carnaby-street curve would be an accurate index of the average closing time of West-end shops, and would tell not a little as to the late hours kept in clubs, and the length and number of acts in an average modern drama. Of course, if all other

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records had been lost, and the above-mentioned curves were the only documents available, the deciphering of them would probably prove about as difficult as that of the first hieroglyphs.

To assist in the elucidation of the accompanying curves of the Cambridge Electric Supply Company, we append a few explanatory remarks. The curves in Fig. 1 were taken from the service mains of several Cambridge Colleges, and give the consumption of electrical energy at these seats of learning during a November

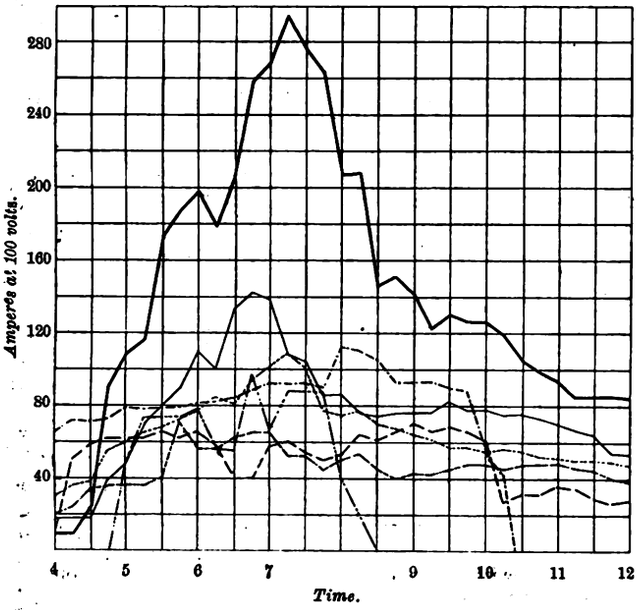

FIG. 1.—College Consumption.

——— Trinity College. ——— Caius College. ——— Union Club.
——·——· Clare College. ——— Newnham College.
------ Sidney College. ——·——· St. John' College.

evening. In the first year of the Company's operations only dining halls and chapels were connected; the curves of these usually overlapped, and for a small total consumption a very large proportion of plant was needed. The authorities are, however, extending the light very largely, and putting it in the men's rooms and in passages and staircases. Caius and Sidney

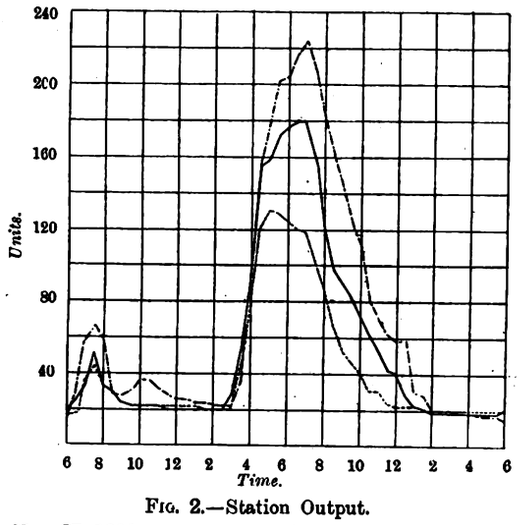

FIG. 2.—Station Output.

——— Nov. 27, 1894. ——·——· Nov. 23, 1895. ------- Dec. 21, 1894.

have it throughout, and Trinity has it in chapel, hall, kitchen, and all men's rooms. St. John's has only chapel and hall lighted, taking no current before 4:45 or after 8:30 p.m. The Union shows the usual regular club load; the peak in this case is owing to the weekly debate, with its pointed remarks. The ladies at Newnham are, as they should be, most regular in their habits; their curve has no chapel spire, and they retire to rest at the commendably early hour of 10:30 p.m.

The regret of the Directors of the Cambridge Company is that the winter term only lasts nine weeks, and that during the darkest months of the year (December and January) the College demand falls lower than in October. In Fig. 2 are shown the all-day curves for the heaviest day in 1894 (November 27th), for December 21, 1894, and for November 23, 1895; the first two showing in a striking manner the contrast between term time and vacation, the last affording an index of the growth of the Company's system since this time last year.

ELECTRIC LIGHTING AND TRACTION NOTICES.

The time for giving official notice in the *London Gazette* of private Bills to be presented to Parliament next Session, and of application to the Board of Trade for Provisional Orders, expired on Saturday last.

From the following list of notices it will be seen that there are 41 electric lighting notices and 37 traction notices. Below are given the figures since 1891 :—

	1891.	1892.	1893.	1894.	1895.
Lighting	34	20	32	32	41
Traction	15	15	17	13	37

Of the 41 lighting notices, 28 are given by local authorities. Only three notices relate to London. Some five notices relate to extensions of areas or amendments of Orders already granted, and one—that of the Burton Corporation—is for power to sell and let out electrical fittings.

The traction notices, even if we make allowance for the extension of time notices, exhibit a great increase over last year's figure, and if only a small proportion of the work foreshadowed is actually accomplished within a reasonable period, the electrical industry will have good cause to congratulate itself.

It is to be observed that four gas concerns are seeking powers to generate and distribute electric energy.

Electric Lighting Notices.

THE METROPOLIS.

District.	Names of Applicants.
Parish of St. Mary, Newington, S.E.	Vestry.
Parish of St. Mary, Battersea, S.W.	Vestry.
District of the St. Saviour's District Board of Works, Parishes of St. Mary (Newington), St. Mary (Lambeth), St. Giles (Camberwell), and St. Mary (Battersea), (London)	County of London and Brush Provincial Electric Lighting Company (Limited).

THE PROVINCES.

Ambleside	Windermere and District Electricity Supply Company (Limited).
Ashton-on-Mersey	Altrincham Electric Supply (Limited).
Bangor (North Wales)	Corporation.
Bath	City of Bath Electric Lighting and Engineering Company (Limited). [Extension of area.]
Bath	Urban Sanitary Authority.
Bray	Town Commissioners.
Burton-on-Trent	Corporation. [To enable the Corporation to sell, let on hire, &c., electric light fittings.]
Colwyn Bay and Colwyn	Urban District Council.
Cork	Corporation.
Cowes (Isle of Wight)	Urban District Council.
Darlington	Corporation. [Amendment of 1890 Order.]
Devonport	Corporation.
Folkestone	Urban District Council.
Gloucester	Corporation.
Godalming	Corporation.
Great Berkhamsted and Northchurch	Bedford Electric Light Company.
Great Crosby, Waterloo with Seaforth, Allerton, Little Woolton, Much Woolton, Childwall and Garston (Lancs.)	Liverpool District Lighting Company (Limited)
Huddersfield	Corporation. [Extension of area.]
Ipswich	County of London and Brush Provincial Electric Lighting Company.
Keswick	Urban District Council.
Ditto	Keswick Electric Light Company.

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District.	Names of Applicants.
Kettering	District Council.
King's Lynn	Corporation.
Kingstown	Town Commissioners.
Lincoln	County of London and Brush Provincial Electric Lighting Company.
Liverpool	Corporation.
Manchester	Corporation. [Extension of area.]
Margate	Corporation.
Merthyr Tydfil	J. C. Howell (Limited).
Middleton	Corporation.
Newmarket	Newmarket Electric Light Company (Limited).
Pembroke (Ireland)	Town Commissioners.
Prescot	British Insulated Wire Company.
Queenstown	Town Commissioners.
Rathmines and Rathgar (Dublin)	Town Commissioners.
St. George, Kingswood, Stapleton and Warmley (Bristol)	Great Western Electric Light and Power Company.
Sale	Urban District Council.
Wells	Corporation.

Electric Traction Notices.

Name of Applicants.	Powers Sought.
Aldershot and Farnborough Tramways	Construction of tramways. Use of electric or other motive power.
Denio, Pwllheli (Messrs. Solomon and Francis Emile Andrews)	Construction of tramways (in the parish of Denio, Pwllheli). Use of electric or other motive power.
Baker-street and Waterloo Railway	Extension of time.
Belfast Street Tramways Company	Use of electric or other motive power.
Bideford, Westward Ho! and Appledore Railway	Incorporation of Company. Construction of railway. Use of electric or other motive power.
Blackpool Corporation	Construction of tramways. Use of electric or other motive power.
Blackpool and Fleetwood Tramroads	Incorporation of Company. Construction of tramways. Use of electric or other motive power.
Blackpool St. Anne's, and Lytham Tramways	Revival of powers and extension of time. Use of electric or other motive power.
Brighton and Rottingdean Seashore Electric Tramroad Company	Extension of time.
Bristol Tramways and Carriage Company	Use of electric or other motive power.
City and South London Railway	Extension of time.
Cork Junction Tramways	Construction of tramways. Use of electric or other motive power.
Derby and Ashbourne Tramways	Incorporation of Company. Construction of tramways. Use of electric or other motive power.
Dover Corporation	Construction of tramways. Use of electric or other motive power.
Dublin Southern District Tramways Company	Use of electric or other motive power.
Dublin United Tramways Company	Use of electric or other motive power.
Edinburgh Corporation	Use of electric or other motive power.
Edinburgh Street Tramways Company	Use of electric or other motive power.
Halifax and District Tramways	Incorporation of Company. Construction of tramways. Use of electric or other motive power.
Huddersfield Corporation	Construction of tramways. Use of electric or other motive power.
Hull Corporation	Construction of tramways. Use of electric or other motive power.
Kidderminster and Stourport Electric Tramways	Incorporation of Company. Construction of tramways. Use of electric or other motive power.
London United Tramways (Limited)	Use of electric or other motive power.
Longton Corporation	Construction of tramways. Use of electric or other motive power.
Newcastle-upon-Tyne Corporation	Construction of tramways. Doubling existing single tramways. Use of electric or other motive power.
Oldham, Ashton-under-Lyne, Hyde and District Electric Tramways	Incorporation of Company. Construction of tramways. Use of electric or other motive power.
Plymouth Corporation	Construction of tramways. Use of electric or other motive power.
Portsmouth Street Tramways Company	Use of electric or other motive power. Authority to enter into an agreement with the Corporation for the supply of electrical energy.
Potteries Extension Tramways	Construction of tramways. Use of electric or other motive power.
Sheffield Corporation	Work tramways. Use of electric or other motive power.
Sheffield District and Rotherham Tramways	Incorporation of Company. Construction of tramways. Use of electric or other motive power.
Sheffield Tramways Company	Power as to leasing from Corporation. Use of electric or other motive power.
Smiley, George Washington (Cowpen)	Construction of tramways. Use of electric or other motive power.
South-Eastern Metropolitan Tramways Company	Incorporation of Company. Construction of tramways. Use of electric or other motive power.
Stone, Darenth & Swanley Tramroads and Thames Jetty	Incorporation of Company. Construction of tramways. Use of electric or other motive power.
Swansea Corporation	Purchase of tramways. Construction of new tramways. Use of electric and other motive power.
Westlake, W. B.	Construction of tramways (Constitution Hill, Swansea). Use of electric or other motive power.

Gas Companies Seeking Powers to Supply Electric Current.

Bournemouth Gas and Water Company	Powers to generate and sell electricity, and to sell and deal in electrical fittings.
Bexhill Water and Gas Company	Powers to generate and supply electric current.
Guildford Gas Light and Coke Company	Powers to generate and supply electric current.
Ilfracombe Gas Company	Powers to generate and supply electric current

THE COST OF LIGHTING BY GAS AND BY ELECTRICITY.*

1. In accordance with your instructions, I visited Hastings on the 2nd inst. (October) and again on the 11th inst., for the purpose of making comparative measurements of gas lighting and of electric lighting.

2. My attention has been called to a comparative test made by your engineer, and I have seen the arrangements by which this was carried out. A useful comparison could be made in this manner, but I considered it preferable to measure each source of light separately with a bar photometer against a certified standard lamp.

3. On the 2nd inst., I brought with me a portable photometer, and made with it some measurements of the candle-power of various lamps, but as the arrangements for screening reflected and diffused light were not suitable for accurate measurement, I prefer to treat the results as preliminary trials, which enabled me to give your engineer instructions for providing conditions for a second test.

4. On the evening of the 2nd inst. I made several measurements of the illumination in certain gas-lighted shops in Hastings. I have given the results of these measurements to your engineer, but as they do not concern the present comparison, I do not include them in the present Report.

5. On the afternoon of the 11th inst. I inspected the arrangements made according to my instructions for the tests. The lights were arranged in a room at the end of the passage on the second floor of the works. A door had been fitted in the doorway, having an opening, allowing the light to shine down the passage, which was otherwise in darkness. A 10ft. batten was fixed to the wall, and formed part of a photometer bar nearly 200in. in length. On this bar travelled a carriage, on which was mounted a "relief" photometer of my own design and construction, somewhat resembling a "Bunsen," but giving considerably greater sensitiveness. Suitable black screens were provided.

6. The standard was an amyl-acetate or Hefner lamp, having a Reichsanstalt certificate No. 15,346. I take the value of this standard as 0·877 of a standard candle.

7. The instruments for measuring the electric current and pressure were provided by your engineer. For the purposes of the present comparison independent check of their indications was not necessary, as they were themselves, or were compared with, the standard instruments by which the electric supply of Hastings and St. Leonards is measured and controlled. They consisted of a Siemens dynamometer, checked by an Evershed ammeter, and of an Evershed voltmeter. I consider that since alternating currents were used errors of from ½ to 1 per cent. are not unlikely, but I give the results as read or averaged to two or three figures.

8. The measurement of the gas consumption was not so satisfactory, an ordinary 5-light Glover dry meter, No. 737,935, was used. The upper dial registering two cubic feet for one revolution was

* A Report, by Mr. A. P. Trotter, on "Photometric Measurements at Hastings," prepared for the Hastings and St. Leonards Electric Light Company.

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read, the time for each quarter revolution was taken in minutes and seconds, for purposes of check, and readings by a stopwatch of a number of complete revolutions were used for obtaining the consumptisn. I consider that errors of 5 per cent. are not unlikely, and even 10 per cent. is possible. I have, however, given the results in two or three figures. A pressuie gauge was used.

9. The electrical pressure provided in the test room was rather higher than that of the standard pressure in Hastings and St. Leonards, varying from 102 to 103 volts. This tells in favour of the electric light, but as lamps of rather low efficiency were provided, the results are no better than might easily be obtained from good lamps.

10. The gas pressure was remarkably high, reaching 35 tenths of an inch, but fell considerably towards the end of the tests, which were concluded after midnight. I understand that a high pressure of gas is common in Hastings.

11. The following electric glow lamps were tested:—(*a*) Three Edison-Swan 16 candle lamps for 100 volts, marked B. 16. 100. These had been in use for some weeks in the works. They were measured simultaneously. (*b*) Three "Gabriel" 16 candle lamps for 100 volts, now, measured simultaneously. (*c*) One Edison-Swan "Sunlight" 100 candle-lamp for 100 volts marked 60 F.A. 100. 100.

12. There are three factors in the cost of electric lighting; the price of the supply per unit, the consumption of supply per candle-power, and the cost of lamp renewals. The price of the supply varies in Hastings and St. Leonards on a sliding scale, from 9d. to 4d. per Board of Trade unit, or 1,000 watt-hours. The consumption per candle-power is measured in watts per candle, and I desire to call your attention to the fact that this second factor is of no less importance than the first. The third factor, the cost of renewals, depends on the cost of lamp and on its life. The factor is, as I shall show, generally of minor importance.

13. The results of the tests are as follows:—

Lamp.	Volts.	Amperes.	Watts.	Total candles.	Candles.	Watts per candle.
E. S. 16	103	1·82	187	61	20·3	3·2
E. S. 100	102	2·46	251	—	103	2·43
Gabriel	102	1·7	173·4	52·5	17	3·03

14. The first of these lamps would probably give about 16 candles at 100 volts with 0·63 ampere, thus taking rather less than 4 watts per candle. The only advantage of using lamps taking so much as 4 watts per candle, is a long life, reducing the expense and trouble of lamp renewals. This advantage is dearly bought and is a false economy.

15. Owing to different conditions of radiation, high efficiency can be more easily attained with high candle power lamps, and as the cost of fittings and wiring is reduced by using fewer lamps, such lamps are to be recommended where it is possible to obtain a convenient distribution of light. They are not of course suitable for domestic lighting.

16. On the other hand, great economy of consumption may be realised in domestic lighting by the use of 8-candle or even smaller lamps, since as many, and no more lamps than are needed, may be turned on.

17. Several different kinds of gas burners as commonly used in Hastings and St. Leonards had been provided by your engineer for testing. On the 2nd inst. I made a measurement of a Welsbach burner, but possibly on account of the absence of a suitable governor, or on account of the high pressure of gas, the results were so much lower than those which can be obtained under favourable conditions, that I have rejected them. The mantle-rod of this very fragile burner was unfortunately broken on the 11th inst. at a late hour, and the test could not be repeated.

18. The following gas burners were tested:—(*a*) One "Christiania," with and without opal globe; (*b*) three steatite "union" burners of the Bray type, two being marked 5, and one 6; measured simultaneously; (*c*) one slit batswing.

The last of these burners flared excessively, as is usual in butchers' and other open shops. The pressure was, however, carefully adjusted by a stop-cock, so as just to avoid flaring. The other burners flared a little, but the test was intended to represent the ordinary conditions of use, and was not a scientific investigation. All the burners faced the photometer.

19. The results of the tests were as follows:—

Burner.	Pressure.	Cubic ft. per hour.	Total C.P.	Candles.	C.P. per cubic foot per hour.
Christiania	34½	6·2	...	13·4	2·16
Ditto with globe	„	6·2	...	7·9	1·27
"Bray"	24	34	39	13	1·15
Batswing	3	16	..	38	2·38

20. There are only two factors in the cost of gas lighting—the price of gas per thousand cubic feet, and the consumption in cubic feet per candle, or, as it is commonly expressed, conversely, candles per cubic foot. The cost of burner renewals per thousand candle-hours is too small to enter into the present comparison.

21. It is usual among gas engineers, when they make comparison with the cost of electric light, to neglect all kinds of burners but the "London" argand, which yields about 16 candles for 5 cubic ft. per hour, when carefully nursed with "initial governors," "balance governors," "micrometer regulating cocks," and cabinet work and curtains, in the hands of an expert gas tester. It is only quite recently that the existence of any other kind of burner has been recognised in gas comparisons. I refer to those of the Welsbach light, published by the Incandescent Gas Company, who adopt in one place "an ordinary open flame gas burner," giving "about 15 c.p. with 7 cubic ft. of gas per hour" as a basis of comparison. In another place the comparison is based on "One ordinary (Bray's, &c.) burner, consuming 7ft. of gas per hour, . . . giving a light of about 14 c.p." They publish a Report by Prof. Carlton alluding to "an ordinary good open burner (Bray's Special No. 5) giving 1·83 candles per cubic foot per hour." The general result of a long series of tests of gas burners made under the direction of Prof. Ayrton, F.R.S., and published in *The Electrician*, Vol. XXXII., pp. 94 and 112, was:—1·95 candles per cubic feet for 21 different kinds of burners, at maximum candle-power, and 2·18 candles per cubic foot, under conditions of maximum efficiency. An article comparing the cost of lighting by gas and by electric light, based on these results, appeared on p. 142 of the same volume.

22. I have dealt at some length upon tests for gas burners other than those which I have made for you at Hastings. In order to show that, although the conditions of my tests were not conducive to accuracy, the average result closely approximates to those which I have quoted, I adopt two candles per cubic foot as the basis of the following comparison:—

23. Let a = price per unit of electrical supply in pence.
b = price per 1,000 cubic feet of gas in pence.
c = cost of lamp renewals per 1,000 candle-hours.
d = watts per candle.
e = candles per cubic foot of gas per hour.

Then to find the equivalent price per unit of electrical supply:—

$$a = \frac{\frac{b}{e} - c}{d}$$

To find the equivalent price of gas:—

$$b = [(d \times a) + c]\, e.$$

24. In plainer language, the cost of 1,000 candle-hours in each case is to be compared. For example—let gas be at 3s. 2d. per thousand cubic feet, as at Hastings and St. Leonards, and let the gas burners give two candles per cubic foot. Then 1,000 candle-hours evidently cost 1s. 7d. Again, let the price of electric supply be 6d. per unit, and let the lamps take 3 watts per candle, then 1,000 candle-hours cost 1s. 6d. To this must be added lamp renewals, which I shall show, may be taken at 1½d., making a total of 1s. 7½d.

25. The two following examples of lamp renewals are not extremes:—

C.P. new.	C.P. mean.	Life.	C.P. hours.	Price.	Cost per 1,000 candle-hours.
25	21	1,200	25,200	1s.	0·476
8	6½	800	5,200	1s. 6d.	3·08

26. Returning to the tests of glow lamps, and using the formula already given, I take the electric supply at 6d. per unit, renewals at 1½d., and a gas burner giving 2 candles per cubic foot. The equivalent price of gas in each case is then as follows:—

* Lamp.	C.P.	Watts per C.P.	Equivalent price of Gas.
E. S. 16	20·3	3·2	3s. 5½d.
E. S. 100	103	2·43	2s. 8½d.
Gabriel	17	3·03	3s. 3½d.

27. Using the corresponding formula for the equivalent price of electric supply, and assuming a glow lamp taking three watts per candle, and renewals at 1½d., and gas at 3s. 2d. per 1,000 cubic feet, the equivalent price of electric supply is as follows:—

Burner.	C.P.	C.P. per cubic ft. per hour.	Equivalent price per unit.
Christiania	13·4	2·16	5½d.
Do. with globe...	7·9	1·27	9½d.
"Bray".....	13	1·15	10½d.
Batswing	38	2·38	4⅝d.

* I have taken the actual figures of the photometric tests. The lamps were new, or nearly new. The mean candle-power during their life would be lower.

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28. It is perhaps somewhat beyond my province here to call your attention to the fact that the comparative cost of lighting by electric light and by gas must be considered on a wider basis than that of light for light. The saving in the cost of re-decoration is very material, and the absence of injury to delicate goods in shops by the products of combustion and vapour of gas, is of no little importance. Besides this, the wholesomeness of electric light for domestic lighting, though it cannot be set down in shillings and pence, is none the less valuable. Especially should this be considered in Hastings, where the very high pressure of the gas doubtless forces much unconsumed gas into the air.

29. I now assume that the price of electric supply varies from 4d. to 8d., and that glow lamps take a mean of 3 watts per candle, and that gas burners yield 2 candles per cubic foot. The equivalent price of gas is as follows:—

Price per unit.	Price per 1,000 cubic feet.
4d.	2s. 4d.
6d.	3s. 4d.
8d.	4s. 4d.

30. Next, I assume that the price of electric supply is kept constant at 6d. per unit, and the efficiency of the lamps is altered. I desire to call your attention to the fact that the effect on the equivalent price of gas is no less marked, and that a knowledge of the efficiency of lamps, which can only be arrived at by careful photometric tests, is as important as a knowledge of the price of electric supply per unit. I have roughly estimated the alteration in life of glow lamps when run at a higher pressure, from the results of various life tests.

Mean watts per C.P.	Renewals of 1,000 c.p. hours.	Price of Gas.
4	1d.	4s. 2d.
3	2d.	3s. 4d.
2½	4d.	3s. 2d.

The old-fashioned 4-watt lamp is not economical, unless the price of electric supply be extremely low; on the other hand, the cost and trouble of lamp renewals eat up the saving in current, if the lamps are overrun too much. Lamps taking 2 watts per candle are offered for sale, but I have no trustworthy information as to their life. The watts per candle rise slightly as the lamp ages.

31. On the 11th inst. I made a number of measurements of the illumination on the pavement between two of the arc lamps on the sea front. The maximum observed illumination on the horizontal plane was found at 18ft. 9in. from the lamp-post, and was equivalent to 0·6 candle at a distance of one foot. The minimum between the lamps was 0·006. The height of the arc above the ground was about 19ft. 8in. Calculating the candle-power from the resulting illumination, I find that the maximum candle-power was at 55½deg. with the vertical. Time did not allow for a sufficient number of measurements, from which the candle-power might be averaged, but the actual single observations give the following results:—

Angle with vertical	35	44½	50	55½	59½	63	66
Candle-power	310	416	475	590	520	500	120

32. Probably nearly as much light is sent upwards, but is nearly all lost. Some of it illuminates the houses facing the sea, and produces an agreeable effect, but the reflected illumination is not appreciable. Lamps giving 500 c.p. in all directions, except at small angles with the vertical, would probably give the same useful illumination.

33. I proceed to compare the cost of lighting of the sea front by arc lamps, with equivalent lighting by "Welsbach" or incandescent gas lamps. But no strict comparison is possible, because the contract for arc lighting includes, I understand, the supply of carbons, trimming, cleaning, all repairs and maintenance of lamps and lanterns and interest on capital outlay. I have no figures before me as to probable cost of lamp lighting and cleaning, damage to mantles by gales and sea water, general repairs and maintenance, nor have I any information as to the possibility of using incandescent gas lights in so exposed a position as that of your arc lamps.

34. According to the price list of the Incandescent Light Company, 60 c.p. can be produced by 3½ cubic ft. per hour. Nothing is said about gradual deterioration of candle power of the mantles, and this too I must neglect. The glass of the lantern will absorb 12 to 14 per cent. (unless cleaned every day), and I doubt if 53 candles would be maintained throughout the life of the "mantles." At this rate 33 cubic ft. of gas would give 500 c.p. At 3s. 2d. per 1,000 cubic ft., 33 cubic ft, would cost 1·254d. I observe that for a consumption of £11 worth of gas, at 3s. per 1,000 cubic ft., the renewals of "mantles" are estimated by the makers at £1. 15s. It may be assumed that for 1·11d. worth of gas the total may be put at 1·43d. for a naked light of 500 c.p. for one hour, exclusive of cost of lamp-lighters, cleaners, damage by wind and water, repairs and interest, on capital outlay.

35. I understand that each arc lamp takes 15 apparent amperes at 50 apparent volts, or 600 true watts, and that for a service of 160,000 lamp-hours per annum, including supply of carbons, trimming, cleaning, repairs to 52 lamps and lanterns, and interest on capital outlay of lamps, post transformers and mains, the sum of £1,300 is paid. This comes to 3½d. per unit, or 1·95d. for a light, reduced and diffused by corrugated glass of a mean of about 500 c.p. for one hour.

36. If incandescent gas lamps were used, a larger number of smaller lights would be employed in order to obtain better distribution, as it would be obviously impracticable to group burners together to give 500 c.p. All the incidental expenses would thus be increased in proportion, although owing to the better distribution of light which would then be possible, some deduction might be affected in the total light.

37. A comparison therefore is impossible without further data, but it is clear that the difference of 0·52 would not cover the incidental expenses, and that, if the two systems of lighting were placed on equal conditions, the cost of gas lighting would largely exceed that of the contract for electric light.

THE ELECTRIC WIRING QUESTION.*

BY FRED. BATHURST, ASSOCIATE.

The author commences his Paper with an outline of the electrical progress of England as compared with that of America. Both countries were, he says, in 1881 on the same basis; the apparatus was crude, experimental and imperfect, and the knowledge in respect to the safe and proper handling of the apparatus employed was limited, and possessed by but few people. In England in 1883 the possible dangers began to attract attention, and rules and regulations were issued which were to control development and progress. In America no regulations were enforced. In 1887 America had in operation (not to mention innumerable isolated plants) some 70 central stations, supplying over a quarter of a million incandescent lamps. In England at this time there was *one* central station, supplying about 5,000 lamps, and a proportionate number of independent plants. On the fire question the author quotes the reports issued by the Underwriters' Electrical Bureau. Taking 1893-1894 as two typical years in which public alarm was prevalent in America, reference to the records shows the occurrence yearly of between 400 and 500 fires traced to electrical causes. Some 320 involve no monetary loss, but the remainder (100 to 200) result in a loss of £300,000 per year. This sum, though apparently large in itself, is less than 1 per cent. of the total fire loss of some £35,000,000 from all causes. The bulk of the electrical loss occurs in the Western States, and for the more populous Eastern towns the proportionate loss is less than one-half per cent. The loss arising from the use of kerosene oil and matches is appalling in comparison, and the figures are best not quoted. Taking the figures from the United States Government records, the average monetary loss per year, for nine years ending 1893, that "lightning" involved amounted to £310,000, or some £10,000 per year more than that caused by the commercial use of electricity. The author, therefore, argues that restrictions of one sort or another have hampered the proper development of the English electrical industry.

The principle obstacle to the general use of electrical applications is that under our present wiring rules it is impossible to place the cost of installation within reach of the great bulk of our people. What is still required is the introduction of rules and regulations which will facilitate the growth of "lower cost wiring." Nothing is further from the author's intention than to advocate cheap, defective, poor, or dangerous wiring. With "lower cost" wiring we could, for instance, successfully compete with the lately introduced "incandescent gas burner," which, priced at about 13s., has had a sale amounting to three-quarters of a million. It is being recognised that the ruling factor which governs public demand is small initial outlay. Even the gas companies are facing the question of fitting consumers' premises free and reimbursing themselves by charging a slightly increased price for the gas supplied.

The five cardinal points of good wiring may be given as safety, durability, convenience, accessibility, and economy. Prof. S. P. Thompson, in a lecture on the subject before the Society of Arts, has embodied the essential features in a few words when he said: "What is wanted is a mode of running wires and fixing switches and other accessories, so that they shall not only be electric tight, but shall also be water-tight, gas-tight, air-tight, oil-tight, fire-tight and even rat-tight." It is the author's belief that all these requirements can be met by the use of *fire-proof insulating tubes.*

* Abstract of a Paper read before the Institution of Electrical Engineers November 28th.

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It will probably be admitted that wood casing fails in many respects. The idea of its use originated with the telegraphic engineer, and 15 years ago electricians were contented with it. Even on the surface it is neither picturesque nor decorative. It is easy to instal, but its nature prevents any very correct or exact estimate being formed of the labour required. If surface work is required on the score of economy, surely it would be better to adopt "open work" on porcelain insulators—a safe and scientific method of wiring, which can be carried out at a very much lower price. We know this system is discouraged; but it is noteworthy that in the only prominent installation in this country where "open work" has been used, the single source of trouble which occurred arose on a circuit in a damp cellar, where, in order to conform with the fire office "requirements," *wood casing* had been employed. Someone may argue that this could not have occurred if the circuits had been "tested" as the "Rules" recommend. Our "insulation test" never yet told far into the future, and it only tells the present to a limited extent. "Insulation test" cannot discover an unsoldered joint or a dangerous diminution in respect to current-carrying capacity. Every practical man will agree that insulation testing will not necessarily indicate that the wires are at places in dangerous proximity to gas or water systems in the event of moisture appearing.

The recognised shortcoming of wood has brought into use iron and "lead compo" piping. Lead compo pipes afford but little mechanical protection in emergency, and, with respect to "accessibility," have serious drawbacks on account of their flexibility. A large amount of "surface leakage" necessarily arises from the use of any ordinary metal tubing. Moreover, if the insulating material on the conductors has from any reason deteriorated and moisture appears, there will be consequent injury both to conductor and tube. Cases have occurred where the protecting fuses on a circuit did not "blow" before electrolysis promoted a dangerous arc which had burnt a hole in the tube and presented a serious fire risk. If a defect occurs anywhere in the insulation of a wire which is within a metal pipe so that there is electrical contact between the conductor and the pipe, the effect of the fault is virtually transmitted throughout the whole length of piping, there to await or invite trouble elsewhere. With two conductors in the pipe a new and unanticipated electrical condition prevails, because one conductor is now of greater carrying capacity than the other, which has been increased by the capacity of the tube itself. Overheating of the intact conductor can now invite serious trouble at any point. This, the author thinks, explains why overloaded wires in pipes have occasionally "burnt out" at several points at the same instant. It must not be forgotten, also, that failure of insulation on one wire means that the voltage tending to break down the other is doubled, and the actual strain (C^2 R) increased fourfold. Perhaps at this point it will be noticed that these criticisms show, incidentally, how much more the immunity from electrical fires has depended upon the honour and integrity of the contractors than upon the "rules" provided for their guidance. Iron pipes have the disadvantages common to all metal pipes, and, as we know, may rust inside, and this rust is not a condition favourable to "insulation"; they often have burrs or other internal roughnesses which may cause serious mechanical damage to the insulating material as the wires are being drawn in. If iron pipes are screwed at the end for the purpose of jointing, oil is probably employed, and any excessive presence inside is not helpful to a rubber insulation. Cases are on record where this oil has caused extensive mischief. Early in the art of wiring it was recognised that gas brackets, when modified so as to serve as "electrics," should be insulated from the remainder of the gas piping; but now that we are using electric wires themselves in metallic pipes, we appear to overlook the possibility of the electric system being elsewhere in hazardous contact with conjointly-installed steam or water systems. It is now apparent that metal pipes, if not actually harmful, are certainly not particularly helpful to the maintenance of insulation resistance.

It may be thought that we must turn away from tube or pipe methods altogether in order to find economic wiring. Experience in other countries, however, does not show that any "rigid" system of conductors is making progress or headway. No insulated wire has yet been produced which in itself can successfully resist the deteriorating influences present in mortar or plaster. Even lead-covered insulating wires, if directly embedded in plaster, have been found wanting, and give trouble from "earths" and "short-circuits" as soon as moisture has made an appearance. With any rigid method, if walls happen to crack and settle, or plasterers and bricklayers cause damage, a fault may develop which is very difficult to find. Usually, also, they are handicapped commercially in respect to making joints and connections, as these involve risk and trouble even with the highest quality workmen. A cardinal objection to "rigid" methods is the lack of accessibility. All good wiring should be accessible, for with this quality assured half the difficulty of "trouble" is already fought, and any imperfection or injury, whether arising from poor work, negligence, or accident, can be remedied with a minimum of inconvenience. A conduit or race-way is the practical way of rendering wires "accessible," for then the wires installed in them are always open to the inspection of owner or wireman, whenever he wishes to satisfy himself as to their condition or to effect a renewal. "Accessibility" ought, therefore, to be a fire office requirement; with it an inspector can use his *eyes*, and have no need to trust to his *ears* for inspection. From the contractor's point of view "accessibility" is desirable as limiting unfair and injurious competition; for, when an installation can be readily inspected, inferior materials cannot be used for the purpose of cutting down prices, workmanship cannot be scamped, and the "death knell" of unprincipled competition could be sounded for all time.

From a labour-saving point of view a flexible conduit would apparently commend itself. Whilst cases do occur where this is true, every flexible conduit has the inherent drawback, as shown by experience, that the property of "flexibility" may so far assert itself that numberless bends will prevent the wires from being drawn out. Any trouble which then occurs will have to be cut out, or else the circuit must be abandoned or wired anew. Flexible conduits are always at a disadvantage either in respect to moisture-resisting properties, or are wanting in mechanical strength. Bends and elbows must be *rigid*, or it is impossible to draw the wires in or out; and for the generality of work it will be found that a conduit construction permanently rigid throughout is preferable.

More than half of the cost of the wire used is referable to "insulation," and it is "insulation" we strive to keep. It would, therefore, appear obvious that the conduit should be an "insulating" one. An ideal insulating tube should not only be mechanically strong, but also fire-proof and water-proof. With a tube complying with these requirements all possible electrical trouble is minimised, the insulation on the conductors themselves protected from mechanical damage, and is enveloped in a preservative, rather than a destructive, element. Temperature changes are reduced to a minimum, and, if the conduit resists acids, alkalies, and gases, the insulating material on the wire is so shielded that its life is indefinitely prolonged. The author contends, therefore, that an insulating tube method of wiring will prove the ultimate solution of the "electric wiring question."

The author then proceeds to describe the method of wiring originated with Mr. E. H. Johnson. The insulating material employed is a specially prepared hydrocarbon of the bitumen class. The necessary strength in tube form is obtained by using a peculiar grade of fireproof paper material which admits of impregnation. The system provides, the author says, perfect immunity from fire, durability of insulation, accessibility to concealed wires, and reliable service. It has had extensive practical test in America, and more recently in Germany, where its reputation for being the safest, least expensive, and most practical method of wiring is now established. Already in various countries some *two million incandescent lamps* are installed in the three varieties of tube—"plain," "brass-covered," and "iron-armoured."

It has been noted that when deterioration takes place in a plain metal tube, the tube itself becomes a conductor, and invites deterioration at many points. If insulated tubes are used (with two conductors inside), the deterioration on one only brings additional stress upon the other conductor at one point. The tendency in this case is to create a "short-circuit" at the spot affected. In these particular tubes a "short-circuit" presents no danger, as the materials of which they are composed will resist the burning effect of the arc. Many tests have been made, and in every case it has been found that the "arc" increased in length until it broke, and severed the circuit without further danger. Any "short-circuit" trouble, then, removes itself, and its injurious effects are confined entirely within the tube. Since the presence of moisture is the principal cause of "short-circuit," the use of these tubes is likely to minimise the occurrence of trouble, because the tube material is non-conducting in respect to heat, and extraneous changes of temperature fail to produce internal condensation. The use of insulating tubes will also remove the increased danger in respect of wires employed for heating or power applications, which may be temporarily overloaded, and in respect of wires protected by a fuse which through careless replacement has been made too large. It may also be that insulating tube methods of wiring will render it possible to materially modify our present practice in respect to "fusing." There is only one point not yet entirely settled. It is whether the two insulated conductors should be kept together or separated—whether one or two tubes should be employed. Owing to the real necessity with a wood-casing system of keeping the wires apart, some authorities urge that this construction should be applied to tube methods, and that a separate tube should be used for each wire. In alternating-current circuits it is essential to keep the wires close together, to prevent a drop in voltage from inductional effects. Clearly, therefore, in this case both wires should by preference be in the same tube. In England two conductors are already allowed in "compo" pipes. Theory, in the author's opinion, points to the advisability of placing both wires together, and so far, the results of practice favour this view.

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As far as present experience has gone, it shows that the bituminised tube will, under ordinary conditions, last indefinitely. It can safely be embedded in the lime and sand plaster used in ordinary building construction. The present tendency towards fire-proof building construction, is bringing into use certain cements, caustic enough to attack nearly any material coming into contact with them. The problem thus presented has been successfully solved by the introduction of the "brass-covered" insulating tube. The bituminous material used in these insulating tubes is inert in its nature, and exercises no deleterious influence on the insulating material of the wires themselves. It has sufficient mechanical strength to resist any damage except that inflicted by gross carelessness or design, and in the case of chance mechanical injury to the tube the "accessibility" it provides renders repair easy. In respect of permanence and durability, the advantage of placing the conducting wires in channels which predetermine their relation to any contiguous conducting bodies, is, the author thinks, beyond question. The mischief done to wood casing and "compo" pipe by rats and other vermin is, in the case of these tubes, entirely obviated. From the fact that such inroads are successfully resisted, it would appear that bitumen disagrees with a rat's digestive machinery.

An insulating tube system is also economical. With trained workmen it is estimated that a saving from 25 per cent. to 50 per cent. in the labour of installation is made. Even though the tube in itself is comparatively expensive, if wires suitable to it are employed, the total cost of material will compare favourably with any other system. The insulating properties of these tubes is such as to provide (approximately) an additional "300 megohms per mile" insulation resistance to the wire. We are beginning to appreciate the fact that, although we provide a costly "600-megohm wire," after having installed a few hundred feet our tests indicate a total insulation resistance of only a few thousand ohms. An insulating tube system can assist us to obtain a more commensurable result. If a high insulation test has to be obtained in wiring work, practical experience shows there is little doubt that an insulating tube, and its suitably insulated wire inside, is commercially ahead of a relatively heavily insulated wire. Perhaps the limit of economy will be reached when we know how to "earth" perfectly, and can use a bare copper conductor within a metal-covered insulating tube.

The author concludes by asking the Institution, in considering "the question of electric wiring," in any rules it may issue, to give recognition to, and make due provision for, the use of insulating tubes.

APPENDIX.—*Table Showing the "Insulation Test" required in Various Countries (compiled from Rules of Supply Companies and Fire Offices), voltage of circuits not to exceed 250 volts.*

Size of installation, wired complete.	Country.			
	England (London).	America (New York).	Germany (Cologne).	Austria (Vienna).
Amperes.	Ohms.	Ohms.	Ohms.	Ohms.
10	500,000	2,000,000	100,000	50,000
25	250,000	1,800,000	40,000	20,000
50	125,000	400,000	20,000	10,000
100	...	150,000	10,000	5,000
200	...	80,000	...	...
250	25,000	...	4,000	2,000
400	...	40,000	...	...
500	12,500	...	2,000	1,000
800	...	11,000	...	...
1,000	...	...	1,000	500
1,600	...	5,500	...	...

CORRESPONDENCE.

THE PRESIDENCY OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A Committee, of which we were invited to act as honorary secretaries, was recently formed of the members of the Institution, representative of all sections of the industry, to give effect to the views of a large number of members and associates, on the subject of the forthcoming election of President.

It was considered that in the interests of the Institution, the President should be a man pre-eminent in electrical science or electrical engineering, and that the Presidency should not necessarily be a matter of rotation among the Vice-Presidents.

The balloting list issued by the Council for the year 1896, which is now in the hands of the members and associates, indicates that the Council, in nominating Dr. John Hopkinson for election as President, share the same views. It is believed that in abandoning an undesirable custom, the Council have acted in sympathy with the general wishes of members of all classes; and that the selection of Dr. Hopkinson will meet with the unanimous approval of the Institution.—Yours, &c.,

R. S. ERSKINE,
A. A. C. SWINTON, } *Hon. Secs.*

December 4, 1895.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November 22, 1895.*

The Niagara Plant.—It is announced that the Niagara Power Company has contracted to extend its wheel pit sufficiently to accommodate ten 5,000 H.P. generating units, and is arranging for the immediate manufacture of three of these units. At the rate at which the Company is now disposing of power it is quite probable that the entire capacity thus provided for will be utilised at no distant date.

Storage Batteries.—The American Institute of Electrical Engineers, at its regular monthly meeting on Wednesday, inaugurated the feature of topical discussion, the storage battery being the subject considered. Communications forming the basis of the discussion were read by Prof. Crocker and by Messrs. Carl Hering, A. E. Childs, N. W. Perry, C. L. Edgar and F. Reckenzaun. Among those who joined in the discussion at the New York meeting, at which the attendance was unusually large, were Messrs. H. W. Leonard, E. T. Birdsall, J. Bentz, J. Appleton, C. Blizard, T. Woolcott, J. W. Lieb, jun., and others. The same evening meetings were also held in Chicago and, for the first time, in San Francisco. Much interest was manifested in this new feature, and it is quite probable that topical discussions will be held hereafter at least once yearly. It can scarcely be said that the storage battery was considered on its merits, as many of those who spoke were commercially interested in its exploitation, while, with one exception, the others seemed to still hold to the idea that, though it may perhaps be allowable at times to speak freely with respect to other electrical subjects, the storage battery must always be handled with the utmost tenderness. Mr. Perry's Paper was the exception referred to, as he not only violently attacked the self-styled "Storage Battery Trust," but contended that the gas engine is in most cases much more efficient than the storage battery as an auxiliary for power houses and central stations. While Mr. Perry very strongly advocated the use of the gas engine generally, he expressed an extremely poor opinion of the sagacity of American gas engine manufacturers and dealers, ascribing to their technical ignorance and business incompetency the fact that the gas engine has received such little employment in this country. Mr. C. L. Edgar, of the Boston Edison station, which has a large storage battery auxiliary, spoke very highly of its use in central stations, the Boston plant having thus far given great satisfaction. Mr. Entz said that the European Tudor Company found it profitable to provide for the depreciation of the central station storage batteries installed by it on the basis of 4 per cent. annually, as the cost thus far of carrying out this guarantee averaged less than 3 per cent. Mr. Hering thought that one of the reasons why storage batteries had not been more successful is that mechanical engineers rather than electro-chemists have presided over its destinies. Mr. J. W. Lieb did not agree with this, but considered that what success had thus far been achieved was through the mechanical engineer and not the electro-chemist.

BOOKS RECEIVED.

"Théorie de L'Electricité." By A. Vaschy. (Paris: Baudry et Cie.)

"Grundgesetze der Molekularphysik." By T. H. Schwartze. (Leipzig: J. J. Weber).

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LEGAL INTELLIGENCE.

Gaskell and another v. Gosling and another.

This case came before the Lord Chief Justice in the Queen's Bench Division on Monday last, and was an action brought by Messrs. Gaskell and Grocott, manufacturers of porcelain parts for electrical apparatus, at Longport, Staffs., against Messrs. Francis and Cunliffe Gosling, trustees to certain debenture-holders in Poole, and White, Limited (in liquidation), formerly trading as electricians at Bread-street, E.C., and Kentish Town, to recover £483 odd, the price of goods alleged to have been sold and delivered between December, 1893, and January, 1895. The defendants denied liability on the ground that the trustees to the debenture-holders had, under their powers, appointed a man named Kelly as receiver, who carried on the Company's business as agent of the Company, and that under such circumstances the Company was liable, and alternatively, if it was held that the winding-up order made in September, 1892, revoked the trustees' powers, then that Kelly was liable personally for the amount claimed. The facts are, shortly, as follows:—Poole and White (Limited) executed at least two trust deeds, the first being in February, 1892, by which all property but uncalled capital was secured for £7,000. On May 18, 1891, a second deed was executed in favour of the Messrs. Goslings as trustees of debenture-holders for £3,000, those gentlemen being members of Messrs. Gosling and Sharpe, bankers, of Fleet-street, London. Those bankers were the holders of the whole of the second issue. To those succeeded a third debenture-holding of £1,000, but that was not material to the present case. On July 22, 1892, Messrs. Goslings appointed Kelly receiver under the deed of May 18, 1892. On July 22, 1892, Kelly took possession as receiver, and carried on the business to January, 1895, and the present claim was in respect to goods delivered by the plaintiffs to the defendants between December, 1893, and January, 1895. Kelly opened a banking account with Gosling and Sharpe, of which firm the defendants were members, and Kelly was required to pay in all moneys received from the business and to draw on that account, his signature being countersigned by that of Mr. John Tryon, a member of the firm of Saltwell, Tryon and Saltwell, of London, defendants' solicitors. This account was opened "Poole and White (Limited), Kelly, Receiver," and it was carried on from July 20, 1892, until September 1, 1892, the date of the winding-up petition, and after that date until January, 1895, in the same fashion.

Mr. HERBERT REED, Q.C., whom with Mr. Hansell represented the plaintiffs, argued that Kelly having by the deed of May 18, 1892, been duly appointed by the defendants, the trustees under the deed of trust of May 18, 1892, and certain debenture-holders, as receiver of Poole and White, Limited, (in liquidation), to carry on the business, was in fact their agent, the defendants being his principals, and as such liable for the goods supplied and delivered to him as receiver by the plaintiffs.

Mr. JELF, Q.C., who appeared with Mr. W. F. Hamilton for the defendants, having addressed the court at some length,

His LORDSHIP decided that the defendants were in fact from December 5, 1893, to January 31, 1895, Kelly's undisclosed principals, and gave judgment for the plaintiffs for the full amount claimed, with costs. In giving judgment his Lordship said that in his view of the case, the question, though in some sense involved in law, was really one of fact—viz., whether, in the circumstances of this case, the plaintiffs were entitled to sue the defendants as undisclosed principals. He read the trust deed of May 18, 1892, under the powers of which Kelly was appointed receiver, and which, he said, was ingeniously framed to clothe Kelly as the agent of the Company. He said he had grave doubts whether Section 24 of the Conveyancing Act would apply to such a case as was contemplated by this deed—viz., the carrying on a concern like this; but from the view he took of the case it was unnecessary for him to decide that point. On July 22, 1892, Kelly, as receiver, takes possession and carries on the business to January, 1895. The present claim is in respect of goods delivered by the plaintiffs to the defendants between December, 1893, and January, 1895, and, therefore, they had only to deal with things as they existed in December, 1893, when the plaintiffs first became creditors to the Company. First, then, what was the position, not as between the defendants and the then going Company, but as between the trustees of the deed of May 18, 1892, and Kelly carrying on this business? He was not prepared to say that the trustees were not the principals even prior to September, 1892, but it was enough for him to consider and determine what was the relationship of the parties and their respective rights during the time when these goods were supplied. After September 2, 1892, he held the position was radically different from the period anterior thereto, because on September 2, 1892, the Company, *qua* Company, had ceased to have any existence as a going concern; and, secondly, the official liquidator took no part in carrying on the Company's business, which was carried on by Kelly. Under the 84th section of the Companies Act date of petition is date of winding-up, and Section 153 says from moment of the order no act or disposition of company whatever is otherwise than null and void. It follows that, if anterior to that there was an agent clothed with the Company's authority, that power had now gone and ceased. But, further, anyone dealing with the Company after that date could have no claim against the Company because the only debts provable are debts due and payable at the commencement of the winding-up. That being so, the liquidator having taken no act or part in business, what is the position? It is going on no longer under the agent of the Company. Months after that, in December, 1893, Kelly had ordered these goods. The plaintiffs were content to take goods without taking Kelly's personal risk, for here Kelly did disclose the fact that he was ordering these goods as receiver, and he therefore clearly incurred no liability as principal. The question was, Who were the real principals carrying on this business? Could it be doubted that they were the defendants in this case?

A stay of execution was granted for a fortnight pending an appeal, and a certificate was given for a special jury.

Kelly's affairs are before the Bankruptcy court, and Mr. F. Mellor watched the case on behalf of the receiver in that matter.

Jeffreys v. the Brush Electrical Engineering Company (Limited.).

This action came before Mr. Justice Hawkins and a common jury on Tuesday last. The plaintiff, Mr. George Jeffreys, 72 years of age, living at Deptford, sued the defendant company to recover damages for personal injuries through the defendants' alleged negligence. The defendants denied liability on the ground that they had not been guilty of negligence.

The plaintiff's case was that on January 8th last, about 7 p.m., he was walking down the City-road, London, when he fell over a small board put about 1½in. above the level of the pavement, at the edge of some works which the defendants were executing in constructing a brick box for electric cables. In consequence of the fall he cut his forehead and injured his eye, and had since been much affected with giddiness.

The defendants called evidence to show that everything that could have been done to protect the public from the excavation had been done, but

The jury returned a verdict for the plaintiff for £50, and judgment was given accordingly.

Cohen v. Electricity Supply Company for Spain.

On page 168 of our last issue particulars were given of an action brought in the City of London Court by Mr. Arthur Cohen, in which it was stated that a verdict was found for the plaintiff and judgment entered accordingly. We regret to say the report, so far as the finding was concerned, was inaccurate, and Messrs. Slaughter and May ask us to state that the jury found for the defendants and not for the plaintiff. It was clearly proved that Mr. Cohen was mistaken in supposing that Mr. Lowrie acted for Mr. Hammond in the matter, Mr. Lowrie having, on the contrary, first approached the Company, and that he was not in the employ of Mr. Hammond at the time. The defendants succeeded on the ground that they bought the transformers in question from Mr. Lowrie direct, without any knowledge that they belonged to the plaintiff. Our report therefore conveys an entirely wrong impression of the result of the action.

Julius Sax and Co. v. Collins.

In the City of London Court the plaintiff company were successful in recovering £12. 5s. for electric current supplied to the defendant at the Central Meat Market, Smithfield. The chief point of interest in the case was that the defendant had disposed of his business to a new tenant, who, he contended, was responsible to the plaintiffs for the sum claimed. The new tenant bore out this statement, but it was admitted that no notice of the change of tenancy was given to the Markets Committee, and that after the alleged change the business was conducted under the style of Collins and Co. The jury, therefore, found for the plaintiffs for the amount claimed.

Sandon and Fowler v. Chelsea Electricity Supply Company.

These are two actions against the Chelsea Company for breach of an injunction granted in respect of vibration caused by the machinery at the Draycott-place station. Counsel moved for a sequestration order, and after some discussion the motions were directed to stand over until this day (Friday) in order that witnesses might be examined in court.

TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Leyton Urban District Council require tenders for electric lighting works, including central station buildings, gas engines, travelling cranes, piping, &c., dynamos, switchboards, &c., storage batteries, and five miles of mains, including laying. Specifications and conditions, &c., can be obtained after Monday next of Prof. H. Robinson, C.E., 13, Victoria-street, Westminster, S.W., and tenders must be sent in to Mr. R. Vincent, Clerk to the Council, Town Hall, Leyton, Essex, before 6 o'clock on Tuesday, 17th inst. Further particulars are given in our advertisement columns.

——— The Corporation of Durban invite tenders for the supply, and for delivery and fixing at Durban, of steam and electrical plant (high-speed steam engines, dynamos, cables, arc and other lamps, accumulators, &c.). Specifications and plans can be obtained from the consulting engineer to the Corporation, Mr. W. H. Radford, Angel-row, Nottingham, and tenders (in duplicate) must be delivered at the offices of Messrs. Webster, Steel and Co. (agents to the Corporation), 5, East India-avenue, London, E.C., by the 28th inst. Further particulars appear in our advertisement columns.

——— The General Direction of the Belgian Posts and Telegraphs invite tenders for the supply of 11,692 telegraph poles. Tenders to the Direction Générale des Postes et Telegraphes, Brussels.

——— The Prussian State Railway telegraph authorities at Saarbrücken invite tenders for the supply of 28 normal sets of Morse telegraph apparatus. Tenders to the Eisenbahn Telegraphen Inspection, Saarbrücken, Germany, by the 16th instant.

——— The Mayor of Charkow (Russia) invites tenders for the supply of steam engines and electrical machinery and apparatus

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necessary for an electric light installation capable of supplying current to 6,000 incandescents and 500 arcs.

TENDERS INVITED.—The General Consul of the South African Republic invites tenders for the delivery of 5,000kg. 2mm. hard drawn copper wire for the Telegraph Department of the Republic. Conditions, &c., from Messrs. Belinfante Bros., Paveljoensgracht, The Hague, and tenders must be sent in to the Consul, at the American Hotel, Leidsche Plein, Amsterdam, by December 20th.

TENDERS ACCEPTED.—The Middlesex Hospital authorities have accepted the tender of Messrs. Crompton and Co. (Limited) for supplying the generating plant and wiring for the electric light for their convalescent home at Clacton-on-Sea for £3,067. 17s. Mr. Adrian C. Collins is the consulting engineer for the work. The following is the list of tenders received :—

	Generating Plant.	Wiring.
Crompton and Co. *(accepted)*	£2,370 17 0	£697 0 0
Siemens Bros. and Co.	3,153 0 0	850 0 0
Mather and Platt	3,164 15 0	568 0 0
Johnson and Phillips	2,333 19 0	1,246 19 0

———The tender of Messrs. Paterson & Cooper for wiring the Derby Municipal Technical College has been accepted by the Town Council.

TENDERS RECEIVED.—The Vienna Municipal authorities have received 10 schemes for the construction of 50 kilometres of railways, to be worked by electric power in the municipal district of Vienna. Some particulars of the system were given in our issue of August 2nd last. The following is the list of tenders sent in :—

Lachmann, Eduard, Hamburg.;
Springer, Adolf, Vienna ;
Continentale Gesellschaft für Elektrische Unternehmungen, Nuremburg.
Allgemeine Elektricitäts Gesellschaft, Berlin ;
Wiener Bankverein ;
Neue Wiener Tramway Gesellschaft, Anglo-Oesterreichische Bank and Siemens and Halske—Alternatvie projects ;
Bau-Unternehmung Ritschel and Cie (Vienna), and Union Elektricitäts Gesellschaft (Berlin)—Joint projects ;
Stadler, Istvan, Neupest ;
Hampl, Franz, Vienna :
Motoren Tramway Gesellchaft, E. Bierenz, Vienna.

The overhead conductor system will probably be employed in the suburbs, but an underground system of electrical distribution will have to be adopted for the Ringstrasse and adjoining thoroughfares.

SALE BY TENDER.—Messrs. Percy Huddleston and Company announce a sale by tender of the surplus plant at the Woking (Surrey) Electric Light Station. Some particulars are given in our advertisement columns.

PLANT, &C., FOR SALE.—Our advertisement columns contain particulars of modern plant, machinery, &c., for sale, and spacious and well-lighted works, near London, to be let.

DIVIDEND.—A first and final dividend of 2s. 2¾d. in the £ in the bankruptcy of Walter Andreae, lately carrying on business as an electrical engineer under the style of Walter Andreae and Co., is payable at the offices of the Official Receiver, Bankruptcy-buildings, Carey-street, London, W.C., any day (except Saturday) between 11 a.m. and 2 p.m.

APPOINTMENT.—Mr. Charles L. Morgan, assistant engineer of the Great Eastern Railway, has been appointed chief resident engineer of the London, Brighton and South Coast Railway.

VACANT APPOINTMENTS.—As will be seen from our advertisement columns the Vestry of St. Mary, Islington, have vacancies for three electricians (salary £2 per week), one foreman fitter, and a number of workmen in connection with their electricity supply scheme. Written applications have to be sent in addressed to the Electrical Engineer, Electricity Department, 50, Eden-grove, Holloway, London, N., by twelve o'clock noon of Monday, the 16th inst.

———The Devon County Asylum require a fitter to take charge of their electric lighting, heating, and pumping machinery. Applications by the 16th to Mr. Ward, 9, Bedford-circus, Exeter.

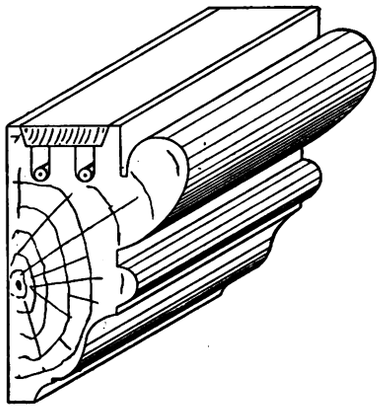
LIQUIDATION.—Mr. Samuel Wheeler, Official Receiver, has been appointed liquidator of the British Steam Generator and Refuse Utilisation Company (Limited). The first meeting of creditors will be held at 33, Carey-street, London, W.C., on Friday, the 13th inst., at 11 o'clock, and the first meeting of creditors will be held at the same place on the same day at 12 o'clock.

BANKRUPTCY.—The first meeting of creditors in the bankruptcy of Walter Raynes Smith, electrical engineer, St. Andries, Hitherfield-road, Streatham, Surrey, takes place at 24, Railway-approach, London Bridge, London, S.E., this day (Friday) at 11:30 a.m. The public examination will take place at the Court House, Wandsworth, S.W., on Thursday next at 12 noon.

HERCULITE AND ELECTRICAL MANUFACTURING COMPANY (LIMITED).—On the petition of the Harburg and Vienna India Rubber Company, Mr. Justice Vaughan Williams on Wednesday last granted a supervision order in the voluntary winding up of this Company.

FINALÉ.—Notice is given that the trustee in the bankruptcy of the Medical Battery Company (Limited), late of 52, Oxford-street, London, W., has been released as from November 21st last.

ELECTRIC WIRE PICTURE ROD.—In our issue of October 4th we gave a description of a form of picture rod adapted for running electric wires, which had been brought to our notice by Messrs.



Skegg and Co., of Salford. To-day we give an illustration of a modified form of the same idea. The rod can, of course, be made of any suitable material, preferably metallic.

BRITISH ELECTRIC TRACTION (PIONEER) COMPANY (LIMITED).—It will be seen from our advertisement columns that this Company is now prepared to develop electric traction enterprise on approved methods according to the requirements of particular localities. Communications must be addressed to Mr. E. Garcke, Managing Director, 1 and 2, Great Winchester-street, E.C.

THE "RADIANT" INCANDESCENT LAMP.—We have received from Messrs. Rose and Bird (Limited), of 120 and 121, Newgate-street, E.C., particulars of the improved incandescent lamps manufactured at the Company's works at Westminster, for which, in addition to low price, it is claimed that a longer life is obtainable for any given efficiency than in any other lamp, that the filaments are of exceptional hardness, strength and uniformity, and that the candle-power and efficiency of the lamps are maintained in a marked degree. The particulars state that these lamps have been made with the utmost care, are accurately tested before being sent out, and that the filament is manufactured by an entirely new process, which, it is claimed, renders the life of the lamp very much longer for the same initial efficiency, resulting in a minimum consumption of current.

THE "ENGINEERING MAGAZINE."—The December number of this Magazine is equal to any of its predecessors, both as regards the variety of the subjects dealt with, and the excellence of its numerous illustrations. The articles in the current issue include "First Principles in Money and Banking," by H. White ; "Side Lights on the South African Gold Boom," by A. Williams, jun. ; "The Distribution of Electric Power at Niagara," by the late F. L. Pope ; "The Education of Mechanical Engineers," by R. H. Thurston, C. E. Emery, and A. E. Outerbridge, jun. ; "Investigation of Public Water Supplies," by F. Davis ; "The Great Modern Transatlantic Steamers," by S. W. Stanton ; "The Cost of Modern Railroad Construction," by J. F. Wallace ; "Schools and School House Architecture," E. C. Gardner ; and "The Manufacture of Steam," by A. S. Writer. The usual exhaustive review of the World's Press is also given. This number, as well as all the back numbers, may be obtained at the offices of the European edition, 1, 2 and 3, Salisbury-court, Fleet-street, London, E.C. A complete index to the main articles in the magazine from the commencement in April, 1891, is now ready, and will be forwarded post free on request.

ASTON.—At a meeting of the Urban District Council the Highways Committee reported that the electrical appliances at the town baths had been examined by Mr. J. C. Vaudrey, of Birmingham, and in consequence of his report notice had been given to Messrs. Fowler, Lancaster and Co. to put in new accumulators in accordance with their contract, failing which the Baths Special Committee have been instructed to obtain tenders for the necessary renewal of the plant and alterations at a cost not exceeding £200.

ASSURANCE OFFICE LIGHTING.—Although the plant for generating electric current at the Prudential Assurance Company's premises in Holborn, London, is still in excellent working order after 10 years' work, the rapid increase of the business has made it necessary to remodel the generating apparatus throughout, substituting plant of a more compact nature. The successful results which have been attained by the use of slow-speed apparatus, has warranted Messrs Drake and Gorham, who have secured the order for the new plant, to keep to this class of plant, but to dispense with all belts and gearing. The engines and dynamos will be built on one shaft, running at 85 revolutions per minute. Marshall

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engines, of the horizontal type, and Crompton dynamos will be used. There will be over 6,000 lights of 16 c.p. fixed in these offices when the work is completed.

A WARNING.—The Committee of the Cancer Hospital, Fulham-road, S.W., have been the victims of a visit from a man who claimed to be connected with the firm who have the electric lighting of the hospital in hand, and Mr. W. H. Hughes, secretary to the hospital, recommends the custodians of public buildings to be on their guard against the visitor, who has a specious tale to tell and all the appearance of a genuine inquirer. In this case a considerable amount of valuable property was purloined.

AYR.—The Town Hall was lighted electrically for the first time on Tuesday night. Current was also supplied to the greater part of the street lamps. The Artillery Bazaar, which is to be opened on Monday next, is to be lighted electrically.

BELFAST.—At the last week's meeting of the Harbour Commissioners Mr. Davidson asked what was the difference between the working expenses of the electric lighting of Queen's Quay and the old system of lighting by gas, not taking into account the original cost of engines, boilers and dynamos. He had received an answer to that question as follows: Gas for the nine months ending September 30, 1893, £205. 4s. 3d.; electric light for the nine months ending November 30, 1895, £555. 6s. 10d. He wished the Press to know this, for the public to know the difference between electric light and gas. Mr. J. H. Greenhill said he thought it would be unfair that these figures should go to the public without it being understood that the increased facilities for discharging vessels given by the electric light were very great, and that the work could go on night and day. In his view the electric light on the quay—though, as everyone knew, more costly than gas—was really a great economy, having regard to its much greater efficiency. Were they simply to consider the cheapness of a light, they might propose to light the quay with candles. Mr. Andrews understood that the greater cost of the electric light was due to their having a much larger plant than was necessary. Mr. Thompson believed everybody knew that the electric light cost more than gas, but it was adopted because workpeople could do more work in a given time by the electric than by gas light. They must look to the efficiency of a light as well as to its cost.——At the Corporation meeting this week a question was asked as to the condition of the machinery at the Electricity Station, and before this question was answered Mr. Councillor M'Cormick pointed out that in 1892 he and ten other members of the Corporation suggested that an installation for 50,000 lights should be put down, but they were out-voted by 20 members, who favoured a 10,000-light scheme. Events had proved that the minority showed the greater foresight, as 50,000 lights would shortly be needed. Mr. Alderman Pirrie said that no apprehension need be felt as to the supply of current. There were certain matters in connection with the machinery that could be put in perfect order without its being removed from the machinery room. With regard to the extent of their installation there was no doubt that at the commencement they experienced considerable discouragement from the opposition to the electric lighting scheme, but he was gratified to find that all the current they could possibly generate had been applied for, and he hoped that by the time the additional plant was required the new engines would be erected and in working order. The Electrical Committee were preparing a scheme which would be placed before the Council shortly, which would gratify Mr. M'Cormick. In addition, they were taking all possible steps to make the Gas Committee improve the quality of the gas supplied for the public lighting.

BLACKPOOL.—The Borough Electrical Engineer (Mr. J. Hesketh) has been instructed to prepare a scheme for extensions at the electricity supply station.

BRIERLEY HILL (STAFFS.).—At the last meeting of the Council the Lighting Committee recommended that they be empowered to engage an electrical expert at a fee of thirty guineas to advise them on the electric light question, but the matter was adjourned for a month.

BURY ST. EDMUNDS.—Mr. F. H. Medhurst has been appointed consulting engineer to the Town Council in connection with the proposed electric lighting scheme.

CARDIFF.—At the meeting of the Electric Lighting Committee of the Corporation on Tuesday, a letter was read from the Great Western Railway Company asking upon what terms the Corporation would undertake the electric lighting of their new passenger and goods stations. The borough engineer is to report upon the amount of current likely to be required.——The revenue of the electricity department for the quarter ended September 30th last was £671. Since November 1st applications for 943 lamps have been received, which have had to be refused until the necessary extensions to the generating plant have been made. The Committee have instructed the engineer to prepare the necessary plans and specifications and to obtain tenders for the extensions to the plant and works forthwith.——The new wing of the Cardiff Free Library was opened to the public last week. The various reading rooms are lighted electrically. The fittings are of special design, and the lamps hang from wrought iron standards rising from the floor.

CARNARVON.—At the meeting of the Carnarvon Harbour Trust on Tuesday the matter of lighting the harbour electrically was referred to the Surveyor for report.

CHAMBERS OF HANDICRAFT.—The German Federal Council at its sitting at Berlin on Tuesday last approved the Bill for the creation of Chambers of Handicraft.

CHELMSFORD FIRE.—At the meeting of the Chelmsford Town Council last week the Mayor made reference to the recent disastrous fire at Messrs. Crompton's works, and stated that he had received a communication from Mr. Crompton, in which it was intimated that if a public subscription were started for those unfortunately thrown out of employment by the fire, Messrs. Crompton and Co. would head the list with 100 guineas.

CHELTENHAM.—At the monthly meeting of the Town Council on Monday, Mr. Alderman Norman stated that current equivalent to 5,120 c.p. incandescents had been applied for, and would all be connected up within the current week. The electric light undertaking was now in a condition to bear all its expenses. The local gas company has intimated its intention to determinedly oppose the Corporation's proposal to purchase the gas works, and have declined to meet in conference with the Councillors to discuss the matter.

CHURCH LIGHTING.—The electric light has just been introduced into St. Andrew's Presbyterian Church, Nottingham. St. Andrew's Church and the Chapel-street Congregational Church are also lighted electrically.——St. Luke's Church, Newcastle-on-Tyne, is now lighted by electricity. The contract was entrusted to Messrs. Rowland, Barnett and Co.

COVENTRY.—The Board of Trade inspection of the Coventry electric tramways was made on Friday last, and the Company have now received the Board's certificate. The section between the Coventry railway station and Foleshill is now complete, and the cars commenced running on Wednesday last. Satisfactory progress is being made with the Foleshill-Bedworth section.

CROSBY (LANCS.).—At the last meeting of the District Council it was decided to refer the plans submitted by the Liverpool District Lighting Company, who have given notice of their intention to apply for a Provisional Order for the district, to the Surveyor.

DUNDRUM (DUBLIN).—A company has been formed to construct a system of tramways in this district. It has been decided to adopt electricity as the motive power.

EAST GRINSTEAD.—Some time ago Messrs. Owen Lucas and Pike made proposals, on behalf of a company about to be formed, for the introduction of the electric light into East Grinstead. These proposals were referred to the General Purposes Committee, who now recommend the Council not to undertake the supply of electric current themselves, but to give an undertaking to the Company to use electricity for street lighting for 10 years, provided the Company will guarantee to supply current to a certain number of 2,000 c.p. arc lamps for street lighting. The cost per lamp must not exceed the sum now paid by the Council for the gas lamps. This recommendation was agreed to by the Council.

ECCLES.—The Town Council again discussed the electric lighting question at their meeting on Monday last. It was decided to refer the matter to the General Purposes Committee for consideration and report, prior to a special meeting of the Council.

EDINBURGH.—At the meeting of the Town Council on Wednesday the question of extensions to their electric light plant, in view of the probable demand for next winter, was referred to the Electric Lighting Committee for consideration and report.

"EDISWAN" VOLUNTEER FIRE BRIGADE.—The fourth annual dinner of this brigade was held at the Holborn Restaurant on Saturday last under the presidency of Major S. Flood-Page. The company numbered upwards of 100. Mr. H. C. Gover, in giving the toast, "The Edison and Swan Company," said that the Company stood to-day at the head of all electrical manufacturing concerns, and employed thousands of hands. At Ponder's End they had large factories, occupying several acres of ground, and possessing even their own gasworks. They had numerous branches in London and the provinces, and agencies in all parts of the civilised world. It was due to their Chairman to say that he was the guiding genius and moving spirit of the Company. Major Flood-Page, in reply, said that the name of Edison Swan was a household word in all parts of the world, and there were very few places where the Edison-Swan lamp was unknown. There were certain tests going on now with respect to incandescent lamps, but the Edison-Swan Company did not mind who was first to make improvement, but were determined to offer the best goods. Cheapness without quality was no recommendation, and he hoped the public would not be led astray by mere cheapness, but would take into consideration other equally important points. If the Company

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produced the best article they need not fear German or any other competition, and they were determined to hold their own against all comers. They were selling more lamps to-day than even in the protected period. They all wished prosperity to their useful fire-brigade. He was sure those present sent their heartfelt sympathy and regret to Mr. Crompton at the serious loss sustained by the burning of the Chelmsford works. At Ponder's End they paid especial attention to their fire-brigade arrangements, especially at meal times and closing times, as it was a fact that nearly all fires in factories originated at those times, and it was only by a well organised and efficient fire-brigade service that any large firm could really feel secure. Capt. Dale responded on behalf of the Brigade. After the toast of "The Chairman" had been cordially drunk and Major Flood-Page had responded, Mr. C. M. Downie, the Company's sales superintendent, proposed the toast of "The Press." The company, having inspected a number of new electric fire alarms shown by Mr. Johnson (Mr. Edison's representative in this country), separated, afrer an enjoyable evening.

"ELECTRICAL IMPROVEMENTS."—Under this heading the *Western Mail* of yesterday contains particulars of an influential syndicate formed at Cardiff for the purpose of working two patents, one for making metallic insulators and the other for an improved method of making insulated tubes for electric wiring purposes. The patentees are Messrs. A. J. P. Whitaker and F. G. Treharne, and the first directors of the syndicate are Lord William Beresford, V.C. (Chairman), Mr. Alderman W. H. Matthias, and Messrs. E. Davies, Whitaker and Treharne. Suitable works have, it is stated, been taken on the East Moors, Cardiff, where the erection and fitting of the necessary plant has so far advanced as to enable the syndicate to commence operations by January 1st next.

ELECTRIC FANS.—The electric fans selected for ventilating the Council Chamber at Spring-gardens were made and fixed by the Blackman Ventilating Company.

ELECTRIC LIGHT FOR RAILWAY CARRIAGES.—Amongst many considerable improvements about to be introduced into the trains run by the Great North of Scotland Railway Company is the lighting of the trains by electricity. The only railway system in Scotland on which the carriages are at present lighted electrically is the Glasgow underground railway.

ELECTRIC TRACTION FOR PORTSMOUTH.—At the general meeting of the Provincial Tramways Company held on Friday last at the offices, the Chairman, Mr. George Richardson, having alluded to the working of the Company for the year under review, said that electric traction had now come forward to a very great extent, and they would find if they adopted it that they were not experimenting as they would have been in the first instance. Every country in the world had done a great deal more than England in that direction, and they were handicapped by people who thought that electricity was dangerous, but he did not think there were more people killed by electricity than by other means of locomotion. The board had given notice at Portsmouth that they meant to apply for a Bill to use electricity as a motive power. That was the only place at which they saw any prospect of carrying through a Bill in the ensuing Session, and if that Bill were carried through, there was no doubt it would be of the greatest advantage to the Company. Naturally, they would have to consider the additional capital which would be required; but as there would be no promotion expenses, it would be done at the lowest possible cost. They would, of course, have to provide a sinking fund for the new capital, having regard to the power of the Corporation to take over the line; but he did not think that would be a very onerous task having regard to the great advantages they might expect in changing from horse traction to electricity.

FIRE.—Late on Thursday evening last week a destructive fire broke out on the premises of Messrs. McGaw and Co., timber merchants, makers of wood casings, &c. The Company's premises in York-road, Lambeth, London, are very extensive, and the fire had taken a strong hold before the premises were discovered to be alight.

GLASGOW.—At the meeting of the Police Department of the Glasgow Corporation on Monday last the Watching and Lighting Committee's minutes stated that the Sub-Committee recently appointed to consider the question of the electric lighting of the city, and particularly the kind of arc lamp to be used, had presented their report. The minutes recommended that a small deputation should visit Blackpool for the purpose of examining the street lighting of that town, and this proposal was, after a brief discussion, adopted.

HAMPSTEAD (LONDON).—The Lighting Committee's report recommended that mains and transformers for the supply of electric current be laid down in Frognal-road (from Arkwright-road to Frognal House) at a cost of £258; Fellows-road, £548; Willoughby-road, £143; Dennington-park-road, £128; Fairhazel-gardens (Goldhurst-terrace to Greencroft-gardens), £152; Chislett-road, Priory-road (from Chislett-road to Canfield-gardens), Canfield-gardens (from Priory-road to Fairhazel-gardens), and Fairhazel-gardens (from Canfield-gardens to Greencroft-gardens), £916; and Greencroft-gardens (from Fairhazel-gardens westward to Gleniffer, £128. This recommendation was adopted, as was also the proposal to lay a distributing main in Holly-hill, from Heath-street to the Grove, at a cost of £56. There are now 18,764 8-c.p. lamps connected, and applications for 1,700 more are in hand. The Willesden District Council have postponed the question of lighting the High-road, Kilburn, electrically. The Vestry have instructed their Clerk to write to the London County Council, complaining of the bad quality and quantity of the gas supplied by the gas company to the public lamps in the parish.

HANDSWORTH.—At the meeting of the District Council on Wednesday last, it was decided to oppose any further application of the South Staffordshire Tramways Company for an extension of time for the use of steam power on their system unless the Company could give satisfactory evidence that arrangements for improved means of traction were actually in progress.

HANLEY.—The Town Council have decided to reduce the charge for electric current for motive-power purposes to 3d. per unit net.

HUDDERSFIELD.—A Local Government Board inquiry was held last week at Huddersfield by Mr. G. W. Willcocks, M.I.C.E., into the application of the Corporation for permission to borrow £50,000 for electric lighting purposes. The Town Clerk (Mr. F. C. Lloyd) stated that the Corporation had already obtained power to borrow £50,000 for the erection ot works and the supply of energy for the electric lighting of the compulsory area of the borough, and the generating station was designed to supply current to 20,000 8 c.p. lamps, and their present plant had a capacity for 13,320 8 c.p. lamps. They had 256 customers, and 36 applicants were waiting to be connected. They had thus applications in hand for a total of 22,050 lamps. That exhausted their borrowing powers, with the exception of £3,000, which was required for work in hand, and which would be sufficient to finish the works already sanctioned. The Corporation had had a large demand for the electric light from districts outside the compulsory area, and their electrical engineer estimated that provision should be made in the proposed extension scheme for a total of 50,000 8 c.p. lamps. In 1890 Longwood district was added to the borough, and the Corporation were applying for a Provisional Order for its inclusion in the district of the 1890 Order. There would be a compulsory area for Longwood, so as to comply with the Board of Trade requirements, and this would subsequently be made the subject of a further application for borrowing powers, but was not included in the present application. The Borough Electrical Engineer (Mr. A. B. Mountain) produced and explained the plans of the proposed extensions. The additional capital would be expended as follows: Buildings, machinery, foundations, &c., £11,000; transformer stations, drainage, flooring and sundries, £4,000; two 400 H.P. boilers, £3,000; two 300 unit alternators driven by two 550 H.P. direct-coupled vertical compound condensing engines, £7,000; additions to steam, exhaust, feed, water and condensing pipes, £500: switchboards and regulating apparatus, £1,000; additions to mains inside the compulsory area, £5,000; outside, £16,000; transformers, meters, switches, &c., £4,000. The additional plant would be capable of supplying current to about 36,000 8 c.p. lamps. Alderman Calvert (Chairman of the Electric Lighting Committee) also supported the application, and said that from the many inquiries he had from districts outside the present electric lighting area he felt that if the proposed extensions were carried out a very large increase in the supply would follow. Last year they had a balance of £1,376, after paying working expenses, &c., but owing to the very short period of the loan this sum was not sufficient to pay the interest and the annual proportion which had to be put aside for the repayment of the borrowed money. He, therefore, urged that the period of the loan should be for at least 25 years, and not for 15 years, as in the last case. Alderman J. J. Brook said already there were several applications for current from the Marsh and Lindley districts, and many people would have had their houses wired long ago if current could have been obtained.——Strong opposition is threatened to the proposal made by the Borough Council in its Omnibus Bill for powers to borrow £100,000 for gasworks extension, and an excited meeting of ratepayers and owners of property in the borough was held at the Town Hall on Wednesday to oppose this and other schemes put forward by the Borough Council.

HULL.—At the meeting of the Electric Lighting Committee of the Corporation last week Mr. W. Holder presented a report of the Sub-Committee which attended the Conference at the Board of Trade to amend the regulations governing electrical supply. The report states that the Sub-Committee are deeply concerned in the success of their desire to introduce high voltage lamps which will, they urge, enable the Electric Lighting Committee to greatly increase their income from the supply of electric current without any considerable increase in expense. The report points out that the recommendations of the Sub-Committee were favourably viewed by Sir Courtenay Boyle who accepted amendments to two clauses of great importance which were made by the Town Clerk and Borough Electrical Engineer of Hull. The report concludes

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by urging that the adoption of a higher voltage will permit of the cheapening of electric supply both for power and lighting purposes, and "presents ideas of economies which will materially cheapen the use of both to the town's benefit." The sub-committee's report was unanimously adopted.

IPSWICH.—The notice given by the County of London and Brush Provincial Company of their intention to apply for a Provisional Electric Lighting Order has been referred to a special committee.

LAMBETH (LONDON).—In our last issue we chronicled the fact that at a special meeting of the Vestry it was decided to appoint a committee of eleven "to consider carefully all the information obtainable on the electric lighting question, and to report thereon to the Vestry." Another special meeting of the Vestry was held on Thursday last, when Mr. Orfeur moved that the above resolution be rescinded. He contended that "there was no necessity for the appointment of a committee, because the Vestry were supplied with all available information three years ago. Moreover, the Vestry was not a trading community, and his view was that if they 'went into' the business of electric lighting, it was only logical that they should 'go into' the business of butchers and bakers." Mr. Orfeur's motion was, after a short debate, carried by 56 votes to 41. No special meeting of the Vestry has, so far, been called to rescind this latest resolution.

LEGAL.—In another column will be found a report of the action "Gaskell and another *v.* Gosling and another," in which a point of the greatest interest to traders was involved. We have several times referred to the peculiar features of the failure of Poole and White (Limited), the appointment of W. J. Kelly as Receiver and Manager for the second debenture-holders, and the subsequent failure of Mr. Kelly. In the light of events connected with the latter failure, it is satisfactory to find that the result of the action has justified Messrs. Gaskell and Grocott, of Longford in taking proceedings to recover their debt of nearly £500. No doubt many other electrical firms will take courage by the result of this action, and proceed to recover their just dues from the debenture-holders in Poole and White (Limited). It was not found necessary in the action under review to call upon Mr. Kelly for evidence, but it would certainly be interesting to thresh out his position in this business. The Lord Chief Justice, in giving his judgment for the plaintiffs, made the remark that "the trust deed of May 18, 1892, under the powers of which Mr. Kelly was appointed Receiver, was ingeniously framed to clothe Kelly as the agent of the Company, and he had grave doubts whether Section 24 of the Conveyancing Act would apply to such a case as was contemplated by this deed." There are several extremely interesting points in this action, and a thorough investigation of all the circumstances of Mr. Kelly's appointment would, we feel sure, prove entertaining. For instance, Mr. Tryon is described in the proceedings as "a member of the firm of Saltwell, Tryon and Saltwell, solicitors, of London, defendants' solicitors"; but our recollection is that Mr. Tryon's name figured very conspicuously for some years in the business of Poole and White, and creditors were uniformly informed by Mr. Kelly, who acted as Secretary to the original firm, that Mr. Tryon's signature was necessary to all cheques passed for payment. Certainly no large credit would have been given to Mr. Kelly himself except upon the understanding that the debenture-holders in Poole and White were his sponsors. It would be satisfactory to learn whether this Mr. Tryon was associated with the original Company of Poole and White (Limited), and, if so, what his interest in that firm really was. There are several more or less recent failures in the electrical trades that call for serious investigation, and, in our opinion, this is especially the case with regard to the failure of Poole and White (Limited) and of W. J. Kelly.

LEITH.—The Leith Dock Commission have decided to extend their electric light installation at the docks. Six arc lamps are to be erected at the Newcastle berth at the back of the Custom House.

LINCOLN.—The Town Council have before them the notice given by the County of London and Brush Provincial Company of their intention to apply for a Provisional Electric Lighting Order for Lincoln.

LIVERPOOL.—For the forthcoming pantomime at the Court Theatre several novelties are to be introduced. These include a large number of electric appliances, the greater part of the work for which has been entrusted to Messrs. G. Ewing Johnstone and Rea, of South John-street, Liverpool. There is to be an elaborate electric curtain, and the preparation of this is entrusted to Messrs. S. H. Heywood and Co., of Manchester. About 1,000 lights are to be put on in the ballroom scene, every person on the stage being made the medium for displaying the electric light in all its glory. There is to be also an electric aerial ballet, "a surprisingly intricate electrical entanglement," and the electric curtain displaying about 700 lights.——It has been decided to light the Princes' Landing Stage by electricity, and the work of erecting four tall posts as a temporary experiment has been completed. If the anticipated success follows the electric light will possibly be placed all over this extensive landing stage.

LLANDUDNO.—The District Council have decided to obtain the opinion of an electrical expert as to the advisability of lighting the town electrically. The Council have received several applications from syndicates for permission to lay a system of tramways in the town and district.——At the meeting of the Llandudno Marine Drive Company last week, the Directors' proposal to sell the undertaking to an electric tramway company for £12,500 was approved.

LLANELLY.—The Town Council have definitely decided to accept the sum of £200 offered by Messrs. J. C. Howell (Limited) for the transfer of their Provisional Order.

LOUGHBOROUGH.—The Borough Surveyor has been instructed to obtain an estimate from the Brush Company for the electric lighting of the Sewage Disposal Works.

MANCHESTER.—At Wednesday's meeting of the Corporation the proposal that application be made to the Board of Trade for a Provisional Order to supply electric current within those areas of the City of Manchester not comprised in the Manchester Electric Lighting Act (1890) was adopted.

MONMOUTH.—The Town Council have received the formal sanction of the Local Government Board for borrowing £20,000 for their combined electric lighting and drainage scheme.

OLDHAM.—At the last sitting of the Electric Lighting Committee a lengthy report from Prof. Kennedy on the pressure at which electric current is at present supplied by the Town Council to its customers was received. The report recommended the Committee to increase the pressure, and to arrange for the introduction new high-voltage incandescents instead of those now in use.

PLYMOUTH.—The local authorities of this town have hitherto been very sluggish in the matter of the introduction of the electric light, but a step in the right direction was taken when it was decided that a deputation from the Corporation should visit Brighton for the purpose of inspecting the famous electricity works in that town. The members of the deputation were wonder-struck at what was shown and explained to them by Mr. Arthur Wright, and it is probable that electric lighting will be considerably advanced in Plymouth by this visit.

PORTSMOUTH.—The Portsea Guardians are considering the question of lighting their workhouse premises electrically.

RIPON.—The City Council are obtaining information with a view to applying to the Board of Trade for powers to supply electric current to the city. Ripon Cathedral is to be lighted electrically by Messrs. G. Harrison and Co., of the Ewer Bank Engine Works.

SHOREDITCH (LONDON, E.).—The Electric Lighting Committee of the Shoreditch Vestry have, it is stated, made arrangements to supply electric current for lighting the stations and tunnels of the new London, Walthamstow and Epping Forest Railway. The Company will, it is estimated, require about 420,000 units per annum. This the Company will take as a purely day load, and will provide the necessary accumulators and subsidiary apparatus to provide current during the hours of heavy load, so that the Vestry will require no extra plant. The Vestry have sealed a contract to supply the Company with a minimum of 300,000 units per annum at 1½d. per unit.

SHREWSBURY.—The formal opening of the Shropshire Electric Light and Power Company's supply station in Eagle Foundry-square is to take place on the 10th inst. An exhibition of up-to-date electrical appliances is to be a feature of the opening.

STAPLETON.—The Electric Lighting Committee have presented a preliminary report on the electric lighting question. The report states that the cost of providing power for lighting such a large district would be prohibitive, especially from one station, and that it would probably be necessary to erect separate generating stations for the Eastville, Stapleton, Ashley Down and Fishponds districts. The Council have decided to oppose the application of the Great Western Electric Light and Power Company for a Provisional Order for the district.

STOCKTON.—Although the Corporation obtained a Provisional Order in 1890, they have taken no steps to comply with its provisions, or to introduce the electric light into the district. In the meantime, several large engineering firms have put down private installations, and as the Gas Committee have discovered that this means decreased consumption of gas, they have just referred the electric lighting question to a sub-committee. The *Northern Echo*, in commenting on this step, says:—

"In Mr. Ford the Corporation have one of the admittedly ablest gas works managers in the country, and he has kept himself abreast with the various new illuminants that have been again and again projected—petroleum, water gas, electricity, &c. We believe that Mr. Ford has never had any doubt that electricity was the coming illuminant, but its application has been so largely experimental as to render him chary in advising the Corporation to adopt it. Its cost is still great, and if we are not mistaken Mr. Ford is still of opinion that almost at any time Edison or some other discoverer may hit upon the invention that will infinitely cheapen it."

Mr. Ford, if correctly described in the above excerpt, is, indeed, progressive. In the meantime isolated installations in the Stockton

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district are rapidly increasing, which, of course, is proof, if proof were wanted, of Mr. Ford's prescience.

STOKE.—At the meeting of the Town Council held last week the Highways and Lighting Committee reported that they were of opinion that the overhead system of electric traction proposed by the North Staffordshire Tramways Company was the best means of traction which could be adopted at present in the borough, but, before giving formal consent to the introduction of the system, the Town Clerk should be instructed to put himself into communication with the other interested authorities with a view to taking combined action.

ST. PANCRAS (LONDON).—The Vestry have decided to borrow a further sum of £10,000 from the London County Council for electric lighting purposes.

THE COLONIAL OFFICE.—By the instructions of the Colonial Secretary (the Right Hon. Joseph Chamberlain, M.P.) the Colonial Office is to be fitted up for the electric light.

THEFT —At the Central Criminal Court last week, before the Common Serjeant, James Murray (described as a clerk) and George Fowler were indicted for stealing 365 incandescent lamps, valued at £22. 16s. 3d., the property of the General Electric Company. The jury acquitted Fowler, but Murray was sentenced to six months' hard labour.——On Tuesday, at the County of London Sessions, Jacob Glass was acquitted on the charge of stealing a battery and other articles value £25 from the same company.

TORQUAY.—At the last meeting of the Town Council a proposal to consider the advisability of purchasing the Market Company's property in Market-street, with a view to utilising a portion thereof as an electricity generating station, was referred to the Electric Lighting Committee.

TUNBRIDGE WELLS.—The Town Council have received the formal sanction of the Local Government Board to borrow £12,000 for electric lighting extensions.

WATERLOO (NEAR LIVERPOOL).—At the last meeting of the District Council a Committee was appointed for the purpose of opposing the application of the Liverpool District Lighting Company for a Provisional Electric Lighting Order.

WELLS.—At the meeting of the City Council on Monday the Electric Lighting Committee's report recommended that the preparations for the installation of the electric light be proceeded with, and that the Committee be empowered to select a site for the electricity generating station. The report was adopted. Mr. G. W. Wheeler then moved that the whole question of electric lighting be left in abeyance for one week, and that, in the meantime, the Town Clerk be instructed to offer the sum of £14,000 for the Gas Company's works. This was seconded, and, after a long debate, carried by the casting vote of the Mayor.

WHITECHAPEL (LONDON).—On the recommendation of the Streets Committee it was decided, at the last meeting of the Board of Works, to take the necessary steps to oppose the application of the Capital and Counties Electricity Company for a Provisional Order for the district.

YORK.—At the meeting of the City Council on Monday last, the Streets and Buildings Committee's report recommended that Prof. A. B. W. Kennedy be engaged to prepare an electric lighting scheme for the city at a fee of 100 guineas. This reportwas adopted.

NEW COMPANIES, STATUTORY RETURNS ,&c

ELECTROLYTIC RESEARCH SYNDICATE (LIMITED).—This Syndicate was registered on November 25th with a nominal capital of £1,000, in shares of £1 each, to acquire patents, brevets d'invention, licences, or the like, relating to an invention for the production of chrome and other metals by electrolysis or other kindred methods, and alloys of the said metals, in Great Britain or other parts of the world, and to carry on the business of manufacturers of and dealers in all substances, materials, machinery, and things serviceable or useful or used in reference to any of the purposes of the business which the Company is entitled to carry on. The first subscribers, with one share, are: George Bennett, Charles E. M. Crickmore, Alec J. Tod, L. de Fonblanque, Lionel Rogers, Ernest Anderson, and Edward Hayes. The first Directors are to be nominated by the above signatories.

EVANS, O'DONNELL AND CO. (LIMITED).—This Company was registered on December 2nd, with a capital of £45,000, in 60 £7 per Cent. Cumulative Preference and 120 Ordinary shares of £250, to carry into effect an agreement between Arthur G. Evans and John P. O'Donnell, and Eldred W. Stead (for the Company), and to carry on the business of railway signalling engineers and manufacturers. The first Directors are Arthur G. Evans, John P. O'Donnell (Governing Directors), and E. Colman.

MEVAGISSEY ELECTRIC LIGHTING COMPANY (LIMITED).—Registered November 26th, with nominal capital of £1,500, in £1 shares, to carry into effect an agreement with Veale and Co. (Limited) for the establishment of a complete electrical installation in the town of Mevagissey, Cornwall, and to carry on the business of electricians, electrical and mechanical engineers, and manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, accumulation, distribution, supply and employment of electric light, heat and power. The first subscribers, with one share each, are: Charles W. M. Grier, M.B., Alfred Roberts, David G. Williams, James Kemble, Richard Nicholls, William U. Treleaven, Josiah K. Roberts. The first Directors to be appointed by the signatories.

CITY NOTES.

MEMORANDA —Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30⅝d. per oz. (Dec. 5th). Consols (2¾ per cent.) 106½ - 105¾ for money, 106⅝—106¾ for account; 2½ per cent. 103⅞—104⅛ (Dec. 5th). Stock Exchange Settling Days: Consols, Jan. 3rd; Stocks and Shares Continuation Day, Dec. 13th; Ticket Day, Dec. 14th; Pay Day, Dec. 15th. Mining Share Carry-over Day, Dec. 12th.

CITY OF LONDON ELECTRIC LIGHTING COMPANY LIMITED.—For the issue of £100,000 Five per Cent. Debenture Stock (at £128) the prospectus of which appeared in our last issue, applications were received for no less than £522,335. Letters of allotment and regret have been posted.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended December 1st were £987, against £928 in the corresponding week of 1894, an increase of £59. The total receipts for the half-year amount to £19,549, against £19,576 for the corresponding period of 1894, a decrease of £27.

COMMERCIAL CABLE COMPANY.—The Directors of this Company have declared a quarterly dividend of 1¾ per cent., payable on January 2nd. The transfer books will be closed from the 20th inst. to January 3rd.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of November are £2,414, against £1,738 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of November, 1895, amounted to £69,461, against £64,095 in the corresponding period of last year.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of November, 1895, amounted to £50,425, and to £43,064 in the corresponding period of last year.

GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).—The traffic returns of this Company for November last were £24,800, and the total receipts for the period from January 1st to November 30th, £286,400, against £248,400 and £261,000 in the corresponding months of 1893 and 1894 respectively.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 1st inst. amounted to £1,020. The amount for the corresponding week last year was £902; increase, £118.

REDUCTION OF CAPITAL.—A petition was presented to the Chancery of the County Palatine of Lancaster, on the 27th November, to confirm a resolution reducing the capital of the Manchester Edison-Swan Company (Limited and reduced) from £550,000 to £350,000, and is now pending. The list of creditors of the Company is to be made out as for the 7th January next.

SMELTING COMPANY OF AUSTRALIA (LIMITED).—At the statutory meeting of this Company last week the Chairman (Mr. A. Fowler), after referring to the progress that had been made with the erection of their works in New South Wales, stated that, before the Company purchased the patent rights of the Siemens and Halske electrolytic process, that firm had erected plant in Berlin for the purpose of treating zinc ores, and especially the sulphide ores from Broken Hill, on a commercial scale. This plant was constructed on the same lines as the Smelting Company proposed to follow, it being only necessary to increase the sections of the plant for any required output of zinc. The plant erected at Berlin was not a mere experimental plant; the vats and all the electrolytic appliances were similar to those which they were now purchasing for their works. The process had been thoroughly demonstrated, and the Directors thought they were right in saying that Messrs. Siemens Bros. were the first people who had produced metallic zinc directly from the ore. Mr. Fowler then produced a bar of zinc which, he stated, was produced by Messrs. Siemens and Halske's process from ores from the Broken Hill Proprietary Company's mines. The sample had been carefully assayed by Messrs. Siemens Bros. and Co., chemists, and by Mr. A. Gordon Salamon, the Smelting Company's representative, with the result that it was proved to be practically pure, containing less impurities than the best Silesian zinc, which obtains the highest value in the market. It contained 99½ per cent. of metallic zinc. In the Directors' opinion Messrs. Siemens and Halske's invention was one of the greatest metallurgical inventions of the day. Messrs. Siemens consider that they have finally solved the very difficult problem of producing metallic zinc from the hitherto refractory ores.

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to allow the further issue of £34,000 Four and a-Half per Cent. First Mortgage Debentures of the Royal Electric Company of Montreal.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended November 29th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,907.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the fortnight ended November 30th were £2,133, against £2,049,

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Nov. 27.		Price Wednesday, Dec. 4.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Nov. 30.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS.								
£1,912,880	Stock	10/0	Anglo-American	44	43	44	43	4 17 10	Jan., Apr., July, Oct.	44½	..
£2,993,560	Stock	20'0	Do. Preferred	84½	85½	84	85	5 5 11	" "	85	83⅝
£2,993,560	Stock	5/0	Do. Deferred	6⅝	7	6½	6⅝	.. ..		–	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	101	105	101	105	3 17 1	January and July	..	..
180,000	£10	5/0	Brazilian Submarine	13	13½	13	13½	5 3 8	Mar., June, Oct., Dec.	13⅞	13⅞
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111	115	111	115	4 8 4	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	164	163	164	163	4 3 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	13	14	13	14	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20½	21½	20½	21½	4 13 0	" "	..	..
12,981	5	2/0	Direct Spanish (fully paid)	3⅝	4½	3½	4½	4 8 11	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10	10½	10	10½	4 5 8	" "	..	..
£80,000	Stock	4½%	Do. 4½% Debentures of £50 each	104⅞	107⅞	104⅞	107⅞	4 6 9	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½	8⅝	8½	8⅝	4 11 5	Jan., Apr., July, Oct.	8⅞	8½
400,000	10	2/6	Eastern	16	16¼	16	16½	3 18 9	" "	16½	15⅞
70,000	10	6%	Do. 6 per Cent. Preference	17⅛	18	17⅛	18	3 6 8	" "	17⅞	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	125	128	125	128	3 2 6	May and November	126½	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 12 2	February & August	..	..
250,000	10	2/6	Eastern Extension	17	17⅛	17	17⅛	4 0 0	Jan., Apr., July, Oct.	17⅛	17½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	126	129	125	129	3 2 6	February & August	128	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102	106	102	106	4 16 2	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	102	106	102	106	4 6 2	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108	111	108	111	3 12 9	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112⅞	115	112⅞	115⅞	3 9 7	May and November	..	..
180,227	10	1/3	Globe Telegraph and Trust	9⅜	10	9⅜	10	4 5 0	Jan., Apr., July, Oct.	9⅞	9⅜
180,042	10	6%	Do 6 per Cent. Preference	16⅜	17	16⅜	17	3 10 7	" "	16⅞	16⅛
150,000	10	5/0	Great Northern	21½	22	21⅞	22	3 17 3	Jan., April, and July	..	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	104	107	104	107	4 14 4	March & September	..	..
M,000	25	12/6	Indo-European	46	49	46	49	5 2 0	May and November	48	..
37,548	10	..	London Platino-Brazilian	..	..	..	..	.. ..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	108	110	108	110	5 10 10	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	109	112	109	112	3 12 3	" "	..	..
11,339	8	4/0	Reuter's	5	6	5	6	.. ..	April and October	..	..
3,881	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	127	132	127	132	4 10 11	" "	128	..
15,609	10	2/0	West African Telegraph	5½	6½	5½	6½	.. ..	January and July	..	..
£233,300	100	5%	* Do. 5 per Cent. Debentures (red.)	102	105	101	105	4 16 5	March & September	..	..
30,000	10	2/0	West Coast of America	1	2	1	2	.. ..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	98	103	98	103	7 19 3	June and December	..	..
88,321	10	1/3	West India and Panama	⅞	1⅛	⅞	1⅛	.. ..	" "	1	..
34,568	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10⅛	10
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½	9⅛	8½	9⅛	6 6 4	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	111	114	111	114	4 9 1	June and December	..	..
64,242	15	3/0	Western and Brazilian	9⅜	10½	9½	10	4 17 6	May and November	..	..
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred xd	6⅜	6⅝	6½	6⅝	..	–	6	6½
33,129	7½	1/6	Do. 5 per Cent. Deferred xd	3⅜	3⅝	3½	3⅝	..	–	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103	107	103	107	5 14 3	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103	107	103	107	5 14 3	" "	..	..
£1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	110	115	110	115	6 1 9	May and November	..	..
£164,800	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100	103	100	103	5 18 10	March & September	101½	–
			TELEPHONES.								
44,000	5	2/6	Chili Telephone (fully paid)	3⅜	3⅝	3½	3⅝	..	–	..	..
224,380	10/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛	⅜	⅛	⅜	..	May and November	..	..
271,504	£1	8·215	Oriental Telephone and Electric (fully paid)	10	11⅜	⅛	⅜	..	Yearly	..	..
484,597	5	2/6	National	5⅝	6⅛	6	6⅛	4 0 0	June and December	6⅛	6
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16	18	16	18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15½	16½	15½	16½	3 12 9	" "	16	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅛	6⅜	6¼	6⅜	3 16 11	–	6⅛	6⅛
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	108	107	105	107	3 6 4	January and July	106½	105½
58,000	5	..	United River Plate	2⅜	3	2½	3	.. ..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	92	97	92	97	5 5 6	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	5/0	City of London Electric Lighting (fully paid)	13	13½	13	13½	1 17 0	–	13⅞	13½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15½	16½	15⅝	16½	3 13 10	–	16	15⅝
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	132	136	132	136	3 14 9	June and December	132½	132
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	–	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½	5⅝	5½	5⅝	..	–	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	–	–	–	–	..	–	..	..
8,822	£5	..	House-to-House Electric	–	–	–	–	..	–	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	–	–	–	–	..	–	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	..	..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅜	8⅛	7⅜	8⅛	..	–	..	..
111,000	5	..	London Electric Supply	..	..	..	..	..	–	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	10⅛	11⅛	11⅛	11⅛	2 12 2	–	11⅞	10⅜
150,000	Stock	4½%	* Do. 4½% Debs.	117	120	117	120	3 16 3	June and December	117	..
6,452	£10	2/0	Notting Hill Electric	8½	9	8½	9	..	–	..	..
..	..	..	Rand Electric	¼	⅜ prem	⅛	¼ prem	..	–	..	..
19,980	£5	2/0	St. James and Pall Mall	8	8½	8	8½	..	–	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	9	10	9	10	3 10 0	–	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8	8½	8	8½	3 2 10	–	8⅝	8½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	2	1/6	Brush Electrical Engineering	1½	1⅝	1½	1⅝	10 0 0	–	1⅞	1½
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝	2⅛	1⅝	2⅛	5 12 11	–	1⅝	1⅝
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112	115	113	115	3 19 0	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2	2½	2	2½	..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1⅞	2⅛	1⅞	2⅛	..		..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104	107	104	107	4 5 9		..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	–	–	–	–	..		..	..
110,000	2	..	Electric Construction	⅝	¾	⅝	¾	..		⅝	⅝
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2	2⅛	2	2⅛	5 11 0		..	..
91,195	2	..	Elmore's Patent Copper Depositing	⅜	½	⅜	½	..		..	..
21,000	5	..	Fowler-Waring Cables (fully paid)	¼	⅜	¼	⅜	..		..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	18	19	18	19	3 18 11	February & August	18½	..
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101	103	101	103	4 8 0	March & September	..	..
15,995	£10	..	International Okonite Ordinary	..	..	..	..	..	–	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..	..	..	..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	..	⅛	..	⅛	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	39	41	39	41	5 17 0	March and July	40½	39½
£160,000	100	5%	* Do. 5 per Cent. Bonds	104	107	104	107	4 15 6	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	..	..	..	..	..		..	..
41,098	£5	..	Do. Preference (fully paid)	..	..	..	..	..		..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	14	14½	13½	14½	4 2 9		..	..
£30,000	10	7/0	Do. 7 per Cent. Preference	15½	16½	15½	16½	4 4 0		..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108	111	108	111	4 1 11		108	..
			RAILWAYS AND TRAMWAYS.								
£680,000	Stock	1½%	City and South London Railway	40	42	40	42	2 19 6	May and November	40	..
7,650	10	5%	Do. 5% Perpetual Preference	14½	15½	14½	15½	3 5 7	.. ..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130	132	130	132	3 0 9	May and November	..	..
37,500	£10	2½%	Liverpool Overhead Railway	10⅞	11	11⅛	11⅜	1 18 9	–	..	..
10,000	10	5%	Do. 5% Preference	15½	15⅝	15⅝	15⅞	3 3 6	.. ..	..	..
125,000	Stock	4%	Do. 4% Debenture	113	115	113	115	3 9 7	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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THE ELECTRICIAN:

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NOTES.

An agreeably falsified prophecy has been made by Prof. A. B. W. Kennedy in regard to the development of the Edinburgh Municipal Electric Lighting undertaking. Prof. Kennedy recommended the City Fathers to lay down a plant capable of coping with 40,000 8 c.p. lamps connected, and led them to anticipate that this lamp connection would be reached in about two or three years, and that the Works Costs (including office expenses) might be expected to amount to 3d. per unit for an annual output of 300,000 units. Although a prophet is usually without honour in his own country, Prof. Kennedy's prophecy was believed in the Scotch metropolis and acted upon, with the pleasing result that after only 7½ months' working some 45,600 8 c.p. lamps are connected to the mains, and the economy of production has been so remarkable that with only 285,000 units sold up to date, the Works Costs (including all office expenses) come out at 1·56 per unit, the greater portion of the period covered being summer time, that season hateful to all true central station engineers. This is, indeed, as Prof. Kennedy states, "quite a record." But, not deterred by previous failures, he still continues to indulge his prophetic vein, and avers that in the first completed year of working the Edinburgh municipal electrical undertaking will have sold over 800,000 units, will have reduced the total working costs to 1½d. per unit, will have earned about £16,000, and last, but not least, will have a credit balance of between £2,000 and £3,000, after paying every charge, including interest and sinking fund. Great credit is certainly due to all concerned, and it will perhaps be divided, as on a well-balanced three-wire system, between Prof. Kennedy, the consumers, and Mr. Monkhouse.

It is needless to say that after this record Prof. Kennedy recommends more plant immediately and 200-volt lamps *in futuro*. Doubling the voltage will, he says, "*quadruple* the present carrying capacity of the mains"; on the assumption, we suppose, of the same *percentage* drop.

It is always a pleasure to contemplate sustained well-organised effort concentrated upon and directed towards a well-defined objective point; and the pleasure is enhanced by contrast with the more common sight of fitful spurts made without any definite notion of what the goal aimed at may be. The spectacle of what has been recently done at Birmingham in the matter of technical education, when contrasted with the vague ideals and frittered funds of many other local authorities, will, we venture to think, give rise to some such pleasurable sensation in the minds of all believers in technical education. In the United States, according to Prof. Thurston, it is impossible to start an institution of the kind with less than £200,000; in Birmingham a capital expenditure of £84,000 has sufficed for the splendidly-equipped school which will be formally inaugurated to-day by the Duke of Devonshire. County Councils here and City Councils there have preferred to grant minute subsidies to all manner of institutions, and have lent a too-ready patronage to the recreative element. In Birmingham art is provided for by the Municipal School of Art; music, languages and recreation—those insidious foes of serious scientific study—by the Midland Institute; but the whole of the money available under the Technical Instruction Act has been devoted to the establishment of a single school in which instruction is to be given in the arts peculiar to the locality and in the fundamental principles of the allied sciences. This is as it should be.

Apparently also the distinction which should exist between a technical college and a technical school—that is to say, between an establishment intended for the training of industrial leaders and an establishment intended for the training of our industrial masses—has been kept well in view at Birmingham. It is generally agreed, at any rate in this country, that technical training is no substitute for the shops, but merely a supplement made necessary by the increasing specialisation of the engineering art. At college the student acquires a firm grasp of scientific principles and a little manual dexterity; in the shops he gains a little more manual dexterity, but above all a knowledge of workshop methods, workshop limitations, and workshop men; in the outside world he rounds off his curriculum with a knowledge of men and manners. Too many, not unnaturally, regard their education as completed after three years at a college and two years in the shop; and late in life, perhaps too late, learn that tact and courtesy—to put it no higher—have their market value. For the apprentice the technical school supplies the systematic manual training now difficult to procure elsewhere, and that insight into scientific principles which, although it may not always lead on to

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fortune, renders its possessor a happier man and, potentially at any rate, a more useful workman.

THE mention of battery cars has a tendency to make an electrical engineer's mouth water, but hitherto they have done little else than make his eyes weep. The long-looked-for and hardly-striven-for has not yet come, at any rate, in this country; and, what is even more depressing, does not give any very notable promise of coming. Electrical industry has yet to produce a battery commercially adapted to the conditions of traffic on common roads and tramways. The non-existence of such an appliance is, we do not hesitate to affirm, one of the most serious hindrances to electrical progress, possibly the most serious of all; and, conversely, its advent will open up an immense field of electrical applications which cannot now be attempted. Yet, though a really commercial traction battery cannot be said to exist, and though the direction from which it may come is not very clearly defined, we should not care to assert that the outlook is quite hopeless. The storage battery of to-day is less imperfectly adapted to this class of work than the battery of a few years, or even of only one year ago. Structural difficulties and mechanical imperfections are being overcome gradually by the practical manufacturers; while we hope the researches of the many electro-chemists who are engaged in this problem will help things forward on the more scientific side.

AN interesting, and in many respects an instructive, experiment in storage-battery traction for tramcars has recently been undertaken by the New York and Harlem Railway Company, on a portion of their New York tramway system. Some account of this undertaking will be found in our columns this week. The object of the experiment is to obtain "a thorough determination of the feasibility of storage traction"; and however instructive it may be in its initiation, we may safely be sure that it will be even more so in its carrying out and conclusion. Everything that could be done to give the cells a chance has been done. The batteries have been suspended, in easily replacible trays, from the motor trucks, and not within the car bodies, thus enabling these latter to be made as cheaply and as lightly as in ordinary horse or trolley cars. Facilities for changing the batteries on each car have been greatly perfected, an ingenious automatic centring system having been devised for adjusting the position of the car when about to take on a new set of cells; and mechanical appliances are everywhere contrived for transferring the batches of cells between the car sheds and the charging station. Each car carries some 2½ tons of cells, independently of the weight of the trays, &c., and to say nothing of the motors and gear. A storage capacity of 400 ampere-hours, from two batteries, each of 30 "chloride" nine-plate cells in series, has been provided. The decision of the New York and Harlem Railway Company, in the matter of adopting battery traction, will depend upon the results of this experiment; but we think that an interest in it will be felt throughout a far wider circle.

AN unusually appropriate use has been found for a secondary battery on the three-wire system run by the local gas company at Lawrence, Massachusetts. The dynamos are driven by turbines which take water from the Merrimac. Further up stream are a number of water mills, where it is daily the objectionable practice to shut down the sluices and pond back the entire stream for an hour or so. As a consequence the turbines at the electric light station are left high and dry, and to provide for the load at this time a storage battery plant has been laid down. We fancy that in this country a miller would have good ground for action at law if the entire head-water were to be cut off at the sweet will of another miller further up the stream; or, what amounts to nearly the same thing, if one further down stream were to dam the river enough to flood the tail-race of a higher mill. Evidently water rights are not very evenly distributed on the Merrimac.

THE *Electric Railway Gazette* observes that it is a well-known fact that two motormen can take the same equipment over the same route in the same time "and yet use vastly different amounts of power." This suggests a rigorous mathematical method of evaluating a motorman. All that is necessary is to let him run a car, loaded up to standard weight, over a given track in an exact pre-arranged time, making a definite number of intermediate stoppages. An electric meter in the car would give the motorman's figure of merit, which would, of course, be the reciprocal of the number recorded by the meter. This reciprocal should be indicated on his certificate, and his wages might be regulated accordingly. The adoption of this practice would be a new version of "motors, meters and money matters."

Cable Interruptions and Repairs.—There are no cable interruptions or repairs to record this week.

Royal Society.—The following Paper was down for reading yesterday:—Prof. J. C. Bose "On the Determination of the Index of Refraction of Sulphur for the Electric Ray."

Expiry of a Swan Storage Battery Patent.—On the 15th inst. Patent No. 5,494, granted to Mr. J. W. Swan in 1881, will expire. The claim is for "The preparation of lead plates for use in secondary voltaic cells by the combined action of acetic acid, carbonic acid, and atmospheric air, and the subsequent reduction of the carbonate of lead formed to metallic lead. . ."

The Grand-Ducal Technical High School at Darmstadt.—We have received a copy of the finely-illustrated account of the Darmstadt Technical High School which was published on the occasion of the opening of the new buildings on October 28th last. The buildings and the equipment are of the palatial order common to the generality of German institutions of the kind.

Prize Awarded to Dr. Borchers.—The Council of Honour of the German Electro-Chemical Society has awarded a prize of £25 to Dr. Borchers, of Duisburg, in recognition of the services rendered to the Society in connection with the publication of the *Zeitschrift für Elektrochemie*, the *Jahresberichte*, and his book on electro-metallurgy, as well as for his experimental work in electro-chemistry.

The Pacific Cable.—A Melbourne correspondent, under date December 9th, states that the representatives of New South Wales, Victoria, and Queensland, assembled in Sydney, have decided to appoint delegates to the Pacific Cable Conference, probably the Hon. Duncan Gillies and Sir Saul Samuel. New Zealand was not represented at the meeting, but expressed her assent. It is expected that South Australia and Western Australia will acquiesce. The Canadian delegates will almost certainly be Sir Charles Tupper and Mr. Sandford Fleming. It is anticipated that the Conference will meet in London in April next.

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Electric Traction on Brooklyn Bridge.—According to the *Electrical World* of New York, three companies, the Westinghouse, General Electric and the Enholme Conduit Trolley Company, made application to have their motors tried on the cars running over Brooklyn Bridge. After some discussion it was decided to allow the Westinghouse and General Electric companies to equip cars with their motors and subject them to a thirty days' test. General Electric motors will have the first trial.

The Electric Light in Hindu Temples.—The *Times of Ceylon* learns that it is in contemplation to introduce the electric light into the Sivan Hindu Temple at Kochicadde, on the main road to Mutwal, Ceylon. The premises of this Hindu place of worship are at present lighted by gas, and the trustees propose to substitute the electric light for gas; but whether they will introduce it into the interior of the building is a matter which is now under their consideration. It is said that, if the Sivan Hindu Temple introduce the innovation, the trustees of equally wealthy temples are sure to follow the example set by their brethren.

Electrical Communication with Lightships.—At a meeting of the Dover Corporation this week the question of the necessity of electrically connecting the whole of the Goodwin lightships with the shore was under discussion. The recent accident to the Ostend mail steamer in the vicinity of the sands was urged as a strong reason for carrying this out. It was proposed that a public meeting should be called for the purpose of passing a resolution impressing the importance of the proposal on the Government, and the arrangements were left in the hands of the Mayor. Similar meetings are to be held in the towns on the East Kent seaboard.

The Classification of Electrical Patents.—Mr. Frederick Walker read a Paper before the Society of Patent Agents at the general meeting of that body on the 11th inst. on "Electrical Nomenclature and the Classification of Electrical Patents." The main object of the Paper was to protest against the classification of the printed specifications at the Patent Office, which, it was urged by the author, are based upon obsolete systems and render what should be a simple search a formidable and harassing undertaking. Mr. Horn, after the discussion, moved "That there should be special divisions of the subject matter indices relating to inventions, and more particularly to electrical inventions, similar to what prevails in the United States and Germany." The Paper and the resolution together form the subject of a memorial to the Board of Trade.

A Flywheel Accident at Albany, N.Y.—The *Electrical Engineer* of New York states that on the 12th ult. a flywheel burst in the power house of the Albany Railway Company. Two houses, one of them two blocks from the power house, were wrecked. Four persons who were in a saloon opposite the power house were injured, one of the pieces of the wheel tearing out the whole front of the saloon, and another piece the whole upper portion of the house. One of the injured men died in the hospital. No one in the power house was hurt. A house two blocks away was wrecked by a flying piece of the wheel 8ft. long and 4ft. wide, which descended in a slanting course, striking the top of the house and tearing out a whole side. A section of the north side of the power house, 25ft. wide, and extending from the ground to the roof, was torn out, and one of the engines and a generator were demolished.

Glow Lamps made in Germany.—The Commission appointed by the Association of German Electric Supply Companies has just published a report on the glow lamp question. A good many tests as to efficiency and life have been made on lamps of various makers, and the result is not very satisfactory. The complaint made by consumers that the lamps have of late been very bad was found to be quite justified. This is mainly put down to the careless sorting, careless marking, low efficiency, and short life of the lamps. Among 70 glow lamps supplied by eight different firms as 16 c.p. lamps with a watt consumption of 3·25 to 3·5 watts per candle, the candle-power ranged from 7·82 to 22·85 candles, and the watt consumption from 2·8 to 6·3 watts per candle. Lamps even of the best makers did not come up to the mark, but the reason for this may be the very low prices which have been brought about by unscrupulous manufacturers who have swamped the market with cheap lamps. The report makes some proposals as to how this state of affairs may be remedied, and as to how lamp manufacturers should be compelled to improve the quality of their lamps.

Water Pipes and Lightning.—M. A. Houdry, in a recent issue of the *Génie Civil*, described a curious case of damage to water pipes, caused by lightning. On October 9th it was found that the water supply of a suburb of Havre was cut off, although the pressure at the distributing point should have been 36 to 44 lbs. per square inch. It was evident that a leak or a stoppage had taken place. Tests showed that it was a leak. The mains were examined, and it was found that a number of lengths of pipe were split. On looking into the matter more closely the pipe was found completely perforated at a spot where the root of a tree was just touching it. Now, on October 9th this very tree had been struck by lightning, and from the point of puncture for a distance of 80 metres almost every length of pipe was split longitudinally. M. Houdry thinks it worth while to call attention to this curious instance, with a view of warning those who are entrusted with the laying of water pipes to keep as far away as possible from trees, not only on account of the damage that may mechanically be done to the pipes by their roots, but on account of the damage that may be done by lightning.

The German Patent Office.—Everyone, says *l'Electricien* in a recent issue, "knows the minute formalities of the Patent Office of the German Empire. The crass Chinese red-tape of the Berlin office is the despair of inventors, and the joy of the patent agent, since the more difficulties there are, the more money flows into his pocket." Applying for a patent, says our contemporary, may only cost 150fr., but its defence may very well cost 1,000fr. But all this is nothing to the case to be mentioned. An electrician applied a few months ago for a German patent. He was informed that the experts entrusted with the examination of patents did not understand his process, did not believe it would work or give the good results he anticipated, and requested him to go to Berlin within two months and show the expert committee the apparatus in working order. The inventor was offered the following alternative. The Patent Office would allow two experts to go to him, and ascertain the actuality of his process—it is needless to say, at the inventor's expense. The electrician in question, not being blessed with too much of this world's wealth, was obliged to decline the visit of the experts from the Berlin Patent Office.

The Rational System of Units.—Referring to recent proposed changes in the system of electromagnetic units, and to the discussion on the Heaviside rational system, the *Electrical World* of New York says:—

"The time would seem to be ripe for the entire subject of rational units and dimensional formulas to be taken up with a view to producing a truly scientific and connected system. This work, of course, is for the savant, and might much better occupy his attention than the creation of further 'practical' units for which there is no need, or, if demanded, might better be left to those who more nearly understand the requirements involved. The fact that such a system would not accord with the units now in use should not deter the work, for it would have its value merely as an exposition of the ideal. In text-books a chapter could be devoted to it, and the student thus taught that the inconsistencies he may find in the accepted systems are not representative of Nature, but come of the limitations of knowledge when the systems were framed, or from the exigencies of practical requirements. Such a chapter would furnish the student's mind with a clearing house for errors, and act as an illustration of the vital necessity for care in the formulation of scientific theory. It is also quite probable that the broad generalisation of scientific ideas which it would represent might direct more attention to higher questions of physical science, as for example, the relation between the various forces of Nature. Nor would it be hopeless to expect that some time such parts of the ideal system as have a practical application will enter into practical use. The teaching of science and the knowledge of scientific methods are becoming more and more general, and we can easily imagine a time when habits of scientific thought will dominate the human mind. Moreover the probable adoption of the metric system by Great Britain will break the spell which has bound the sentiment of her people to illogical systems of units, and, after the first plunge, it may be that she will be the first to welcome, and even advocate further changes, instead of, as would otherwise most probably be the case, rendering futile any hope of international unity.'

Aluminium Solders.—At a recent meeting of the Franklin Institute of America, Mr. J. Richards made some remarks on the above subject. Referring first to the different metallic

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mixtures which have been proposed for soldering aluminium since M. Christofle's first experiments at Paris in 1855, and pointing out the faults of the various alloys, he proceeds to describe his own investigations into the subject. After experimenting about two years he found that an alloy of zinc and tin in certain proportions, containing a little aluminium and some phosphorus, would meet almost every requirement. The alloy was made by fusing together: Aluminium, 1 part; 10 per cent. phosphor-tin, 1 part; zinc, 8 parts; and tin, 32 parts. It was found, however, that on smelting this solder a more fusible alloy liquated away from it, which also was found to solder better than the original mixture. An analysis showed that its composition was very close to that expressed by the formula Sn_4Zn_3. To obtain this solder Mr. Richards used the ingredients in the proportions of 1, 1, 11, 29, instead of 1, 1, 8, 32, as stated above. The percentage composition of the alloys described may be thus compared :—

—	Original solder.	Found in the liquated alloy.	The formula Sn_4Zn_3 calls for	Solder, as now made, contains
Aluminium	2·36	...	...	2·38 } Zinc + aluminium,
Zinc.....	19·04	...	29·3	26·19 } 28·57 per cent.
Tin	78·34	71·65	70·7	71·19
Phosphorus	0·24	...	...	0·24

The Influence of Electromagnetic Waves on the Electrical Conductivity of Tinfoil Grating.—In connection with the results communicated to the Berlin Physical Society in November, 1894, by Herr E. Aschkinass and the Paper of Prof. Mizuno published on p. 186 of our issue of December 6, 1895, the following experiments of Herr H. Haga (*Wied. Ann.*, No. 11, 1895) will be read with interest. Herr Haga used an apparatus giving long oscillations, as recommended by Ebert. The oscillatory discharges were sent through pieces of copper wire, iron wire and tinfoil, but no change in the resistance was observed, though arrangements had been made for measuring changes of $\frac{1}{20}$th per cent. After these negative results the effect of radiation with different wave lengths was tried, the objects being placed at a distance of less than 50cm. (19½in.) Different tinfoil gratings, 0·05 and 0·01mm. thick, pasted on to ebonite frames, and having resistances of 0·478, 3·155, 11·31 and 36·31 ohms, were employed; also a grating of thin iron wire attached to an ebonite frame which had a resistance of 5·504 ohms, also a german-silver wire of 0·578 ohm, and a tinfoil strip of 1·068 ohms The two last resonated with the primary spark, and secondary sparks could be observed between them and a file. In none of these objects could a trace of a change be observed. When, however, the tinfoil grating strips were only fixed, but not pasted to the ebonite frame, the phenomena observed by Aschkinass and by Mizuno appeared, but the strips had to be placed very close to each other. The changes in the resistances were often very large: the resistance of a grating of 6·7 ohms became, after being exposed to radiation from a primary spark, 3·6 ohms, on tapping it became 5·1 ohms and after another exposure it dropped to 3·2 ohms. This grating was immersed in paraffin, and had then a resistance of 7·85 ohms which was reduced by exposure to radiation to 4·75 ohms, and on tapping the grating it rose to 7·6 ohms. The grating had to be shaken very hard to produce this high resistance. In gratings with larger distances between the strips no change in the resistance was ever observed. For instance, a grating of 22 strips, each ¾mm. wide and ¾mm. from each other, after being exposed to radiation kept its original resistance of 11·85 ohms. After these experiments and those of Mizuno already referred to it is clear that the amount of the change in the conductivity of tinfoil gratings, &c., exposed to electromagnetic radiation depends solely upon the distance of the strips from each other.

Transmission of Electric Power for Dock Pumping.—A plant for the transmission of electric power, that will probably prove to be of interest to engineers concerned in dock-pumping machinery, is being arranged at North Shields, for Smith's Dock Company (Limited), under the superintendence of Mr. A. A. C. Swinton. The Dock Company are engaged in the construction of a floating dock, which will be one of the largest ever built. The pumping out of the dock will be effected by eight 18in. centrifugal pumps, coupled direct to eight 60 B.H.P. electric motors. The pumps, which will be of the type with vertical spindles, are to be placed at the bottom of the dock, and the motors, situated on the top of the dock, above the water line, will be coupled to them direct by means of vertical shafts, the weight of the armatures and spindles being supported by ball thrust bearings. The motors are being supplied by Messrs. Scott and Mountain, and the pumps by Messrs. Gwynne. The necessary switches and resistances for starting and stopping the eight motors will be placed together in a cabin on the upper deck of the dock, being thus under the absolute control of a single attendant. For supplying the necessary current for these motors there will be provided, at a distance of about 200 yards from the dock and connected to it by armoured Fowler-Waring cables, a plant consisting of two 314 B.H.P. Belliss engines, coupled direct to two Crompton dynamos, each developing 425 amperes and 500 volts at a speed of about 250 revolutions per minute. The entire plant is intended to be capable of pumping about 16,000 tons of water per hour through a mean head of a little over 18ft., so that it will be possible to raise the dock loaded with a ship of the largest tonnage it can take in the short space of half an hour. It is believed that this will be the shortest space of time ever attained on such a large scale. Eventually this system may be extended to a second floating dock, and also to an already existing graving dock. At present the pumping in the existing floating dock is effected by pumps placed on the dock worked by steam, which is supplied to them from boilers on the shore by means of flexible steam pipes, an arrangement which is for many reasons uneconomical, troublesome, and therefore unsatisfactory. The electric generating plant under construction will suffice for the working of all the three docks, as they will never be required to be worked simultaneously. It is hoped that by adopting this new system there will be considerable saving of fuel effected. This is probably the first instance in which electricity will be applied to the raising of floating docks.

Contemporary Electrical Science.—It is not often that we can record the discovery of a simple law, and when it does happen it appears surprising that it was not discovered before. Such a law is enunciated in a Paper by Robert Lang in *Wiedemann's Annalen*, No. 11, on the dielectric constants of gases and their chemical properties. The specific inductive capacity K of a gas is determined by its valency. If s is the sum of the valencies of the atoms composing the gaseous molecule or the molecular group, then $(K-1)/s = a$ constant $= 123 \times 10^{-6}$ for all gases at normal temperature and pressure. $K-1$ may be called the electrification number, since it represents that portion of the electrostatic strain which is due to the presence of matter. CO_2, N_2O, and CH_4, having the same valencies, have the same values for K. For CO it is smaller, and for C_2H_4 greater, in the proportions of 3:4 and 3:2 respectively. Hydrogen, being far removed from its critical temperature, occupies a slightly anomalous position. Herr Lang gives a very interesting and suggestive theoretical explanation of the new law.——F. Linde discusses the validity of the Clausius-Mossotti formula for specific inductive capacities in the case of liquefied gases, including CO_2, N_2O, Cl, and of vaseline oil, benzol, and toluol. Plotting the calculated and observed values in curves, the latter are all found to curve the wrong way.——The influence of electric waves upon electric conductivity has been investigated by H. Haga. Tinfoil gratings mounted in ebonite frames had their resistance altered as much as 40 per cent. by electric waves proceeding from an induction coil 50cm. off. But the strips had to be very close together (about 0·1mm.), and they must not be stuck on. The original resistance could be very nearly re-established by concussion.——The circular magnetisation of iron wires traversed by electric currents gives rise to strong "extra currents," from which the magnetic susceptibility may be calculated. This was done by I. Klemencic. He found that in soft iron the circular is smaller than the axial susceptibility. On hardening the wire by drawing, the axial susceptibility decreases more quickly than the other. In Bessemer steel the circular considerably exceeds the axial susceptibility.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(*Continued from page 147*).

Graded Charge Governors.—Graduation of charge is now almost exclusively effected by controlling the period of gas admission, the entry of air into the cylinder being the same for all loads. The main objection to the reduction of both gas and air is that it gives an attenuated charge which cannot properly be compressed, and which burns uneconomically and with considerable escape of unburnt gas at the exhaust. On the other hand, although the reduction of the gas alone will produce much less fall in initial pressure, because the bulk of the charge is not so greatly reduced, yet the decrease in richness of the gas, especially at very light loads, leads to such augmented after-burning that much of the gas is still unburned by the end of the working stroke. It is advisable, therefore, to limit this method of control to loads which are not small fractions of full load. It must also be observed that with a certain degree of poorness the uncertainty of ignition is much increased. The graded charge governor is commonly used in gas engines for electric lighting purposes, where great steadiness of speed is required. In the early forms of "Otto-Crossley" engine a graded charge governor was used, the gas valve being controlled by a lever which might be actuated by any one of three cams, each of which opened the gas valve for a different length of time. The principle of construction of most modern governors of this class is not essentially different from this arrangement.

Exhaust Governors.—A quite uncommon mode of governing, met with in some small gas engines, is by means of the exhaust governor. In this the escape of the exhaust gases is checked, when it is desired to omit an explosion; the resulting high back pressure in the cylinder causing the gas and air valves to remain closed.

Exhaust Silencers.—An important adjunct to a gas engine is often some means for reducing the noise of the exhaust. The apparatus which is used must not put any great restraint on the escaping gases, otherwise there will be a wasteful back pressure in the engine. The best conditions are met with where several engines exhaust into one common exhaust main, as at the Belfast electric supply station. One of the simplest forms of silencer is a large cone orifice on the end of the exhaust uptake. This has the effect of gently slowing down the gases and passing them into the air with little shock. A modified form is the silencer recommended by Mr. P. Simon. This is very simply made by longitudinally slitting some six or seven feet of the discharge end of the exhaust pipe, and then forcing the slit open to such an extent that the diameter of the slit at the extreme end is about equal to that of the uncut pipe. The slit may be kept in this shape by iron rings and distance plugs placed at intervals. A common form of silencer is constructed of a wrought-iron cylindrical chamber loosely filled with shingle and placed as a cap on the end of the uptake. Occasionally a cylindrical cap without shingle is used.

Starting Apparatus.—Very small gas engines are usually started by hand, simply by giving the flywheel a turn or two until an explosion takes place. With large engines this practice is not only very dangerous, but the amount of effort required makes it inconvenient. Automatic starting devices may be classified under: (1) explosion starters; (2) compressed gas starters; and (3) mechanical starters.

Explosion Starters.—In modern explosion starters gas and air in explosive proportion are admitted into the cylinder, by means of auxiliary valves or cocks, when the piston is at the middle of its forward stroke. An explosion results, the gases being fired either electrically or by the usual ignition tube; and the engine attains high enough speed for the regular valves to be put into action. In some forms, *e.g.* the "Crossley" starter, a number of auxiliary explosions is allowed to take place before the engine goes into regular action. The "Stockport" starter may be taken as representative of this class, and is shown attached to the cylinder in Fig. 79. To use this apparatus the piston must be brought forward to half-stroke, on the usual "impulse" stroke. The ignition tube must be brought to a bright red heat. In this condition all the valves, except the ignition timing valve, will be closed. On the exhaust cam of the engine there are two parts, side by side, the one causing the exhaust to open during every other back stroke (for regular work), and the other opening the exhaust during every back stroke. The roller of the exhaust lever must now be shifted so as to roll on the latter part of the cam. The inlet valve, A, and outlet valve, B, of the starter must next be opened; and the cock, C, connecting the starter with the gas valve box must also be opened. This will cause a mixture of gas and

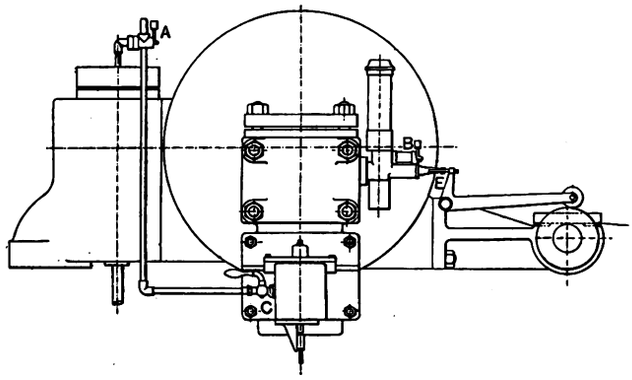

FIG. 79.—"Stockport" Self-Starter.

air to flow slowly through the engine, gradually filling the space behind the piston with an explosive mixture. In a couple of minutes or so an explosion will take place; to be followed by an exhaust stroke; then by another explosion; and so on. When six of these auxiliary explosions have taken place, the extra cocks are closed, the exhaust lever is set to be acted on by the ordinary half of the cam, and the regular valves come into action. Fig. 80 shows an indicator diagram taken during the first and second explosion with the starting apparatus in action.

Compressed Gas Starters.—In early forms of the Otto gas engine the pressure of compressed exhaust gases was used in starting the engine. During the last few strokes, before stopping an engine, the exhaust gases were forced at high pressure into a receiver, where they remained until wanted for

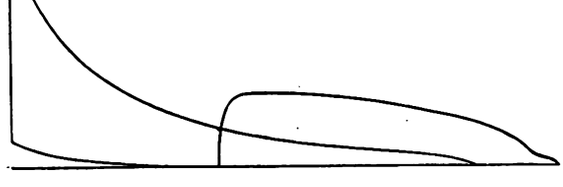

FIG. 80.—Self Starter Diagrams from the "Stockport" Gas Engine.

the next start. Unfortunately, all the gas did not remain; and the leakage was found to be so considerable that the starting impulse could not always be relied on. At a later date it was proposed to make the engine compress an explosive mixture into a receiver; but the danger due to the leakage of such a gas made the plan prohibitive. At the Coatbridge gas engine electric supply station the engines were set in motion by steam derived from the boilers of the gas producer plant. A hand timing valve, by which the regular recurrence of impulses on the engine piston could be controlled, was used.

Mechanical Starters.—In many large gas engine installations the start is made by means of a very small gas engine, which when set in motion is caused to press its flywheel upon the flywheel of the larger engine, and thus to turn the latter

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by friction gear. When the larger engine is in full motion the smaller engine is withdrawn and stopped. In electric supply stations where continuous current is used, the engines may be started by running the electric generators temporarily as motors, by means of power derived from the 'bus bars of the switchboard; or, where secondary batteries are available, the current from these may be used to drive the electric motors. This mode of starting is employed at the Belfast electric supply station. The machines are ordinarily shunt-wound, but during the start they are separately excited from the storage cells. The automatic switch is put open at the start, and a gradually lowering resistance is placed in the gap of the open switch. This sends a gradually increasing current to the dynamo running as a motor; and when the engine has given one or two explosions the starting current is cut off, and the engine is run up to speed, the volts being regulated by a resistance in the field circuit, which is still separately excited. When the proper volts have been obtained, the automatic switch may be thrown over to close the circuit and put the dynamo in parallel with the cells. The field coils are then removed from the cell circuit and coupled in simple shunt to the machine.

Cycles other than the Otto.

At a time when every gas engine of importance, and well-nigh every other gas engine, is working on the Otto cycle, it would be inadvisable to devote much space to other cycles. Yet in these there is considerable theoretical interest now, and in the near future there may not improbably be a revival of the practical importance of those types of gas engines which are constructed to work on cycles other than that of Otto.

The Atkinson Cycle.—A genuinely scientific attempt to improve the economy of the gas engine, by modifications of the Otto cycle, was that made by Mr. Atkinson in the cycle which he has employed in his "Differential" and "Cycle" gas engines. It is unnecessary here to describe the details of construction of either of these unfortunately almost obsolete engines. Suffice it to say that both of them were designed to produce a more rapid and extensive expansion of the working substance during the working stroke, as compared with the period and extent of the other strokes. The cycle was as follows: (1) During the first stroke gas and air were drawn into the cylinder, the stroke being comparatively short; (2) during the next, or first return stroke, these gases were compressed, this stroke being somewhat shorter than the first one; the ignition now took place, and then (3) the working stroke of some two or three times the length of the charging stroke ensued; and finally, completing the cycle, (4) the exhaust stroke drove the products of combustion almost completely from the cylinder. For example, in one of the "Cycle" engines the length of the four strokes were respectively 6·3in., 5·03in., 11·3in., and 12·43in. The effect of this considerably augmented expansion of the hot gases is seen in the following comparison between the distribution of heat in an "Otto" and in an "Atkinson" engine. The data are taken from the published results of the Society of Arts trials of gas engines in 1888-9.

Distribution of heat.	"Otto" cycle. Per cent.	"Atkinson" cycle. Per cent.
Heat utilised in indicated work.....	21·2	22·8
Heat absorbed by jacket.....	43·2	27·0
Heat otherwise wasted	35·6	50·2
	100·0	100·0

This Table forcibly brings out the fact that an attempt to recover heat from the water jacket is apt to result in augmented exhaust waste. Mr. Atkinson has succeeded in preventing 37·5 per cent. of the Otto-jacket heat from going into the jacket; but, of this heat thus saved, he has made a present of 90 per cent. to the exhaust and only 10 per cent. to the useful work. Nevertheless, the improvement is a decided one, and it is based upon a sound principle that will doubtless, in time, be further developed.

The Griffin Cycle.—A six-stroke cycle was adopted in the "Griffin" engine, made by Messrs. Dick, Kerr and Co. The main feature of this cycle was the interception of two complete strokes between the exhaust and the charging stroke of the ordinary Otto cycle. Otherwise the six-stroke cycle was not different from that of Otto. The purpose of this entire idle revolution was to draw a charge of fresh air into the cylinder, and to reject along with it the residual products of combustion. This is known as a *scavenging charge*. Its effect is twofold; firstly, to cleanse the inside of the cylinder, thus enabling a richer explosive charge to act on the piston; and secondly, to cool the cylinder walls. Working on this cycle, the gas engine is found to run very cool and to be capable of making unusually long runs. The defect of the cycle, when it is applied to only one end of the cylinder, is the great interval between the impulses, there being only one explosion during every three revolutions at full load. This defect is usually remedied in the "Griffin" engines, by making those engines double acting. In this case the following represents the distribution of the two cycles:—

Stroke.	Crank end.	Back end.
First forward (*i.e.*, *towards crank*).	Compression of gas and air.	Drawing in air.
First backward.	Ignition and expansion of explosive charge.	Driving out air and residual waste gas.
Second forward.	Exhaust.	Drawing in gas and air.
Second backward.	Drawing in air.	Compression of gas and air.
Third forward.	Driving out air and residual waste gas.	Ignition and expansion of explosive charge.
Third backward.	Drawing in gas and air.	Exhaust.

"Motor and Pump" Cycles.—A numerous class of gas engines has been constructed to work upon what may be styled the "motor and pump" type of cycle. In these engines the gas and air are drawn into a cylinder separate from the motor cylinder, and are usually there compressed, before being passed into the motor cylinder for explosion and ultimate exhaust. The direct advantage of this arrangement is that an explosion can be effected once during every revolution, since the first half of the Otto cycle can be made simultaneous (in the pump) with the second half (in the motor). The first practical example of this class was the Clerk gas engine, with the slight modification that the compression took place in the motor cylinder. In the Clerk engine gas and air were first drawn into the pump cylinder; but during a later part of the stroke of the pump piston, only air. On the opening of the communication between the two cylinders, the contents of the pump cylinder were forced into the motor cylinder, driving from out the latter the products of combustion which had remained in it. It was supposed that the various gases would be so stratified that the explosive charge would drive out the waste gas without the escape of any gaseous fuel into the exhaust pipe; but in reality a good deal of gas was thus lost. The return stroke of the motor piston was completed during the compression of the explosive charge in the motor cylinder (the exhaust having been closed at half-return-stroke); and during the next forward stroke the ignition and expansion of the charge occurred. In the more modern engines worked on the "motor and pump" cycle, such as the early "Stockport" engines, the charge is fully compressed in the pump and is delivered in a compressed state to the motor cylinder just before ignition.

Rotatory Gas Engines.—The existence of a cycle in a gas engine is the cause of two of its chief defects: (1) the great variation of temperature of the different parts of the cylinder; and (2) the enormous variation in the useful effort exerted by the engine. Both of these defects would be removed if a gas engine could be made rotatory in its action, as in a water or steam turbine. What is required is that the expansive force of the igniting gas should act continuously—or at most by a quick succession of impulses—upon rotating vanes or curved surfaces. Passing from one series of vanes to another, the gas would gradually impart its energy to the rotating parts; but each particular

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vane would be at a constant, or nearly constant temperature, and would exert as nearly constant an effort. The only drawback at the present time is the practical impossibility of finding a material suitable for such vanes; but the problem might be simplified if we were to be content to have a large clearance space between the vanes and their chamber, for then they might be made of some refractory material such as is used for furnaces at very high temperature. In fine, it will not be until we work the gases in a gas engine at furnace temperatures, and permit of the engine itself becoming a furnace, that we can realise the best part of the available energy in an explosive charge of gas and air, or oxygen.

(To be continued.)

CROMPTON-D'ARSONVAL GALVANOMETER.

A d'Arsonval type of galvanometer has just been brought out by Mr. Crompton which embodies many valuable improvements suggested by his long experience with this class of instrument.

The base of the galvanometer is of solid brass, insulated and levelled by means of ebonite-headed screws, the heads

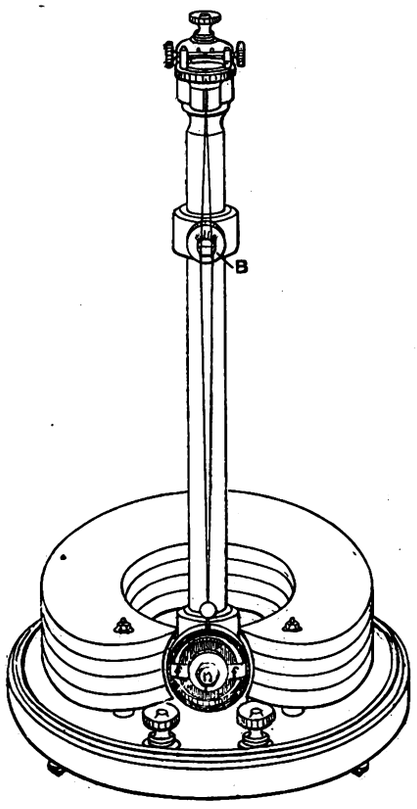

FIG. 1.—Front Perspective View of Galvanometer, with Case removed.

having the section of an inverted pyramid with sharp steps easily wiped at any time and affording exceedingly high insulation. The permanent magnet, it will be seen from Figs. 1 and 2, is of nearly true horseshoe shape, and is composed of four sections, which are secured to the base by three holding-down bolts.

The connecting wires are brought to the two terminals shown in Fig. 1 in the front of the instrument, and the circuit is taken thence to the bifilar attachment by a lead running up inside the central pillar. The details of the bifilar attachment at the top of the central pillar are given in Fig. 3. The attachment takes the form of two conical pins, P P, revolving in pillars, *p p*, which are diametrically placed upon an ebonite sleeve, E, having a rim with milled surface, and free to turn in the collar of the projecting arm A cast upon the main sleeve S encircling the cap C of the pillar. The sleeve S is free to revolve around the cap, and when properly adjusted is fixed at the side by the set screw *s*; the cap itself is capable of being raised and lowered by the milled nut N, shown at the top, and is prevented from turning by a set pin working in a slot in the pillar. The suspension wires, which are of phosphor-bronze, are secured to the pins by being passed through holes and plugged.

The sensibility and period of the instrument is altered by means of the device shown at B in Fig. 1. This consists of a thin slip of insulating material, which is carried by an arm attached to a sleeve which is free to move vertically or radially on the central pillar, and which is fixed, when properly set, by a screw at the side. Using the full sensibility of the galvanometer, this slip would lie parallel with the bifilar suspension; by setting the slip at right angles to the bifilar suspension, and raising or lowering the sleeve, both sensibility and period may be adjusted to requirements.

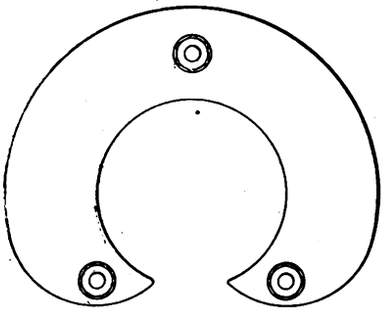

FIG. 2.—Plan of Magnet.

The coil is of copper wire, and is of the ring type. The utmost care has been taken to free the copper, silk, and other materials used, from all magnetic particles. The extreme importance of this has been pointed out by Prof. Ayrton, and all makers of galvanometers of this type are indebted to him for this. The coil is attached to the two hooks at the ends of the suspending wires by two metallic loops. The removal of one coil and the substitution of another is thus only a matter of a moment or two. Several coils can be supplied with each instrument; these weigh from 6 to 10 grammes, and have resistances ranging from 50 to 1,500 ohms. The coil is clutched, when travelling, between two light springs tipped with rubber. The front spring is shown at *f* in Fig. 1, also the nut *n* by which the springs are bent round on to the coil.

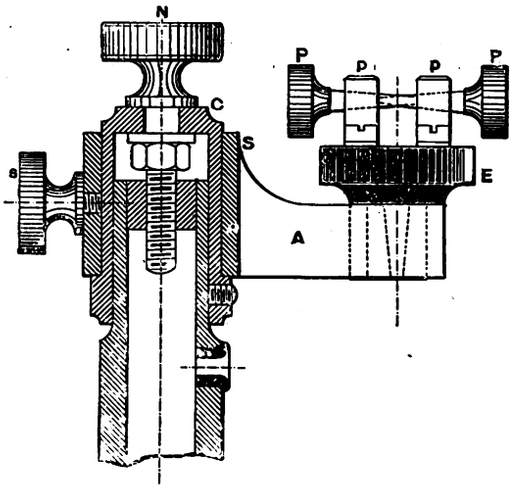

FIG. 3.—Bifilar Attachment. Sectional Elevation.

The whole instrument is protected by a brass guard ring. A portion of the front of this is cut away, and purest plate glass of thin section substituted. In some instances the glass screen is partially cut away, and a disc of microscopic film glass about $\frac{1}{100}$th of an inch thick is cemented over the opening. The whole is surmounted by a French glass shade.

The deflection ordinarily attainable is 10 scale divisions at a distance of 2,000 scale divisions, with the terminals of the instrument connected in shunt to $\frac{1}{100}$th of an ohm in series with 20,000 ohms, and a secondary cell, the P.D. over the $\frac{1}{100}$th of an ohm corresponding therefore to one-millionth of a volt, the resistance of the coil and its suspension being about 1,500 ohms.

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THE BIRMINGHAM TECHNICAL SCHOOL.

The Technical Instruction and Local Taxation Acts of 1889 and 1890 have placed at the disposal of the municipal authorities throughout the country large sums of money, which, in most cases, have been expended in supporting the technical education movement; and the result has been that a great number of well-equipped institutions have been brought into existence during the last four years. The Birmingham Municipal Technical School, which is to be formally opened to-day by the Duke of Devonshire, is probably the finest of these new

FIG. 1.—Exterior View.

institutions existing in the country at the present moment. These municipal schools correspond in many respects with the large polytechnics with which Londoners are familiar, and of which there are now no less than eight in existence within the metropolitan area. But, although there are many points of resemblance, there are considerable differences too. While each of the London polytechnics maintains numerous classes in science and its technical applications, it also performs a similar function with respect to classes in music

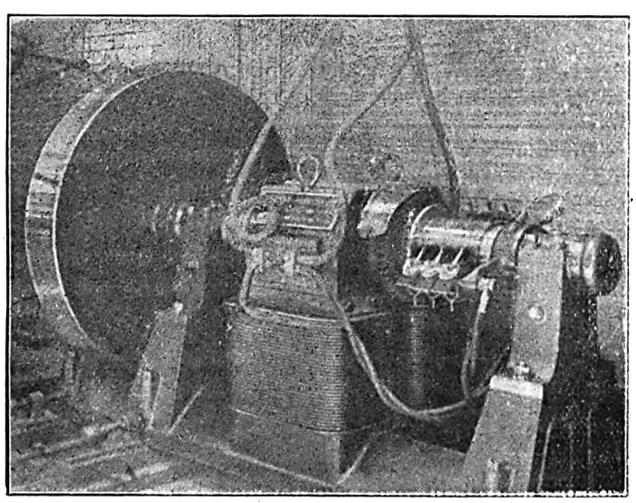

FIG. 2.—One of the Dynamos.

and in art, and with respect to classes in languages and commercial subjects. Moreover, in addition to all this, the athletic, recreative, and social functions of a London polytechnic are a most important part of its action. In the newer ones, it is true, less prominence is given to this side of the work, but it is notorious that in the older ones the social and recreative elements are relatively the most important of all. In Birmingham these different functions are not all undertaken by any one institution, and the purpose of the present Technical School is solely to provide instruction in science and its useful applications. Students in art subjects are already well provided for by the Municipal School of Art, which has been in existence for many years, and has earned a high and well-deserved reputation. Similarly, the Birmingham and Midland Institute provides high-class instruction in music and languages, and also performs many of the popular and social functions of a London polytechnic. Indeed, until four years since, this Institute possessed in addition a large number of science classes, all of which were transferred to the municipal authorities after the passing of the Local Taxation Act in 1890; and it was these classes which formed the nucleus of the present Technical School. While, therefore, the tendency in

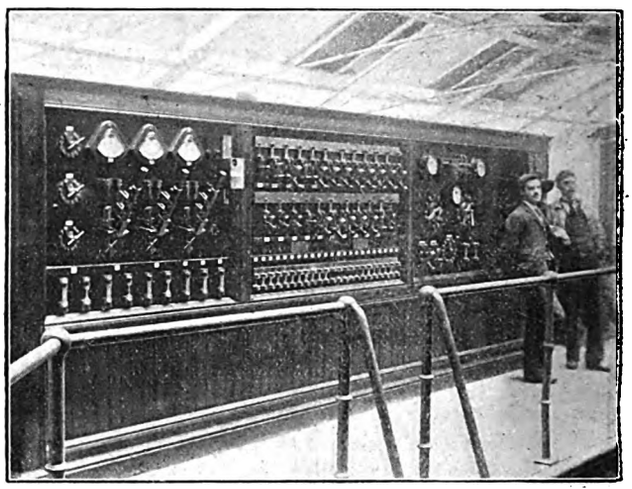

FIG. 3.—The Switchboard.

London has been rather towards the establishment of several institutions, each claiming all subjects as being within its scope; the tendency in Birmingham has been towards specialisation. The portion of the taxation money handed over to the Corporation for the purposes of technical instruction amounts in the case of Birmingham to about £10,000 every year; and the municipal authorities have wisely decided to devote this money towards the establishment and proper equipment of a single institution, rather than divide it among

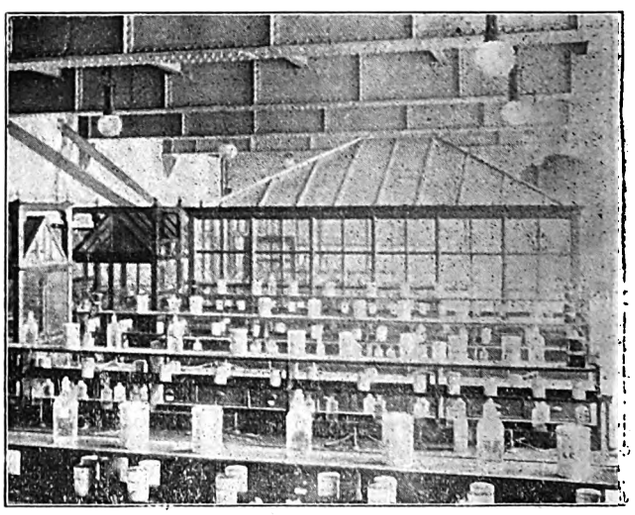

FIG. 4.—Metallurgical Laboratory.

a number of smaller schools placed in different parts of the town, and necessarily less completely equipped. The money thus provided, together with students' fees and the annual grants from the Science and Art Department, amounts in all to an income of about £12,000 per year available for the School, without resorting to the local rates, and means are thus provided for establishing and maintaining an institution of the first rank. The capital sum spent upon land, buildings, fittings, and plant of the new School amounts to £84,000,

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including a sum of £6,000 for the electric lighting and power plant.

To electricians the most interesting feature of the School is the electrical installation. The building, of which an outside view is shown in Fig. 1, is very large, occupying an area 210ft. long by 120ft. wide. It is six stories high, its total floor area is 103,000 sq. ft., and it contains 134 rooms besides staircases, corridors and lavatories. The lighting is electrical throughout, and the machinery in the various workshops is electrically driven by 15 motors of various sizes, the aggregate power of which is 46 H.P. The lighting involves the use of over 800 glow lamps and 80 arcs. The motive power in the engine room is provided by three

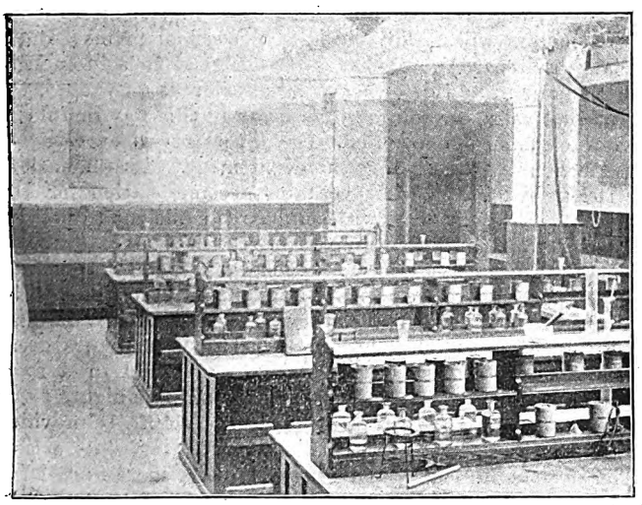

FIG. 5.—Electro-Metallurgical Laboratory.

Tangye gas engines running at 160 revolutions, and each capable of continuously generating 53 brake horse-power at that speed. Two heavy flywheels, 7ft. in diameter and 10in. wide, are attached to each engine. The dynamos are compound wound, made by Thos. Parker, Limited, of Wolverhampton, and can each generate 350 amperes at 113 volts, when running at 900 revolutions. To ensure steady running each dynamo is provided with three bearings, and a very massive flywheel 4ft. in diameter, having a solid rim 8in. by 8in. (see Fig 2). Compound

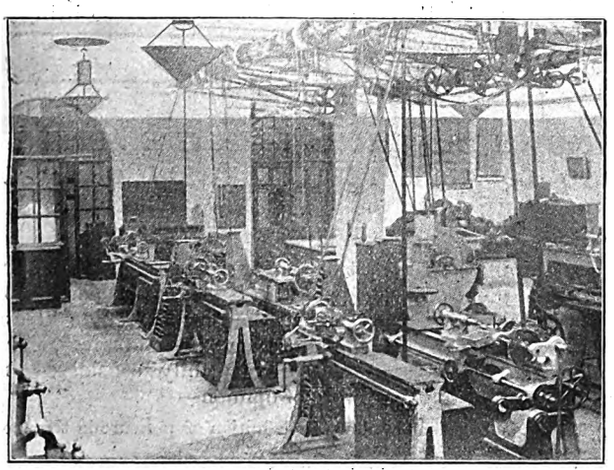

FIG. 6.—Iron Shop.

iron and leather pulleys, specially designed by the consulting engineers to prevent belt slip, are used with each dynamo.

Above the dynamos is a gallery carrying a handsome switchboard. This consists of four slate panels in a teak frame, and is shown in Fig. 3. The first panel contains the main dynamo switches and ammeters, a Kelvin voltmeter, and the regulating resistance switches in the shunt circuit of each machine. Each main switch interlocks with a smaller switch by means of which special connections are made enabling the three dynamos to be run in parallel without risk of reversal. The second panel of the board contains the switches and fuses for the motor and lighting circuits, and the third carries the charge and discharge ammeters and the regulating switches for the accumulator circuits, besides two other regulating switches used with a motor transformer in charging the cells. The fourth panel of the board carries two recording instruments by Richard Frères, used to continuously register the pressure and current in the accumulator circuit. At the end of the gallery is a four-unit motor transformer converting from 110 volts to 40 volts, and used to "boost" up the voltage to the extent necessary to charge the 58 "E.P.S." cells provided as the storage plant. These

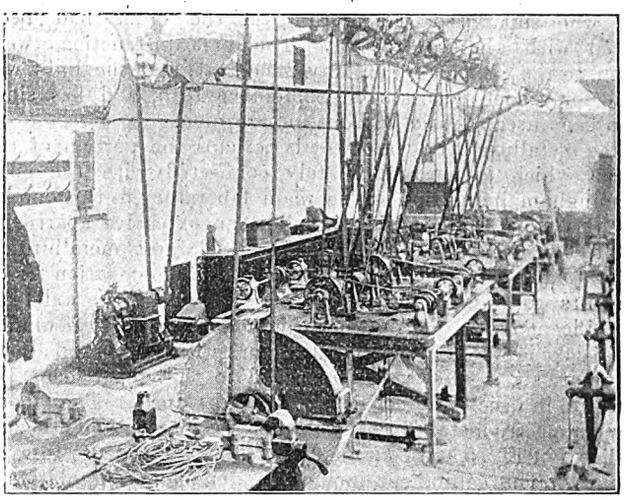

FIG. 7.—Brass Shop.

cells are of the central station type, in lead boxes, and each contains 34 plates. They are placed in an apartment closely adjacent to the engine room. A special change-over switch is provided on the switchboard for connecting the motor transformer with leads to the electrical department of the school, so that when not wanted for charging purposes it can be used for supplying current to the dynamo room at a voltage differing from that of the lighting circuit. The storage capacity of the accumulators is sufficient to light the corridors, staircases

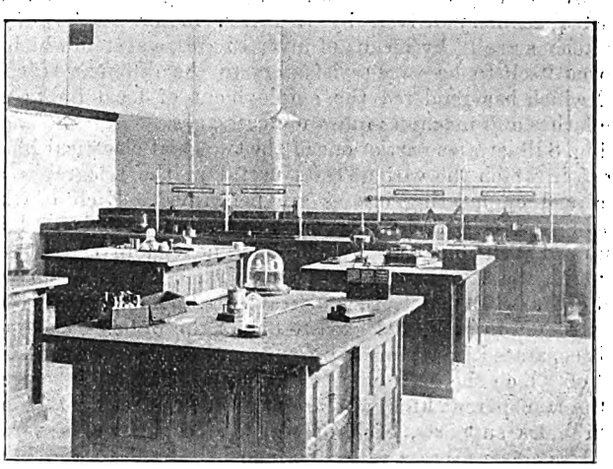

FIG. 8.—One of the Electrical Laboratories.

and certain other lights after the engines have stopped, and to take the day load.

The glow lamps are of the obscured type made by the Edison-Swan Company, and are of three different candle-powers, viz., 8 c.p., 16 c.p. and 50 c.p. The arc lights are of Crompton's make. Some are of the ordinary type, with diffusing globes, but the majority are of their inverted type, with the lower carbon as positive, throwing all the light up to the ceiling for subsequent diffusion downwards.

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These inverted arcs, which were introduced at the suggestion of the principal of the School, have proved very suitable for the workshops and drawing offices. In fact, the conditions which usually obtain in an institution of this kind are specially favourable to the success of this particular system of lighting. The walls and ceiling can easily be kept white, and the height of the room is as a rule about that which gives the best effect. Circumstances have hence conspired to make this method of lighting one of the most striking and successful features of the installation. The motors used in the workshops were all supplied by Messrs. Crompton. The contractors for the entire installation were Messrs. B. Verity and Sons, and the consulting engineers were Messrs. Henry Lea and Thornbery, of Birmingham, who drew up the specifications and plans, and who supervised the work after the order had been placed with the contractors. The first instructions were given to the contractors on May 22nd last, and the light was used for school purposes on September 16th, and has since then been used nightly without interruption.

The metallurgical department is perhaps the portion of the school which is most intimately connected with the chief Birmingham industries. The main laboratory in this department is illustrated in Fig. 4, and is an extensive apartment 100ft. long by 45ft. wide. It is the largest metallurgical laboratory in the country, and contains accommodation for 80 students working at one time. Alongside one of the walls is a magnificent range of 34 furnaces, in addition to 28 gas muffles and 6 coke muffles for experimental work with metals and alloys. There are six smaller rooms attached to this department, the students in which number nearly 200 individuals. The laboratory for electro-metallurgy and for metal colouring and bronzing is shown in Fig. 5 and contains benches for 50 students to work at once. The equipment includes a dynamo, accumulators, a large number of depositing vats, and a very complete system of electrical connections between these and the students' benches. The chief laboratory covers an area of 56ft. by 30ft., and there are four smaller rooms attached. There are eight well-equipped workshops for plumbing, iron and steel work, brassfounding, carpentry, pattern making, metal plate work and electrical instrument making. As many as 525 students attend these workshops every week, and of these nearly 200 work in the iron and steel shop, which is illustrated in Fig. 6. The lathes and machines here are driven by a 7 H.P. Crompton motor, and the area of the shop, including the adjoining smithy, amounts to 3,500 sq. ft. The brass shop is shown in Fig. 7, and is abundantly equipped with lathes and other machinery driven by a 4 H.P. motor. Most of the workshops are lit by means of inverted arcs, a system which has proved itself to be very satisfactory to the different teachers, and which has rendered the employment of local lights near the lathes and machines quite unnecessary.

Fig. 8 illustrates part of one of the two chief electrical laboratories in which the various tests useful in the telegraphy and electrical engineering classes are performed. Each of these laboratories is 44ft. long by 22ft. wide, and is well fitted and equipped with apparatus. The chief novelty in the arrangements of the laboratory is a special bench for galvanometers and other delicate reflecting instruments. This is very solidly constructed in teak, and fixed to one of the walls of the room. It is separated by a gangway from another bench parallel to it, and on which the galvanometer scales are fixed. These are all of the transparent kind, and are suspended in suitable frames from brass supports, each of which is capable of a vertical adjustment on a brass pillar permanently fixed to the bench. The measuring apparatus used by the students is arranged on the bench in front of the scales, on the side remote from the reflecting instruments. The light which provides the ray is produced by a glow lamp fixed on the galvanometer bench, and the ray is thrown on to the reflecting instrument by a suitably inclined mirror.

The dynamo and battery rooms are conveniently near the laboratories. The battery room contains 40 small cells discharging at 7 amperes, and 12 larger ones, from each of which 120 amperes can be obtained. The dynamo room is as yet only partially equipped, some of the machines intended for it being involved in the recent disastrous fire at the Crompton works, just after they had been tested preparatory to sending them to their destination. The equipment, when complete, will include two 7 H.P. continuous-current machines, belt-coupled through shafting, one dynamo being shunt wound and the other compound, the series coil being led to independent terminals. There will also be two direct-coupled 3 H.P. machines, one series and the other shunt wound, with the latter suspended in a cradle in such a manner that the torque transmitted by one machine to the other can be registered while running. In addition to these there will be four machines of 5 H.P. each, forming two pairs of machines, each consisting of a continuous-current motor direct coupled to an alternator, and the arrangements being such that the two pairs of machines can be either run separately or coupled together with any required phase difference between the alternators. All the motors will be driven from the school mains from a special switchboard which has been designed so as to enable each machine to be run either as a motor or as a dynamo, the educational value of each machine being in this way doubled.

In the chemical department the laboratory is even larger than that in the metallurgical department. Its dimensions are 104ft. by 57ft., and it contains accommodation for 104 students working at once, with cupboards sufficient to provide one each for six times that number of students.

The drawing classes at the school are remarkably well attended, since there are over 600 students in these alone. The three rooms for the machine drawing classes occupy an area measuring 46ft. by 50ft., and are used on five nights every week. The geometrical drawing classes are held in a room measuring 60ft. by 20ft., and this is also used five nights every week. A separate room measuring 60ft. by 40ft. is provided for the drawing classes in the subject of building construction.

The students in the school already number more than 1,700 individuals, and the total number of entries in the various classes this session exceeds 3,500. These figures are exceeded by the London polytechnics, but it must be remembered that in most cases only a small proportion of the students at these institutions attend the science and technical classes, whereas the Birmingham School confines its work entirely to such matters. The number of entries in some of the chief groups of subjects are as follows: drawing classes, 664; chemistry, 623; physics and applied electricity, 545; workshops, 525; metallurgy and electro-metallurgy, 474; engineering lectures, 450. The three chief departments of the school, viz., the chemical, metallurgical and electrical departments, are respectively directed by Mr. C. J. Woodward, B.Sc., Mr. A. H. Hiorns and Dr. W. E. Sumpner, the last-named also being the Principal of the School.

REPORT OF THE SPECIAL COMMITTEE APPOINTED TO CONSIDER THE DEFINITION OF "LOW PRESSURE."

The following is the report of the Committee appointed by the Board of Trade to consider whether it was desirable that the limit of low pressure, as defined by the Board of Trade Electric Lighting Regulations for the protection of public safety, should be altered. The Committee, having duly considered the question referred to them, were of opinion—

(I.) That it is expedient to alter the definition of pressure in the above-mentioned Regulations as follows, viz.:—

Firstly, omit the following words—"pressure on any alternating current system being taken to be the equivalent of pressure on a continuous current system when it produces an equal heating effect if applied to the ends of a thin stretched wire or carbon filament."

Secondly, in place of paragraphs (*a*), (*b*), and (*c*) substitute the following, viz.:—(*a*) Where the conditions of the supply are such that the pressure may at any time exceed 500 volts if continuous, or 250 volts if alternating, but cannot exceed 3,000 volts whether continuous or alternating, the supply shall be deemed a high-pressure supply. (*b*) To be worded as existing. (*c*) Omitting "or the equivalent of 3,000 volts."

(II.) The Committee further advise that the following amendments should be made in the proposed Regulations, viz.:—

(*a*) Regulation 1 to read as follows:—"Save as hereinafter provided, the pressure of a supply delivered to any consumer shall not exceed 250 volts at any pair of terminals."

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(*b*) Regulation 31 add: "No such conductor shall be at a higher pressure than 300 volts from earth."

(*c*) Regulation as to Supply, No. 6, omit the words "or less than 45 volts if continuous, or the equivalents thereof respectively if alternating." In place of "150 volts" read "250 volts." Add at the end the following proviso—viz., "Provided that no change shall be made in the pressure of the supply to any consumer in consequence of the issue of these Regulations except with his consent."

(III.) With reference to the suggested alteration to Regulation as to Safety, No. 31, the Committee are of opinion that to enable the use of 500 volts continuous pressure between the outer conductors of a three or five-wire system with bare conductors laid in conduits, the Board of Trade may give a provisional sanction to an earth connection being applied to one point of the middle conductor in any case in which they are satisfied that a high insulation is maintained on all other points of the system, and that suitable and sufficient means are provided for the immediate detection, localisation and correction of any fault of insulation.

(IV.) The Committee consider that in making the above suggestions they have indicated clearly how, in their opinion, the question of limitation of pressure should be treated to adequately secure the safety of the public, and to meet the requirements of Electric Lighting Undertakers and the convenience of their customers. They do not, however, wish to insist upon the exact wording suggested, and would leave the final drafting of these amendments, and any consequential verbal amendments of the Draft Regulations, in the hands of the Board of Trade.

(Signed) KELVIN, W. H. PREECE, P. CARDEW.

8, Richmond Terrace, Whitehall, December 2, 1895.

THE BEHAVIOUR OF TRANSFORMERS UNDER THE INFLUENCE OF ALTERNATING CURRENTS OF DIFFERENT WAVE FORMS.*

BY DR. G. ROESSLER.

(Concluded from page 187.)

The Difference in the Primary Currents.

The investigation with the transformer has shown that for constant R.M.S. of the primary potential difference the R.M.S. current is smaller with pointed than with flat curves. The general explanation of this difference is not easy, as the relation between the variations of potential difference and current, as above shown, are very complicated; this explanation requires a general method of calculating the current from the potential difference. In what follows this is investigated on the assumption that the secondary circuit of the transformer is open. The no-load current can be most easily calculated by first obtaining B_{max}. We then have

$$B_{max}=\frac{c}{4 n_1 \nu s}\sqrt{M(E p_1^2)}.$$

If we then suppose that the demagnetisation of the iron by the action of the alternating currents at 41 ∿ was so conducted that we could measure the magnetising force H_{max} which B_{max} requires, by magnetometer or by ballistic galvanometer, we should have the equation

$$H_{max}=0{\cdot}4\pi\frac{n_1}{l}J_{max},$$

from which, in closed magnetic circuit transformers, J_{max} could be calculated. Hence $\sqrt{M(J_0^2)}$ can be obtained from the relation

$$K=\frac{\sqrt{M J_0^2}}{J_{max}},$$

which, like *c*, depends only on the shape of the current curve, and which, for the current curves of the two machines, has the value K=0·515 (Ganz machine), and K=0·546 (Wechsler machine). If this conclusion be correct, the great difference of the no-load currents with the two machines can be at once explained, since B_{max} is proportional to *c*; hence for peaked potential curves there are much smaller values of H_{max} and J_{max}, and thus also of $\sqrt{M(J_0^2)}$, than for flat curves, and since also K is smaller for pointed than for flat curves.

To decide the question of the calculation of $\sqrt{M(J_0^2)}$ from these simple considerations, the magnetising curves of the transformer iron were taken with the ballistic galvanometer, and also from the values of $\sqrt{M(E p_1^2)}$ and the corresponding values of $\sqrt{M(J_0^2)}$, from Table VI., by the aid of the formulæ

$$B_{max}=\frac{c\sqrt{M(E p_1^2)}}{4 n_1 \nu s},$$

and

$$H_{max}=0{\cdot}4\pi\frac{n_1}{l}\frac{\sqrt{M(J_0^2)}}{K},$$

from which B_{max} and H_{max} were calculated. If the above method of calculation of $\sqrt{M(J_0^2)}$ from $\sqrt{M(E p_1)^2}$ is exact, the curves giving $B_{max}=f(H_{max})$ from the measurements with both machines must agree among themselves, and with the curve obtained by the ballistic galvanometer measurements.

For the ballistic galvanometer measurements the transformer was magnetised by accumulators connected to the primary, while the ballistic galvanometer was connected to the secondary. In order to get accurate absolute values of B_{max}, the reading of the galvanometer was checked carefully by a Reichsanstalt standard. The value of the "constant" is calculated thus: A current $J=1{\cdot}292\times10^{-6}$ amperes, given by the standard, gave a reading *a*, such that $\tan a=0{\cdot}04524$; also $c=\frac{J}{\tan a}=2{\cdot}857\times10^{-5}$. The periodic time was T=11·97sec. The log. dec. λ was so small that $e\frac{\lambda}{\pi}\tan^{-1}\frac{\pi}{\lambda}$ never differed ½ per cent. from unity. Hence for a momentary discharge through the ballistic galvanometer the quantity

$$Q=c\,.\,\frac{T}{n}a$$
$$=2{\cdot}857\times10^{-5}\,\frac{11{\cdot}972}{\pi}a.$$

If a reading *a* is produced by suddenly reversing the primary current J, then the magnetic induction

$$B=\frac{w\,Q\,10^8}{2 s n_2}$$
$$=\frac{w}{2\times20{\cdot}19\times265},$$

in which *w* is the total resistance in the galvanometer circuit; hence, finally,

$$B=20{\cdot}36\,w\,.\,a.$$

The measurements gave the following magnetisation curve:—

Table VII.—*Magnetisation Curve of the Transformer, Measured with the Ballistic Galvanometer.*

H.	B.	H.	B.	H.	B.
0·770	116·3	7·308	9,138	16·92	13,780
1·532	624·4	8·232	9,934	18·52	14,090
3·330	3,932	11·52	11,930	21·34	14,640
4·800	6,502	14·26	12,880	...	...

Also, the calculations of B_{max} and H_{max} from the values of $\sqrt{M(E p_1^2)}$, and $\sqrt{M(J_0^2)}$ from Table VI., give the results:—

Table VIII.—*Magnetisation Curve of the Transformer, Deduced from the Alternating-Current Measurements.*

Ganz machine.		Wechsler machine.	
H_{max}.	B_{max}.	H_{max}.	B_{max}.
4·012	2,839	4·056	3,855
5·136	3,982	5·566	5,873
6·246	5,217	7·281	7,830
7·635	6,742	9·098	9,410
9·142	8,109	13·12	11,620
11·54	9,477	17·98	13,280
15·18	10,940	30·94	15,530
19·03	12,320	...	...
24·33	12,910	...	...
28·96	13,590	...	...
32·95	14,150	...	...

Fig. 23 shows this graphically. The upper curve gives the result of the ballistic measurements, the middle the results of the measurements with the Wechsler machine, and the lower those for the Ganz machine. The three curves do not lie together, but differ somewhat widely.

For this result there are several reasons. First, it must be remembered that the same induction B in the iron, if produced by alternating currents, requires a greater current than with continuous currents, since eddies are produced. These variable currents in the iron increase the primary current, for the same reason that it is increased by short-circuiting the secondary. The magnetising curves measured with alternating currents must therefore fall below those with direct currents. The difference is even greater than shown by the above measurements, since with the ballistic galvanometer only those lines are measured which are produced in the secondary when the primary is excited, whereas in the alternating measurements the total number of lines cut by the primary itself is measured. Thus, on account of magnetic leakage, the induction measured by the ballistic galvanometer is about 2·5 per cent. too small.

* "Das Verhalten von Transformatoren unter den Einflusse von Wechselströmen verschiedenen periodischen Verlaufs." A Paper read at the third annual meeting of the Verband Deutscher Electrotechniker, Munich July 6, 1895.

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The difference between the two magnetisation curves, measured with the alternators, is explained by the difference in the intensity of the eddy currents. In an earlier part of the Paper it is shown, theoretically and experimentally, that peaked potential difference curves for equal values of B_{max} give greater eddy current loss than flat curves. The facts shown above, that alternating currents with peaked potential difference curve require a greater value of J_{max} to produce a given value of B_{max} than steady currents, and than flat curves, thus hold universally.

There still remains the question whether the explanation of the observed differences is due to so-called magnetic viscosity. By this term, as is well-known, Ewing has denoted that property of the iron which causes it to take a definite time to take up the magnetisation induced by the magnetising force. Since, in the present case, it takes about $\frac{1}{100}$th of a second for the current to alter from its zero to its maximum value, it is possible that the magnetisation does not reach its full value in so short a time, and that since the given value of $\sqrt{M(E p_1^2)}$ assumes a definite value of B_{max}, the current J_{max} required is greater than that given by the magnetisation curve. If the influence of magnetic viscosity were very great, the difference between the ballistic magnetisation curve and all alternate-current curves would be nearly the same. The difference of these curves among themselves, however, is almost as great as their variation from the ballistic curve. This agrees with Ewing's observations that the viscosity for ordinary periodicities is not important. The correction for magnetic leakage on the ballistic measurements does not affect this conclusion.

The results given for the no-load current J_0 can be got at once from the primary current J_1, when loaded, since it is approximately

$$\sqrt{M(J_1^2)} = \sqrt{M(J_0^2)} + \frac{n_1}{n_2}\sqrt{M(J_2^2)}$$

In general the primary current cannot be so simply calculated from the primary potential difference as given above on account

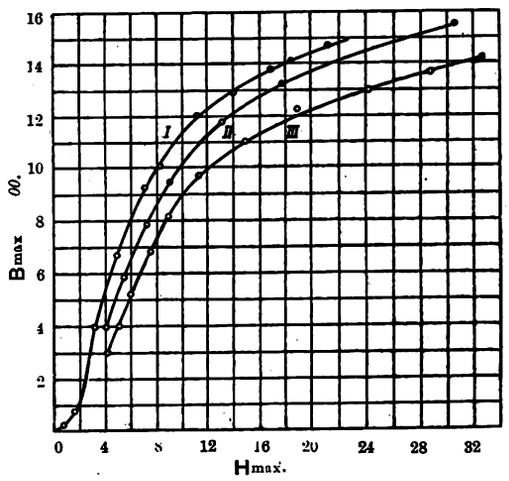

FIG. 23.—Magnetisation Curves. I. Ballistic Galvanometer. II. Wechsler Machine. III. Ganz Machine.

of the influence of eddy currents. The diminution of B_{max}, for peaked forms of potential difference curve, as compared with flat curves, is accounted for in the foregoing extreme case by the increase of J_{max} by eddy currents, so that in general *for equal* $\sqrt{M(E p_1^2)}$, *the current* $\sqrt{M(J_1^2)}$ *is always smaller for pointed than for flat potential difference curves.*

The consideration of eddy currents by the predetermination of $\sqrt{M(J_1^2)}$ is a problem of great difficulty; an accurate calculation from $\sqrt{M(J_1^2)}$ is also impossible. On account of the difficulty, that the true no-load current of a transformer is always greater than that calculated from the magnetisation curve, one introduces, in the calculation of this "magnetising current," a second current in quadrature, which is called the energy component, and from the above consideration has the value $J_A = \frac{C}{Ep}$.*

If we denote the magnetising current by $J\mu$,

$$J_0^2 = J\mu^2 + \left(\frac{C}{Ep}\right)^2.$$

This method of calculation gives the following results: From the equation for the load of the alternate current, $A = Ep\,J\,F$, which for sine alteration of the potential difference and current takes the form $A = Ep\,J\cos\phi$,

where ϕ is the phase difference between potential difference and current, the part to be considered is only the part $J_A = J_0\cos\phi = \frac{A_0}{Ep}$. With close approximation, also, $J_0\cos\phi = \frac{C}{Ep}$. If we consider this part as a component of the current, then, for the calculation of the total current a second component, $J_0\sin\phi$, is required, which is in quadrature with the other, and has the peculiarity that it has no power factor. This second component, $J\mu$, has the property of producing the alternating flux without loss of energy; we find it as above from the total value J_0, and from the magnetisation curve of the iron, after one has calculated B_{max} from $\sqrt{M(E p_1^2)}$. The conclusion, that $J\mu$ so calculated has no power, appears to me incorrect, since the correct calculation of $J\mu$, by the use of the quantities c and K, which depend on the shape of the potential difference and current curves, also depends upon the form of these curves, which are known by the hysteresis curve of the iron. From this it is seen that the current $J\mu$ supplies the power in hysteresis itself, and it only remains to consider the loss in eddy currents. If we only calculate with those values of c and K which hold for sine curves we naturally get a greater error, since Ep_1 and J_0 cannot simultaneously have this form. That the building up of J_0 from these two components is not theoretically justifiable is shown by the above investigation, since if, for both potential difference curves, the current $J\mu$ is corrected by adding a component in quadrature, the increase of $J\mu$ for peaked potential difference curves would be smaller than for flat ones, since the total power A_0 is smaller. The investigation shows that the correction of $J\mu$ for peaked curves must be greater; the assumption that the eddy currents alone cause the increase of $J\mu$ gives a satisfactory explanation.

Since the knowledge of a method, even though only empirical, of calculating J_0 from $J\mu$ is of the greatest importance, in (Table IX.) the current is calculated by this method from the potential difference and power given in Table VI., and the measured values compared.

The calculated values are in the last column but one, the observed values in the last.

It is known that, with the sine variation of the Wechsler machine, the assumption is much closer than with the pointed curve of the Ganz machine. In both cases the calculated values are too small, although the component $J_A = \mathfrak{E}/Ep$, which is added to $J\mu$, contains the whole power, whereas in practice $J\mu$ should only be increased by the eddy-current loss. This apparent contradiction is explained by remembering that J_A is at right angles to $J\mu$, and that when it is small compared with $J\mu$ the total current, $J_0 = \sqrt{J_A^2 + J\mu^2}$, is very little increased. For the Wechsler machine, the assumption is sufficiently correct for the transformer maker; for normal the potential difference of the transformer of 60 ν, the calculation gives, for example, $J_0 = 1{\cdot}997$ amperes, and measurement $J_0 = 2{\cdot}103$ amperes. This result confirms almost exactly the method of calculation in the case of sine variations.

The Differences of the Secondary Potential Differences.

The investigation on the transformer has shown that for given R.M.S. of the primary potential difference the secondary potential difference was the same with both machines at no-load. When loaded a difference arose in this way, that, with the pointed Ganz curve, the drop in secondary potential difference as the load increased, was more marked than with the sine curve of the Wechsler machine. The difference at full load was about 1 per cent. But, on the contrary, with equal secondary current the primary current, and hence also the ohmic potential difference, drop is greater with the Wechsler machine, hence the difference in the secondary potential difference can only be explained by a difference in the magnetic leakage. The measurements also show that the leakage of the loaded transformer is greater for pointed than for flat curves. This result can be easily explained by the magnetisation of the iron.

If we denote the maximum value of the flux which the primary current induces in the primary coil by N_1, and the maximum flux that the secondary current induces in the same coil by N_2, then all the lines N_1 do not pass through the second coil, nor do all the lines N_2 cut the first coil. On account of the magnetic leakage, let the quantities leaking be $Z\,N_1$ and $Z\,N_2$; then the first coil induces $(1-Z)\,N_1$ in the second, and the second induces $(1-Z)\,N_2$ in the first. As in the case of the currents, the phases of the inductions are opposite, and, at higher loads, the maximum values are simultaneous.

Hence the total lines cut are

$$N_1 - N_2(1-Z) \text{ by the primary,}$$

and

$$N_1(1-Z) - N_2 \text{ by the secondary coil,}$$

* Here and henceforth the R.M.S. of potential difference and current and the mean power are denoted by Ep, J, and A respectively.

* $J\mu$ is calculated from the equation

$$H_{max} = 0{\cdot}4\pi\,132\,\frac{J\mu}{K}$$

from which, for the Ganz machine, $H_{max} = 6{\cdot}61\,J\mu$,

Wechsler machine, $H_{max} = 6{\cdot}24\,J\mu$.

H_{max} is found from the ballistic magnetisation curve.

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Table IX.

—	No.	B_{max}.	H_{max}.	J_μ.*	$J_A=\frac{\mathfrak{E}}{Ep}$.	J^2_μ.	J^2_A.	$J_0^2=J^2_\mu+J^2_A$.	J_0. Calculated.	J_0. Observed.
Ganz machine.	1	2,839	3·1	0 46	0 244	0 212	0·060	0·272	0·522	0·607
	2	3,982	3·4	0 51	0·352	0 264	0·124	0·388	0·623	0·777
	3	5,217	4·2	0 63	0·436	0·402	0·190	0 592	0·769	0·945
	4	6,742	5·1	0·77	0·495	0 593	0 245	0·838	0 916	1·155
	5	8,109	6 2	0·94	0·546	0 874	0·298	1 182	1·087	1·383
	6	9,477	7·8	1·18	0·625	1 390	0 391	1·781	1·335	1·746
	7	10 940	10 0	1·51	0·683	2·280	0·467	2·747	1·657	2·297
	8	12 320	12·6	1 90	0 734	3 62	0·539	4 160	2·040	2 990
	9	12,910	14·2	2 14	0·793	4·58	0·629	5·21	2·228	3·680
	10	13,560	16·1	2·43	0 805	5·90	0·648	6·55	2·56	4·381
	11	14,150	17·8	2·69	0·807	7·24	0·651	7 89	2 81	4 985
Wechsler machine.	1	3,855	3 4	0·56	0 377	0·297	0 142	0·439	0·663	0·650
	2	5,873	4·6	0·74	0·541	0 542	0 293	0·835	0·914	0·892
	3	7,830	6 0	0·96	0·671	0·922	0 450	1·372	1·175	1·167
	4	9,410	7·7	1 23	0·750	1 520	0·563	2·083	1·443	1·458
	5	11 620	11·2	1·80	0·875	3·22	0 766	3 988	1·997	2 103
	6	13,280	14·9	2·39	0 933	5·69	0 8,1	6·561	2·56	2·881

and the R.M.S. of the induced E.M.F.'s are

$$\sqrt{M(e_1^2)}=\frac{4\nu n_1}{c}(N_1-N_2+N_2Z),$$

$$\sqrt{M(e_2^2)}=\frac{4\nu n_2}{c}(N_1-N_2-N_1Z).$$

The transformation ratio has then the value

$$\frac{\sqrt{M(e_2^2)}}{\sqrt{M(e_1^2)}}=\frac{n_2(N_1-N_2-N_1Z)}{n_1(N_1-N_2+N_2Z)}.$$

This is smaller than $\frac{n_2}{n_1}$, and falls off with increasing values of N_1 and N_2—that is, with increasing current and load on the transformer. The quantity must be greater, the greater the values N_1 and N_2 are in comparison with their difference N_1-N_2.

These facts explain the difference of the behaviour with pointed and flat curves. For the same load of the transformer, and also for equal values of $\sqrt{M(J_2^2)}$, J_{2max} and J_{1max}, and thus also N_1 and N_2, are greater for pointed curves than for flat, and at the same time N_1-N_2 is smaller, since the resultant magnetisation B_{max} of the transformer iron, as has been already shown, for the same value of $\sqrt{M(Ep_1^2)}$, is always smaller for pointed than for flat potential difference curves.

Comparison and Extension of the Results.

The above investigations have indeed only been concerned with the behaviour of a transformer when loaded with glow lamps. The results are, however, applicable to the case of an inductive load. Firstly, the difference of the iron loss, it seems, remains the same, since this only depends on the value of the potential difference and its variation. Secondly, the difference of the primary current also remains the same if there is any lag between the secondary current and potential difference, since the equation

$$\sqrt{M(J_1^2)}=\sqrt{M(J_0^2)}+\frac{n_1}{n_2}\sqrt{M(J_2^2)}$$

holds with equal approximation from the conditions of constant magnetisation. Thirdly, the conditions given above for the difference of the magnetic leakage are independent of the kind of resistance in the secondary circuit, and hence the same difference of the potential difference drop is to be expected with inductive resistances. Measurements, in which the same transformer was loaded by a Swinburne "hedgehog" transformer, which gives a very great phase difference between primary and secondary current, have confirmed these conclusions. Particular cases of this investigation are yet to be settled. Considering these conclusions now, however, as generally accepted facts, we know that the use of peaked potential difference curves, so far as concerns the effect upon the power and the primary current, gives far better results than the use of sine or flat curves. These differences, which have been found in the above measurements, are of great importance in the economy of a transformer system, frequently even paramount. These great advantages of peaked potential difference curves, which tell in favour of their adoption, stand on the one side, and the greater secondary potential difference drop on the other. The percentage difference of this potential difference drop was, in the above cases, very much smaller than that of the differences of the primary current and power, and therefore it yields no important argument against the adoption of pointed curves if many transformers are on a secondary network whose potential difference can be regulated automatically from the central station. The regulation of the alternators necessitated by the increased fall of volts would not be appreciably augmented.

A much more important argument, however, against the pointed potential difference curve is the difficulty of insulation which the high maximum value of the potential gives rise to. In the above case, for the Ganz machine $c=\frac{\sqrt{M(Ep_1^2)}}{Ep_{max}}=0\ 285$, and for the Wechsler machine $c=0{\cdot}663$; hence, for equal values of $\sqrt{M(Ep^2)}$, Ep_{max} was three times greater in the first machine than in the second. In consequence of this fact it follows that for the Ganz machine, for the same insulation of the coils and leads, a much smaller value of $\sqrt{M(Ep^2)}$ is allowable than for the Wechsler machine. When one considers that the great advantage which a transformer possesses for the transmission of electrical energy arises from the ability to use very high line potentials, and that the use of this new advantage would cause great practical difficulties in the insulation, one finds an important objection to the pointed potential-difference curve.

For the consideration of these *pros* and *cons* the question arises: For what form of potential-difference curve is the power loss and the primary current least, if the insulation of the transformer and leads is the same in both cases? We will consider this question for the case of the secondary transformer of a power distribution.

Using the Ganz machine, the R.M.S. of the high potential, $\sqrt{M(Ep_1^2)}$, would be only the $\frac{1}{2{\cdot}3}$ part of the permissible value for the Wechsler machine. From the formula

$$B_{max}=\frac{c}{4n_1\nu s}\sqrt{M(Ep_1^2)},$$

we find that B_{max}, and also the iron loss, is not altered. Working with the Ganz machine would be in this respect the better. The diminution of n^1 to the $\frac{1}{2{\cdot}3}$ part for the same B_{max} and H_{max} by the equation

$$H_{max}=0{\cdot}4\,\pi\frac{n}{l}J_{max}$$

shows that $\sqrt{M(J_1^2)}$ must be increased to 2 3 times its value. If the primary current for the same high potential difference, $\sqrt{M(Ep_1^2)}$, was the same in both cases, then, by the diminution of $\sqrt{M(Ep_1^2)}$, for the Ganz machine, an increase of the loss in the primary winding and in the high-potential leads of $2{\cdot}3^2=5$-fold would result. For higher loading of the transformer, this result would be correct; on open circuit the no-load current for the Ganz machine for the same $\sqrt{M(Ep_1^2)}$ stands in the ratio of $\frac{1{\cdot}474}{2{\cdot}104}=0{\cdot}7$. By the diminution of $\sqrt{M(Ep_1)^2}$ the no-load current with the Ganz machine $=2{\cdot}3\times0{\cdot}7=1{\cdot}6$ times that with the Wechsler machine, and the loss in the high-potential leads $=1{\cdot}6^2=2{\cdot}6$ times as great. The cost of the energy with the Ganz machine would be considerably the higher, under all loads, if the insulation remained the same.

In general the adoption of one or the other machine must be based on the load diagram of the locality, and on the length of the leads. If power is required which during the greater part of the day takes only a small portion of its maximum value, as in the case of a central station in a town which gives power and light to many consumers, then the peaked potential curve would probably give the greater economy. For transmission of power to long distances the use of flatter potential difference curves is to be recommended.

It is to be remarked that in the above considerations the assumption is made that for the expression of the insulation only the value

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$E p_{max}$ is of importance. It is, however, not impossible that with the use of higher potentials the insulation of the material is affected by time. In this case $E p_{max}$ would no longer be the quantity fixed by the insulation, but a value which approximates to the mean value of the pointed potential difference curve. Then the properties of pointed curves would be better than those given above.

These results are given for the behaviour of transformers alone. The smaller candle-power of arc lamps with pointed curves tends to throw the balance more to the side of flat curves. For a decision on all points an investigation on the behaviour of motors is necessary.

It should be observed that by the name "peaked" potential difference curve in what has gone before, is meant curves in which a part of the ordinates have a much larger value than all the others without thereby creating an actual sharp point. The typical properties of these "peaked" curves are given by the small value of $c = \frac{M E p_1}{\sqrt{M (E p_1^2)}}$, which arises from the lengthening of a few of the ordinates; hence all the properties of these curves may be obtained without an actual point. The curve of Fig. 24, for

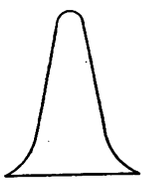

Fig. 24.

example, gives a very small value of c, yet the maximum does not become large. With a suitable form of curve of this type, one could remove most of the objections based on the higher insulation required without otherwise affecting the properties of these curves.

BATTERY CARS IN NEW YORK.*

The first attempt worthy of the name, to operate a street railway by storage battery cars in the United States, was carried out in 1889 by the New York and Harlem Railway Company in New York, on Fourth and Madison-avenues. These cars, ten in number, were equipped with Julien cells and were operated for several months, sandwiched in among the horse cars of the line. The reasons which induced the Company to abandon the further use of battery cars need not be here gone into, but suffice it to say that the question of cost of operation was not the principal one, and hence the Company has always looked with favour on the system and has ever since expressed its willingness to give fair trial to any system of this nature showing promise of success and quite free from the annoyance of patent litigation.

The time that has elapsed since the first attempt has served to bring about vast improvements in the storage battery, and, besides, the experience gained in storage traction work abroad served as a valuable guide to present American work in this field.

With these points in view, the Electric Storage Battery Company a short time since entered into negotiations with the New York and Harlem Railway Company for the equipping of a number of cars, with a view to a thorough determination of the feasibility of storage traction for its lines. These negotiations have resulted in the equipment of the cars, described below.

Starting out with the source of current, the storage battery, as a reliable piece of apparatus, and having constantly before them the troubles due to a mechanical nature with which previous attempts in this direction had been hampered, the Electric Storage Battery Company have been enabled to bring together a system which presents not only decidedly novel features, but in some respects radical departures from previous practice. First and foremost among these perhaps may be mentioned the method of handling the batteries, and the manner in which they are carried on the car. In all previous work of this class the batteries have in one way or another been carried within, or suspended from, the car body. Thus in the older forms the batteries were disposed under the seats for the passengers, and either let into the sides or through the platform ends of the cars. This in the first place required a heavy construction of the car body to withstand the strain of the additional weight imposed upon them. In the second place, this method required the seats to be wider than would otherwise have been necessary, and invariably resulted in an uncomfortable seat for the passengers, besides taking several inches from the width of the aisle running through the car. To this is to be added the fact that even with the greatest care exercised to prevent it the acid fumes were usually noticeable in the cars.

It has been sought to overcome part of these troubles by the methods of battery suspension adopted in the storage cars now in operation in Paris. There the batteries are contained in trays suspended from the car bodies between the two bogie trucks upon which the car rests. This, it is true, removes the batteries to the outside of the car body, but does not relieve the car body itself of the strain brought upon it by the weight of the battery, while it also subjects the passengers to the more pronounced shocks due to the increased mass of the car body loaded with batteries.

In the method adopted on the new Madison-avenue cars all these objections have been at once brushed aside by suspending the battery on the car truck. This relieves the car of all strain, so that it can be built as light as any horse car, and does away with all the other objections, and, as will be seen later, it permits of a facility in the operation and handling of the batteries rendered impossible by the methods employed heretofore.

In general terms the system of handling the batteries on the Madison-avenue line has been so arranged that all work which involves any movement of the batteries whatever is done below the level of the street, or of the ground floor of the car house. The batteries are assembled in trays mounted on four-wheel trucks; after being charged they are wheeled to a line of rails extending the complete length of the car house, and by means of turntables transferred to the track running parallel with the track above, upon which the cars are standing. The track upon which the cars enter the car house forms the top of a continuous pit. The small truck carrying the batteries is wheeled directly on to an elevator platform, which, when lifted, brings the batteries directly under the centre of the car at its proper place, and automatically suspends it on to the truck. The elevator with the small battery truck descends free of its load, ready for the next charged battery.

It will be noted that with the exception of the wheeling of the small trucks carrying the batteries, from their location while charging, no manual labour whatever is required in their handling, and even this part of the work it is intended shortly to free from manual work by a system of hauling cables, which will shift the battery trucks from one position to another automatically. The desire to press forward the equipment as fast as possible has prevented carrying out this detail for the present. This in brief will give a general idea of the methods employed. The details by which these methods have been worked out exhibit considerable ingenuity.

Each car is provided with 60 cells, grouped in two series of 30 cells each. The nine-plate traction type of chloride cells is employed, having a capacity of 400 ampere hours, and capable of sustaining a current discharge of 40 amperes for 10 hours. The cells weigh 95lb. each, making a total weight of 5,700lb. It is proposed, however, to put in service shortly a lighter type of battery, weighing only 2,400lb., which will, of course, necessitate more frequent change of battery. The connections of all the cells are burned together solid throughout, no screws or bolts of any kind being employed. The flexible cables are also burned on at all points, and are brought out to large brass plates on the sides of the trays, which form the terminals to which double shoes on the car make contact when the battery is lifted into place on the truck. The cells rest in a tray supported by four channel irons, which are bent up at the sides of the tray, and form ears from which the tray is suspended on the car truck. The outside measurement of the battery cells is 18in. high, by $5\frac{3}{16}$in. by $8\frac{1}{2}$in.

In order to prevent splashing, hard rubber grids are placed on the top of the cells, which break up any waves that may be formed by the vibration of the car.

As stated above, the trays containing the batteries rest on four-wheel trucks, running on twenty-one inch gauge tracks, which run at right angles to the main track running along the bottom of the pit, over which the street car runs on entering the car house.

The elevator employed in the Madison-avenue stables for this purpose is of the worm and worm-wheel type, and specially designed for this purpose, and built by the Sprague Electric Elevator Company. It can be worked from either side and the arrangement is such that it only requires to be started, stopping automatically at the proper point to land the batteries in the car truck overhead. It may be remarked also that by means of the elevator an armature can be readily removed from the motor.

The tray is provided with bevelled cast-iron corner pieces, so that even if it should be out of centre three-quarters of an inch when lifted on to the truck it will automatically slide into its proper place.

The truck upon which the batteries are mounted is of the Peckham type and of a special design. The Peckham standard truck is employed, but in addition thereto elliptical springs are placed at the ends on which the car body rests, together with extra spiral springs in the centre. The battery tray is hung from two cross-bars, the suspension bar being pushed forward under the ears of

* Abstract from the *Electrical Engineer* of New York.

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the tray, and firmly held in place by a locking arrangement. The truck has a 7ft. 6in. wheel base with 30in. wheels.

In employing an elevator in the handling, it became necessary, of course, to provide means for automatically bringing the batteries in the centre of the car truck when raised. This has been provided for in an ingenious centring arrangement. The result is that should the car have come to a stop not directly above the centre of the elevator, the batteries will nevertheless be guided to the centre of the car by guide bars. This arrangement, it will be readily seen, economises greatly in time and obviates the necessity of any exceptional vigilance or skill on the part of the motorman in bringing his car to a stop.

The motors with which the truck is provided are of the General Electric "800" type, wound for a maximum of 24 miles an hour, and hence revolving at a greater speed than is usually employed on cars of this type. This winding was selected in order to effect as high an average efficiency of motor as possible with the varying potential employed. In practice it is not proposed to run above a speed of 12 miles an hour. Contrary to usual practice, the motors are turned toward the outside of the axles. This arrangement became necessary in order to allow of sufficient room for the insertion of the battery trays.

The "K.S.B." controller of the General Electric Company is employed, giving six combinations. These are: (1) batteries in parallel, motors in series; (2) same, with field shunt; (3) batteries in series, motors in series; (4) same, with field shunt; (5) batteries in series, motors in parallel; (6) same, with shunt.

When the trays are lifted into position on the truck, the terminal plates at their sides are brought up against double contacts at each terminal plate, so as to insure the absolute continuity of circuit. These double-contact shoes are pressed forward by steel springs, which, however, do not carry any current.

The car bodies employed are the widest built by this Company. The woodwork is no heavier than that of the ordinary horse car, and the whole car has an air of lightness about it in strong contrast to the previous types of storage battery car bodies. It is lighted by two three-light clusters, one connected to each set of batteries, so that light will always be available.

At the present time the current for charging the batteries is obtained from a 13½ kilowatt General Electric generator, driven by an Otto gas engine, but there will shortly be erected in addition to this a 30 kilowatt Eddy generator, belted direct to a 36 H.P. Otto gas engine.

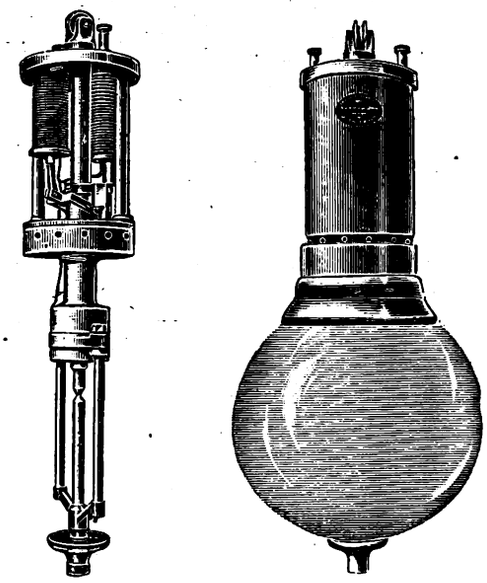
The charging switchboard is arranged for five circuits. At the top are placed the main ammeter and the voltmeter and below these the ammeters for the individual charging circuits, followed by handles for operating the resistance in each charging circuit, for obtaining uniformity of charge. At the bottom are placed the main dynamo switch and the rheostat for regulating the field of the generator and the overload and underload switches.

At the present time two cars are in operation on the Madison-avenue line, and these will be subjected to a series of tests which will determine the future course of the Railway Company, looking to the adoption of the storage battery system for its lines.

Theories of Electrolysis.—In the current number of *Science Progress* Mr. C. Dampier Whetham summarises existing theories of electrolysis. Starting with the application of Ohm's law to electrolytes, he discusses the evidence which Kohlrausch educed in regard to the specific character of ionic velocities. The hypotheses of Arrhenius, Ostwald and others concerning dissociated ions are next considered, and a number of interesting tables have been compiled by the author bearing upon the coefficient of ionisation and constants of affinity of a number of electrolytes. The dependence of general physical properties, such as the osmotic pressure, freezing point, &c., upon the electrolytic characteristics of the liquid are discussed in relation to the researches of Mr. H. C. Jones on this subject. From established data, the author proceeds to summarise the hypothesis in regard to the dissociation accompanying the solution of highly stable solids. In regard to this branch of the subject he arrives by independent reasoning at the conclusions: "That pairs of opposite ions must be separated, and the ions exist free from each other's influence, and, secondly, that there must be a tendency towards the formation of more or less stable molecular aggregates between salt and solvent." The apparent contradiction involved in these two conclusions is got rid of by the fact that "since it is evident that one salt molecule can influence a large number of water molecules, it follows that the chemical forces are very far-reaching."

THE "I.R." ARC LAMP.

The accompanying illustration shows the general construction of the Richardson "I.R." arc lamp, which is the invention and manufacture of Mr. A. W. Richardson, of Patricroft. A glance at the illustration shows that it is of the differential rocking-lever type, the lever directly actuating a central tube, to which the feeding gear is fixed. This gear is fitted in a box below the lamp bottom plate. Carbons of equal size are used for the top and bottom, and it is the practice to use the short end of the positive as a negative



The "I. R." Arc Lamp.

when re-carbonning. It is claimed that this is an advantage, though it might be difficult to persuade most arc lamp makers that it would be a good thing to abandon carbons of unequal diameters and lengths in continuous-current lamps. The maker of the "I.R." lamp considers it advisable to reduce the waste from two ends to only one in the manner indicated. The lamp is made in ordinary sizes to take from 5 to 12 amperes, giving from 500 to 2,000 nominal candle-power.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(TO-DAY) FRIDAY, December 13th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read: (1) "A Mechanical Device for Performing the Temperature Corrections of Barometers," by Dr. Shield; (2) "On the Existence of Earth-Air Electrical Currents," by Prof. Rücker.

INSTITUTION OF ELECTRICAL ENGINEERS.

7 p.m. for 7:30 p.m. Annual Dinner at the Freemasons' Tavern.

MONDAY, December 16th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture III.: "Mechanical Road Carriages," by W. Worby Beaumont.

TUESDAY, December 17th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read and discussed: "The Design and Testing of Centrifugal Fans," by Hammersley Heenan and William Gilbert.

WEDNESDAY, December 18th.

ROYAL METEOROLOGICAL SOCIETY.

7:30 p.m. Ordinary Meeting at the Institution of Civil Engineers, 25, Great George-street, Westminster.

SOCIETY OF ARTS.

8 p.m. Fifth Ordinary Meeting. Paper to be read: "Machines for Composing Letterpress Printing Surfaces," by John Southward.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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"THE ELECTRICIAN" will be published as usual on Friday in Christmas week, but as the Offices will be closed on Wednesday and Thursday it will be necessary that Contributions, Correspondence, News Items and Advertisements should reach the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London, by, at latest, Tuesday's post.

THE REPORT OF THE BOARD OF TRADE EXPERT COMMITTEE.

The general body of electric supply undertakers must give the strong Committee appointed by the Board of Trade credit for wishing to meet their requirements, while endeavouring at the same time to ensure the safety of the public. The evident desire of the Board of Trade to placate the central station industry is shown by the granting of the two following important concessions to continuous current undertakings:—

(1) The Committee inferentially suggest that a system of continuous-current electric supply shall be considered low pressure when the pressure in the distributing mains cannot at any time exceed 500 volts.

(2) They are also of the opinion that the Board of Trade may give provisional sanction to the earthing, at one point, of the neutral conductor on certain conditions.

Notwithstanding these important concessions to the requirements of the undertakers, we shall not be surprised if the remaining suggestions of the experts meet with considerable criticism, not only on account of their debatable nature, but because of the great importance that will inevitably be attached to these recommendations, in view of the high standing of their originators and the fact of their having appeared after the recent Conference, at which the general views of the undertakers were so very clearly expressed.

We are afraid the value of the first concession will, in the eyes of most central station engineers, entirely vanish if the following proviso, which the Committee suggest, be inserted at the end of Supply Regulation No. 6:—"Provided that no

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change shall be made in the pressure of supply to any consumer in consequence of the issue of these Regulations, except with his consent." This proviso obviously puts it in the power of any one obstinate consumer in a district to prevent the undertakers reaping any benefit by increasing their pressure of supply to that district. In connection with this matter, it must be remembered that the important step Mr. BAYNES has initiated in inducing consumers to take the supply at double the ordinary pressure is only the first step towards greater economy in the cost of mains, and is of no advantage in itself to the undertakers, until every consumer in the district is also supplied at the higher pressure, for not until this is effected can the great economy due to the higher pressure in connection with the three-wire system be realised. Taking human nature as we find it in this year of grace, it is not very likely that this general consent to the change will be readily obtained. We must bear in mind that, as a rule, undertakers have no other inducement to offer than that of exchanging old lamps for new, also that higher voltage lamps are at present more expensive and less durable than the ordinary lamps in general use, and that there will probably be one or more black sheep in the general body of consumers who will see their chance of making themselves suddenly important by resisting the proposed change.

We are not at all clear as to the reasons which induced the Committee to make a very important distinction between the systems of bare and insulated conductors when they suggested that in the former case it should be stipulated "that no such conductor should be at a higher potential than 300 volts from earth." It seems to us that this stipulation is as essential in a continuously-insulated conductor system as in that with bare conductors, for it would be quite as possible for the public to get a 500-volt shock in the one case as in the other, should one of the outer mains be at earth potential. With either system of distributing mains it seems to us absolutely necessary for the Board of Trade to not only sanction, but to insist on, the earthing of the neutral at the same time that they permit the raising of the limits of low-pressure supply.

With regard to the Committee's suggestion that the Board of Trade be empowered to sanction the earthing of a system of conductors at one point on certain conditions, we were under the impression that there was less danger of electrolysis happening with a system of conductors in which the neutral is earthed at the several feeding points than at one point, such as the generating station. In the latter case it is obvious that should a fault occur on any part of the neutral in a distributing network, the difference of potential between the fault and the station may be quite sufficient to cause electrolysis, should an extreme want of balance on the two sides of the three-wire system occur; whereas, if the neutral be earthed at all the feeding points, it is hardly likely that there would be a greater difference of potential than one volt between the neighbouring pipes and earth, under any circumstances.

We expect great disappointment will be felt by the majority of central station engineers at the Committee's suggestion that the invidious distinction between alternate and continuous currents existing in the old regulations should be retained, and that the limit for the low-pressure alternate-current supply should be just half that for continuous currents, viz., 250 volts. We cannot imagine what has induced the Committee to believe that alternate currents are just twice as deadly as their more constant rivals. On theoretical grounds it may be argued that the fatal effect of an alternate current is proportional to the maximum value of the difference of potential that occurs in any one period; with this assumption, and assuming further the average wave-form met with in English practice, about 350 volts should be considered equally as safe as 500 volts continuous. But when the Committee recommend lowering this limit by another 100 volts it must be apparent that the thought of some other danger in connection with alternate currents was the cause of their being so seriously handicapped. We trust that the academic bugbear of statical effect on low-pressure mains was not responsible for this. Many practical men are under the impression that, quite contrary to the above theoretically greater danger of alternate currents, as many fatal shocks have arisen from contact with continuous-current circuits as with alternating ones; and, knowing from painful experience the deadly gripping nature of a continuous-current shock compared to the well-known kicking-off effect of an alternate-current one, they cannot see any reason for maintaining the old idea of the greater danger of alternate currents.

THE ELECTRIC ARC.

BY HERTHA AYRTON.

(*Continued from page 39.*)

ANALYTICAL TREATMENT OF FIG. 46.

Let E be the E.M.F. of a generator in volts, let r be the total resistance in ohms in the circuit, outside of the arc itself, let there be a P.D. of V volts between the carbons, and let a current of A amperes be flowing through an arc of l millimetres. Then, referring to Fig. 46 (p. 37 *The Electrician*, November 8th), E is represented by the distance between P and the axis of current, r by the ratio of the distance from P Q of any point on one of the resistance lines to its distance from the axis of P.D. This is the same thing, of course, as r being represented by the tangent of the angle between a resistance line and P Q. A is represented by the distance between any point at which a resistance line cuts a curve and the axis of P.D. and V by the distance between that point and the axis of current.

Then $$E = V + A r.$$

But from equation (4) (p. 420, *The Electrician*, July 26th),

$$V = a + b l + \frac{c + d l}{A},$$

therefore $$E = a + b l + \frac{c + d l}{A} + A r, \quad . \quad . \quad . \quad . \quad . \quad (7)$$

or $$A^2 r - (E - a - b l) A + c + d l = 0; \quad . \quad . \quad . \quad (8)$$

hence $$A = \frac{E - a - b l \pm \sqrt{(E - a - b l)^2 - 4 r (c + d l)}}{2 r} \quad . \quad (9)$$

Thus we find, as before, that with a generator of given E.M.F. two different currents, or one, or none may be sent through the arc. The conditions for the three cases in the equation are that $(E - a - b l)^2$ shall be greater than, equal to, or less than $4 r (c + d l)$, and these correspond with the conditions in the figure that the resistance line shall meet the curve at two points, at one, or not at all.

Since the value for A obtained by using the positive root in equation (9) is greater for any given length of arc than that obtained by using the corresponding negative root, it follows that the positive root will give values which correspond with right-hand points of intersection between the resistance line and the curve, while the negative root will give values that correspond with the left-hand points of intersection. As it has already been shown that these left-hand points can never be obtained in practice, it will not be necessary here to discuss the negative root of the equation, and therefore henceforward when equation (9) is mentioned it will be understood that the positive root only is alluded to.

As before, we shall for the present discuss only the case in which the E.M.F. of the generator is constant, and we shall consider what happens, first, when r is constant and l is varied;

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next, when l is constant and r is varied; and finally, when r and l are both varied in such a way that A is constant. In equation (9), if A is to have a real value at all, $(E-a-b\,l)^2$ must be not less than $4\,r\,(c+d\,l)$ whatever A, E, r, and l may be. Taking the first case—r constant, *i.e.*, following one of the resistance lines in Fig. 46—evidently, with the positive sign before the root, A is greatest when l is least, diminishes as l increases, and is least when l is greatest—that is, A is a maximum when l is a minimum, and a minimum when l is a maximum if the resistance external to the arc is kept constant.

But, since the expression under the root cannot be negative if A is to be real, l is a maximum when

$$(E-a-b\,l)^2-4\,r\,(c+d\,l)=0, \quad . \quad . \quad . \quad (10)$$

for, since E is constant, $E-a-b\,l$ is smallest when l is greatest, and since r is constant, $r\,(c+d\,l)$ is greatest when l is greatest. Hence when r is constant the condition that A shall have only one value, which is the condition that the resistance line shall be a tangent to the curve, is also the condition that the length of the arc shall be a maximum, as was shown when the subject was dealt with graphically.

Since A has been shown to be a minimum when l is a maximum, it follows that the smallest current that can flow with a constant resistance in circuit when the E.M.F. of the generator is also constant is given by the equation

$$A=\frac{E-a-b\,l}{2\,r}. \quad . \quad . \quad . \quad . \quad . \quad (11)$$

These maximum and minimum values for l and A may be found in terms of E, r, a, b, c, and d, all of which are known.

For from equation (10) we have

$$b^2\,l^2-2\,l\,\{b\,(E-a)+2\,d\,r\}+(E-a)^2-4\,c\,r=0,$$

hence

$$l=\frac{b(E-a)+2\,d\,r\pm\sqrt{\{b(E-a)+2\,dr\}^2-b^2\,\{(E-a)^2-4\,cr\}}}{b^2}$$

$$\text{or}\quad l=\frac{(E-a)}{b}+\frac{2dr\pm\sqrt{\{b(E-a)+2\,dr\}^2-b^2\{(E-a)^2-4\,c\,r\}}}{b^2}.$$

But from equation (9) it may be seen that l cannot be greater than $\frac{E-a}{b}$ when the quantity under the root is zero, otherwise A would be negative. Therefore, in the last equation the *negative* sign must be used before the root.

The quantity under the root is

$$b^2\,(E-a)^2+4\,b\,d\,r\,(E-a)+4\,d^2\,r^2-b^2\,(E-a)^2+4\,b^2\,c\,r,$$

which equals

$$4\,r\,\{b\,d\,(E-a)+d^2\,r+b^2\,c\}.$$

Therefore

$$l=\frac{E-a}{b}+\frac{2\,d\,r-2\,\sqrt{r\,\{b\,d\,(E-a)+d^2\,r+b^2\,c\}}}{b^2}. \quad (12)$$

And, substituting this value for l in equation (11) we get

$$A=\frac{\sqrt{r\,\{b\,d\,(E-a)+d^2\,r+b^2\,c\}}}{b\,r}-\frac{d}{b}. \quad . \quad (13)$$

Hence, if the E.M.F. of the generator is known, and also the external resistance that it is desired to have in the circuit, the longest silent arc that can be maintained and the smallest current that will flow are found in terms of the known E.M.F., the known resistance, and the known constants depending on the carbons used.

For instance, let us take

$$E=48{\cdot}88 \text{ volts},$$
$$r=\ 0{\cdot}5 \text{ ohm}.$$

Then, from equation (12) we get

$$l=1{\cdot}35\text{mm}.$$

Also, from equation (13) we have A = 7·2 amperes.

Thus, with an E.M.F. of 48·88 volts in the generator, and a resistance of 0·5 ohm in the circuit external to the arc, the longest silent arc that can be maintained with the carbons in question is one of 1·35mm., and the smallest current that will flow is one of 7·2 amperes.

Next let l be constant and r variable, that is, let us follow the course of one of the curves for constant length of arc in Fig. 46. Then, of course, A will also vary, and will again be a minimum when equation (10) holds. But r will also be a maximum when equation (10) holds, since any value of r greater than $\frac{(E-a-b\,l)^2}{4\,(c+d\,l)}$ would make the quantity under the root in equation (9) negative. Hence we have for A a minimum

$$A=\frac{E-a-b\,l}{2\,r},$$

and for r a maximum

$$r=\frac{(E-a-b\,l)^2}{4\,(c+d\,l)}.$$

By combining these two equations we can obtain the following one for A in terms of known quantities only, r being already given in known terms,

$$A=\frac{2\,(c+d\,l)}{E-a-b\,l}. \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Thus, when the E.M.F. of the generator is known, and it is required to maintain a silent arc of fixed length, the maximum external resistance that can be used, and the minimum current that can be maintained, are found in terms of the known E.M.F., the fixed length of arc, and the known constants of the carbons.

For example, let

$$E=58{\cdot}88 \text{ volts},$$
$$l=3\text{mm}.$$

Then, from equation (10) we have

$$r=1{\cdot}1 \text{ ohms}.$$

Also, from equation (14) we get

$$A=6{\cdot}28 \text{ amperes}.$$

Hence, with an E.M.F. of 58·88 volts in the generator, and a silent arc of 3mm. to be maintained, a resistance of 1·1 ohms is the greatest that can be placed in the circuit outside the arc, and a current of 6·28 amperes is the smallest that will flow.

Lastly, let r and l be both varied in such a way that A remains constant, that is, let us follow some such line as S R_1 R_2 R_3 in Fig. 46. Then, from the equation

$$r=\frac{E-a-b\,l+\sqrt{(E-a-b\,l)^2-4\,r\,(c+d\,l)}}{2\,A},$$

it is plain that r diminishes as l increases, and becomes a minimum when

$$r=\frac{E-a-b\,l}{2\,A},$$

—that is, when the quantity under the root vanishes—or

$$r=\frac{(E-a-b\,l)^2}{4\,(c+d\,l)},$$

which is also the condition that l shall be a maximum for a fixed value of r.

By combining the last two equations we can determine the minimum value for r and the maximum value for l in terms of the known quantities, when E and A are constant,

$$r=\frac{d\,(E-a)+b\,c}{A\,(A\,b+2\,d)}. \quad . \quad . \quad . \quad . \quad (15)$$

$$l=\frac{A\,(E-a)-2\,c}{A\,b+2\,d}. \quad . \quad . \quad . \quad . \quad (16)$$

Thus, when the E.M.F. of the generator is known and the current is fixed, the minimum external resistance that must be placed in circuit, and the maximum length of silent arc that can be maintained, are found in terms of the known E.M.F., the fixed current, and the known constants of the carbons.

For example, let us take

$$E=58{\cdot}88 \text{ volts},$$
$$A=10 \text{ amperes}.$$

Then from equation (15) we get

$$r=0{\cdot}56 \text{ ohm},$$

and from equation (16) we have

$$l=4{\cdot}2\text{mm}.,$$

which shows that if with an E.M.F. of 58·88 volts in the generator we wish a current of 10 amperes to flow, the smallest resistance that can be placed in the circuit outside of the arc is one of 0·56 ohm, and the longest arc that can be maintained is one of 4·2mm.

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THE RATIO OF THE POWER EXPENDED IN A SILENT ARC TO THE POWER DEVELOPED BY THE GENERATOR.

The ratio of the power expended in a silent arc to the power developed by the generator is an important factor in determining the most efficient arrangement to use in maintaining an arc. We are now in a position to determine when this ratio of A V to A E will be greatest.

From equation (4) (p. 420, *The Electrician*, July 26th), and equation (7) we have

$$\frac{V}{E}=\frac{a+bl+\frac{c+dl}{A}}{a+bl+\frac{c+dl}{A}+Ar}. \quad . \quad . \quad . \quad (17)$$

Hence, whatever value l may have, $\frac{V}{E}$, and therefore, $\frac{AV}{AE}$, is greatest when Ar is least; but from equation (9) it is evident that Ar is least when

$$(E-a-bl)^2=4r\,(c+dl),$$

that is, when equations (10) and (11) hold. From those two equations we find that when $\frac{V}{E}$ is greatest,

$$Ar=\frac{c+dl}{A}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

Equation (18) gives a value for Ar, which holds when $\frac{V}{E}$ is as large as possible, for any given value of l. It is still necessary, then, to find what values of l and A make $\frac{V}{E}$ greatest. If we substitute $\frac{c+dl}{A}$ for Ar in equation (17), and multiply numerator and denominator by A, we get

$$\frac{V}{E}=\frac{(a+bl)A+c+dl}{(a+bl)A+(c+dl)+(c+dl)},$$

from which it is plain that whatever A may be $\frac{V}{E}$ is greatest when $c+dl$ is least—*i.e.*, when l is least.

Thus *the ratio of the power expended in a silent arc to the power developed by the generator is greatest when the arc is shortest*—that is when the length of the arc is zero if we preclude negative lengths, of the existence of which we have no proof.

To find what value of A makes $\frac{V}{E}$ greatest for any given value of l, we may put the last equation in the form—

$$\frac{V}{E}=1-\frac{c+dl}{(a+bl)A+2(c+dl)},$$

which shows that, for any given value of l, $\frac{V}{E}$ is greatest when A is as large as possible. But A is as large as possible for a silent arc of given length *when the arc is about to hiss*, so that the value of A when $\frac{V}{E}$ is greatest for any given length of arc must be found from the equation connecting l and A for all the points on the hissing curve $X_1 X_2 X_3$ Fig. 46 (p. 37, *The Electrician*, November 8th). *Hence the ratio of the power expended in a silent arc to the power developed by the generator is greatest when the arc is on the point of hissing.*

It is still necessary to find what value of E makes $\frac{V}{E}$ greatest when A and l are fixed, but this is easy, for

$$\frac{V}{E}=1-\frac{Ar}{E},$$

and it has already been shown that Ar must be as small as possible for $\frac{V}{E}$ to be as large as possible. Therefore evidently E must also be as small as possible, or *the ratio of the power expended in a silent arc to the power developed by the generator is greatest when the E.M.F. of the generator is the least possible.*

Since the experiments upon which the curves in Fig. 46 are founded, and upon which the above reasoning is based, were made with arcs of not less than 1mm. in length, and with solid carbons, it is impossible to be sure that the laws which have been shown to apply to these arcs would also be true for arcs of less than 1mm. and with cored carbons. We can, however, be quite sure of the following: *In silent arcs of from 1mm. to 7mm. with solid carbons, the ratio of the power expended in the arc to the power developed by the generator is greatest when the arc is shortest, when the current is the largest that does not cause hissing, and when the E.M.F. of the generator is the smallest possible.*

The equation to the curve $X_1 X_2 X_3$ I have found—as I shall show later on—to be

$$A=\frac{11{\cdot}66+10{\cdot}54\,l}{1{\cdot}17+0{\cdot}4146\,l},$$

which, put in the general form, is

$$A=\frac{c+dl}{e+fl}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

where c and d have the values already used in other equations, and

$$e=1{\cdot}17,$$
$$f=0{\cdot}4146.$$

Thus we have the three equations (10), (11), and (19) connecting the four variables l, A, E, and r, when $\frac{V}{E}$ is a maximum, and hence, if circumstances determine any one of the four, the other three can be found.

It appears from what has gone before that the length of the arc is the most important variable to choose first in making any arrangement to maintain an arc, for we know definitely that that should be as small as possible.

The difference between the greatest value of $\frac{V}{E}$ with one length of arc and its greatest value with another is not, however, very large. For instance, for the carbons I used, with an arc of 0mm. the greatest value of $\frac{V}{E}$ would be 0·97, obtained with a current of 10 amperes, an E.M.F. of 41 volts, and a P.D. of 40 volts between the carbons. With an arc of 3mm. the greatest value of $\frac{V}{E}$ would be 0·95, obtained with a current of 18 amperes, an E.M.F. of 50 volts and a P.D. of 45·5 volts between the carbons. Hence, although the actual power consumed in the shorter arc (400 watts) would be less than half as large as the power consumed in the longer arc (819 watts), yet the ratio of the power expended in the arc to the power developed by the generator would be nearly the same—viz., 0·97 and 0·95—for the two lengths of arc when the largest non-hissing current was used in each case. But at the meeting of the Electrical Congress in Chicago in 1893 it was shown by Prof. Carhart that the ratio of candle-power to electric power supplied to the arc was a maximum when the P.D. maintained between the carbons was increased to a certain value, and independently by Prof. Ayrton, that this ratio of light to electric power was a maximum when the length of the arc was increased to a certain value. Hence, to decide what length of arc, current and E.M.F. should be used in order to insure the largest ratio of the light emitted to the power developed in the generator, it would be necessary to find what length of arc gave the greatest amount of light for the energy consumed when the current flowing was the largest that did not cause hissing, and we might then find out what resistance to place in the circuit, and what E.M.F. to use, from equations (10) and (11).

For example, let us suppose that the preceding considerations have led to an arc of 3mm. in length being chosen, and that the arc lamp is fitted with a series regulating coil, and supplied with current from a generator of constant E.M.F. With such an arc a current of about 18 amperes is the largest that can be used without hissing, and from equations (10) and (11) we find that the generator should have an E.M.F. of about 50 volts, and that the total resistance in the circuit outside the arc should be about 0·13 ohm.

The current actually used must not, however, be so large that an arc can have any tendency to hiss. Suppose, therefore, a normal current of 15 amperes is selected, and that when it

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falls to 13 amperes, and the arc has increased in length to 3·2mm., the regulator begins to feed the carbons.

Then, remembering that the current that is to flow is no longer the greatest non-hissing current, but something less, and that E and r are to be the same whatever the current and length of arc may be, we must put

$$A = 15$$
$$l = 3$$

and also

$$A = 13$$
$$l = 3{\cdot}2$$

in the general equation

$$A = \frac{E - a - bl + \sqrt{(E - a - bl)^2 - 4r(c + dl)}}{2r}$$

in order to find E and r. In this way we shall find that E must be 55·5 volts and r must be 0·5 ohm.

Hence we have V or $E - Ar = 55{\cdot}5 - 7\,5$

and

$$\frac{V}{E} = \frac{48}{55{\cdot}5}$$
$$= 0\,87.$$

Thus with these carbons, if a silent arc of 3mm. be maintained with a current of 15 amperes flowing, the arrangement can be made so efficient that 87 per cent. of the power developed by the generator will be used in the arc, and only 13 per cent. will be wasted in the resistance outside the arc. This total resistance external to the arc includes, of course, the resistances of the generator, the leads, and the coil of the regulator, so that it might be practically impossible to make it as small as 0·5 ohm, but the greatest value of $\frac{V}{E}$ would in that case be obtained by making this outside resistance as near 0·5 ohm as possible.

Without, however, for the moment considering the new circumstance that this impossibility of using a small enough resistance introduces into the problem, we may sum up the ideal conditions to be striven for in an arc, in order that the ratio of the power expended in the arc to the power developed by the generator may be as large as possible. They are:

(1) That the arc should be as short as possible.

(2) That the current should be the largest that will certainly give a silent arc.

(3) That the regulator should start feeding the carbons for as small a diminution of current and as small an increase in the length of the arc as possible.

(4) That the E.M.F of the generator should be the smallest that will send this diminished current through the increased length of arc.

(To be continued.)

THE NEW FRENCH ATLANTIC CABLE.

The following is an abstract of the Agreement which has been entered into between the French Government and the Compagnie Française des Câbles Télégraphiques in connection with the proposed new cable from Brest to Cape Cod. This Agreement is embodied in a *projet de loi* which has just been submitted to the French Chamber.

By Article 1 the Compagnie Française undertakes to run from Brest a cable connecting France directly with the United States, and landing near Cape Cod, and to work and maintain this cable for 30 years, the cable to be prolonged to New York by special land or submarine lines independent of those which the Company possesses at the present moment. The Company further undertakes to work the existing cables belonging to it between Brest and St. Pierre, St. Pierre and Cape Cod, St. Pierre and Canso, and to maintain all these cables in such a condition that they can act as auxiliaries until the transatlantic cable mentioned in Article 9 is laid. The Company further undertakes, within two years from the final signature of the Agreement, to manufacture and lay an independent cable connecting the network which the Company possesses in the West Indies with its transatlantic system.

By Article 2 it is laid down that the period covered by the Agreement shall be 30 years, and that the authorisations now granted do not confer any exclusive right.

By Article 4 it is laid down that the new cables are to be entirely manufactured in factories situated on French territory; they are to be laid by French *personnel* in vessels one of which at least is to be French. The old and new submarine cables belonging to the transatlantic and West Indian networks are to be maintained by French boats manned by French crews, and all cable intended for repairs is to be made in France.

By Article 5 the Company undertakes to keep its offices in France and only to have French directors. It may not cede any rights conferred upon it by the present Agreement, nor let any lines referred to therein, nor amalgamate its interests with those of any other company, either French or foreign, without the express consent in writing of the French Government. It further undertakes not to take part, either directly or indirectly, during the time which the Agreement is in force, in any line which may reduce the traffic passing over the transatlantic lines referred to in the first clause, without the express permission of the French Government given in writing.

Article 6 —"The French Government grants to the Company, in return for laying, maintaining and working the cable between Brest and Cape Cod, an annual subsidy of 800,000fr. (£32,000) for 30 years from the date on which the cable and the line joining it to the West Indian system come into operation. When the gross receipts arising from the transmission of telegrams by the transatlantic cables of the Company amount to more than 1,650,000fr., two-thirds of the excess shall be applied to the reduction of the subsidy alluded to in the first paragraph of the present clause. Consequently the payment of the subsidy will be suspended during those years in which the receipts reach 2,850,000fr."

Article 7.—"When the gross annual receipts referred to in the preceding article shall exceed 2,850,000fr., the Company undertakes to devote 50 per cent. of the excess to the formation of a special reserve fund. This fund will be invested under the control of the Minister of Posts and Telegraphs in agreement with the Minister of Finance, in French *rentes*, in shares guaranteed by the French State, or in French municipal or departmental stock, or in French railways, or in the Crédit Foncier de France. The interest accruing is to be annually added to the fund. This special fund is to be allocated as follows: (1) To the diminution of the subsidy if it has once more to be paid; (2) to the improved working of the cable and the extension of the Company's system, especially to the manufacture and laying of the transatlantic cable referred to in Clause 9: "In no case may it be employed without the permission in writing of the Minister of Posts and Telegraphs. The proportion of the surplus referred to in the first paragraph of the present clause, which is to be devoted to the reserve fund, will be reduced from 50 per cent. to 33 per cent. from the moment when the transatlantic cable, referred to later, has been brought into operation."

By Article 8 the Company is empowered to issue bonds for a sum not exceeding 20,000,000fr. (£800,000). The State subsidy is to be specially allocated to paying the interest and to redeeming of these bonds, and is to be supplemented by such proportion of the receipts as may be necessary to complete the total sum.

Article 9.—"While the present Agreement lasts, the Administration of Posts and Telegraphs will send, by preference, over the lines of the Company all telegrams for North America and the West Indies, for which the senders have not designated a special route, on the condition that the rapidity of transmission is equal to that of other routes, and the tariff is not higher. On its part, the Company will send, by means of its transatlantic lines, all European traffic received by it, and will direct it on to the points served by its cables, unless the senders have designated another route, and unless, owing to interruption or other causes, transmission by its lines would be prejudicial to the rapid and regular expedition of the telegrams concerned. When the gross annual receipts referred to in Clause 6 attain, during two consecutive years, 4,500,000fr., the French Government may demand that the Company shall lay, within eighteen months, the new transatlantic cable intended to replace the existing Brest-St. Pierre-Cape Cod cable. The route of this cable will be determined in agreement with the French Government. It is to be constructed upon the same terms as the direct cable, and it will be worked under the same regulations.

By Article 10 it is laid down that State telegrams shall enjoy a reduction of 75 per cent. upon the ordinary tariff between France and the United States, and in the case of the other lines of the Company, it shall receive at least as great a reduction as that granted to any other foreign country, and in no case is the reduction to be less than 50 per cent.

By Article 11 the Company undertakes to deposit caution money within one month from the signing of the Agreement to the amount of 400,000fr., the money to be restored to the Company upon the new transatlantic cable coming into operation.

By Article 12, the Company renders itself liable to a fine of 1,000fr. per day, in case of delay in carrying out the lines contemplated in the Agreement, and if the delay exceeds six months, the Agreement may be cancelled by a decree of the Minister of Posts and Telegraphs, and the State may confiscate the money.

By Article 13, a fine of 1,000fr. per day is imposed in the event of an interruption lasting more than 90 days, the fine to be com-

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menced from the first day of the interruption, provided always that the Company is unable to plead *force majeure*. A fine of 500fr. is to be imposed in the same way in case of interruption of any of the Brest-St. Pierre, St. Pierre-Cape Cod, St. Pierre-Canso cables. This fine is to be increased to 1,000fr. per day, to count from the first day of interruption, if these cables are not repaired within nine months.

Articles 14, 15 and 16 deal with the governmental control and traffic organisation, &c.

Article 17.—"The Minister of Posts and Telegraphs may cancel the present Agreement and take over the operation and maintenance of the transatlantic cables in the following events :—

(1) The interruption of the Brest-Cape Cod or the junction cable for more than a year, no case of *force majeure* being made out.

(2) If, after the laying of the cable referred to in Clause 9, the two new transatlantic cables be simultaneously interrupted for more than three months, except in the case of *force majeure*.

(3) The non-observance of one of the essential clauses of the present Agreement, such as 4, 5 and 9 (second paragraph).

Articles 18 and 19 deal with the settlement of disputes between the Company and the French Government, and the stamping of the Agreement.

The Agreement is dated Paris, July 2, 1895.

INSTITUTION OF ELECTRICAL ENGINEERS.

The following members constitute the Council of the Institution of Electrical Engineers for the year 1896. New members of Council, or members occupying new offices on the Council, have their names in italics :—

President.

Dr. John Hopkinson, M.A., F.R.S.

Vice-Presidents.

Sir David Salomons, Bart., M.A.	Robert Kaye Gray, M.Inst.C.E.
Sir Henry Mance, C.I.E., M.Inst.C.E.	*Prof. S. P. Thompson, D.Sc., F.R.S.*

Ordinary Members of Council.

Major A. H. Bagnold, R.E.	William E. Langdon.
Frank Bailey.	Augustus Stroh.
G. von Chauvin.	*Henry Edmunds.*
W. B. Esson.	*Prof. J. A. Fleming, M.A., D.Sc., F.R.S.*
S. Z. de Ferranti.	
Prof. A. B. W. Kennedy, LL.D., F.R.S., M.Inst.C.E.	*Dane Sinclair.*
	J. W. Swan, F.R.S.

Associate Members of Council.

Capt. W. P. Brett, R.E.	*Sydney Morse.*
H. W. Miller.	

It was announced in the course of the reading of the Annual Report that the Institution Premium had been awarded to Mr. Mark Robinson for his Paper "On the Recent Development of the Single Acting High Speed Engine for Central Station Work"; the Paris Electrical Exhibition Premium being awarded to Prof. J. A. Ewing for his Paper, "A Magnetic Tester for Measuring Hysteresis in Sheet Iron"; and the Fahie Premium to Mr. J. E. Kingsbury for his Paper, "The Origin and Development of the Telephone Switchboard." A Student's Premium was awarded to Mr. Eborall for his paper on "Single-Phase Alternate-Current Motors."

HOW TO THROW ON A RAILWAY GENERATOR.*

Many subordinates in power stations who are striving to climb higher do not know how to properly throw a railway generator on to the line, or to throw it off when the run is ended. Railway generators are usually arranged for connection to the switchboard in one of three ways. Some are provided with a double-pole switch, and the equalisers are permanently connected together. Some have a triple-pole switch and an equaliser bar, while others have three separate switches. These three methods of connection are shown in Figs. 1, 2, and 3, and in each case it is necessary to follow a slightly different method in throwing the machine on the line. In any case the following precautions should be carefully observed :—

A generator must not be thrown on a set of 'bus bars to which several dynamos are supplying current unless the voltage of that generator is equal to that of the 'bus bars. A large generator when thrown into multiple with a small generator will operate the latter as a motor unless the larger generator has a slightly lower voltage. If several small generators are connected on the line, and their combined capacity is greater than that of the large one, this precaution need not be observed. It should be remembered that when there are two machines the 'bus-bar voltage is always that of the generator of the greater capacity. Therefore this should not be high enough to overpower the smaller machine. It is wise to have the voltage slightly lower at the time the machine is thrown in.

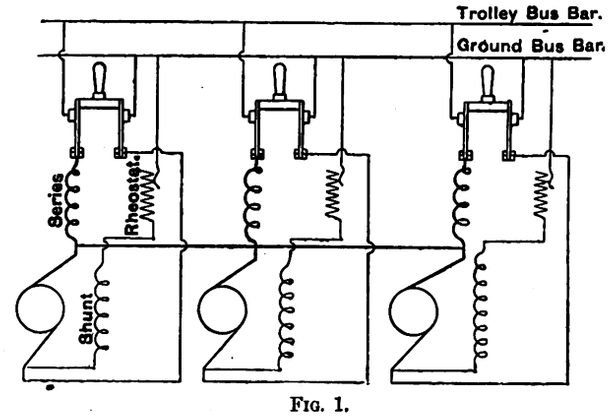

Fig. 1.

The method of procedure in case of Fig. 1 is as follows: With the brushes raised start the generator, being sure that the oiling devices are working properly. When full speed has been attained, see that all switches are open and then let down the brushes, being careful to adjust them so that they run without cutting or "squealing." Then step to the switchboard. Throw in the equaliser

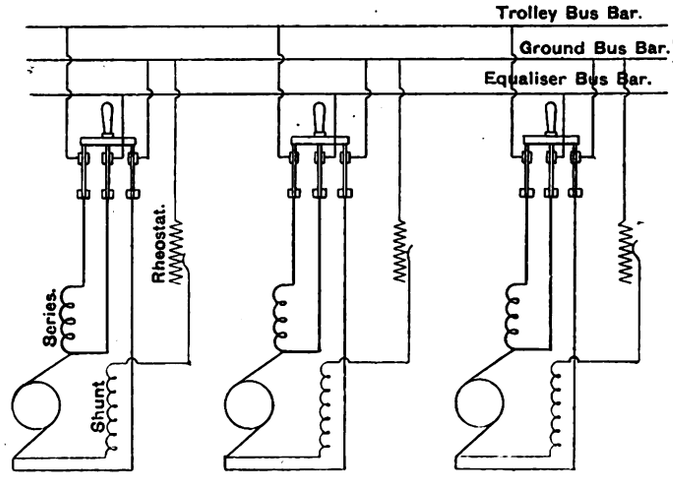

Fig. 2.

switch if there is one, and give the rheostat a turn, and let the machine build up. While the machine is building up consult the ammeter, which gives the total load on the station, and then make some such calculation as this: "I have at present a total load of 800 amperes. When this new machine is thrown in the combined

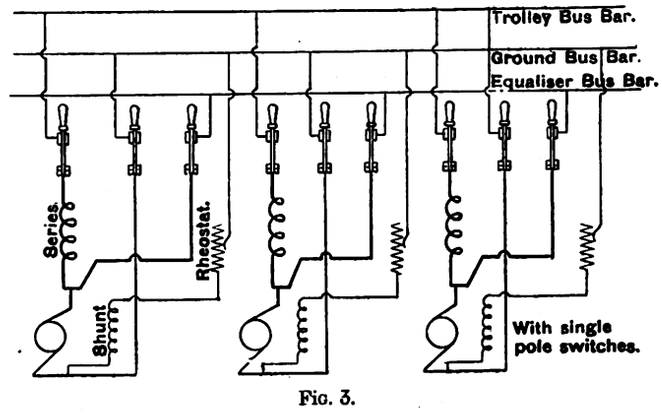

Fig. 3.

capacity of all the machines running will be 1,200 amperes. Therefore eight-twelfths of the capacity of the machine is the load it should carry.

The capacity of the machine is 250 amperes; $\frac{8}{12}$ths of 250 is 167 amperes approximately. This, then, is the load which the generator

* From the *Electric Railway Gazette* of New York.

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should carry. Probably before this calculation is finished the machine is ready to be thrown in. Bearing in mind the precautions already mentioned, bring the voltage of the machine up to the proper amount. Proceed slowly. It takes time for a machine to regulate. After the desired voltage has been reached, and shows no tendency to change, throw in the double-pole switch. Attention should at once be directed to the ammeter. By means of the rheostat adjust the current to 167 amperes, in accordance with the previous calculation. It will be found that the instrument will now readily respond to the motions of the rheostat, while the voltage depends on the voltage of all the machines, and therefore has passed out of control.

With the three-throw switch the procedure is exactly the same, only the equaliser is thrown simultaneously with the other terminals.

With the three separate switches the controller is a little more convenient. The equaliser should be thrown first, and then the switch on the positive side. All coils and instruments are by common custom placed on the outgoing wire, hence the series coils are thrown in multiple with the series coils of other machines, and are receiving a current which provides an initial excitation for the field-magnet. This prevents annoying refusals of the machine to build. After the machine has acquired the proper voltage, throw the positive switch, observing the same precautions as in the other cases.

To shut down a machine at the end of a run, stand with one hand on the main switch, and give the rheostat a slight turn, which will tend to weaken the field. The load will gradually come off the machine, as will be shown by the ammeter. Watch this instrument, and when the reading denotes about one-fourth load, throw the main switch at once. This permits the load to be gradually thrown off, and the danger of racing and wrenches to both dynamo and engine are avoided.

RESEARCHES ON ALTERNATE-CURRENT ARCS.*

BY H. GÖRGES.

These investigations were carried on during a number of years at the Charlottenburg works of Messrs. Siemens and Halske. They were conducted by Messrs. Oelschläger, Greisser and Dr. Michalke.

It is well known that with a continuous current the positive carbon assumes a much higher temperature and greater luminosity

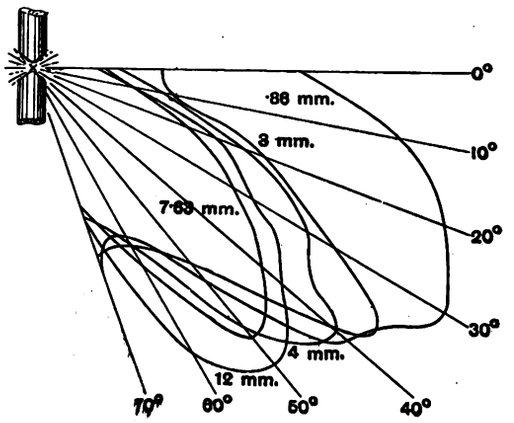

FIG. 1.

than the negative carbon. With an alternate current the upper and lower carbons are positive in turn, and the stronger light is alternately thrown upwards and downwards. The limit of perception of the flickering differs subjectively and lies at about 60 periods per second. At 40 per second it is still unendurable, at 50 it is barely perceptible. It is less seen when the arc is surrounded by a ground glass globe and when the lamp is at a greater distance. A reflector of the Helios pattern, placed close above the arc, reduces the flickering considerably by reflecting the impulses of the lower carbon and sending 100 light-impulses to the eye instead of 50. The length of the arc largely influences the luminosity with the same expenditure of energy. It is evident that each carbon takes away much of the light by creating its own shadow. Hence the arc should not be made too small. On the other hand, the temperature of the ends is highest when they are as close together as possible. Fig. 1 shows how the brightness decreases with an increasing length of arc, the energy remaining the same. The curves represent the light per watt for a 12-ampere lamp; 1mm. represents ¼ Hefner candle. The numbers at the side of the curves represent the length of arc. The shape of the current curve has also a great influence upon the character and behaviour of the arc. With some machines the curve may be altered by simply changing the connections. For the following experiments one of Siemens and Halske's "drehstrom" machines was used, which could be connected at will in triangle or in star. Taking one branch only, a flat curve was obtained (Fig. 2, I.). On connecting in star, the superposition of the curves due to both branches produced a new curve somewhat resembling the sinusoidal curve (Fig. 2, broken curve). Finally, on connecting the two branches in series in the opposite direction to the connection in star, a pointed curve is obtained (Fig. 2, II.), which is not adapted for practical use since the output of the machine is too small.

The noise made by the arc depends greatly upon the current curve. By the periodic heating and expansion of the carbon points and of the air between them, notes and noises are produced. They always occur in the alternate-current arc. With a sinusoidal curve the note is soft and musically pure; with suddenly varying curves, overtones and impure noises appear, which are perceived as a more or less loud humming. This becomes louder as the length of arc, the number of alternations and the current increase. With a greatly extended arc it sounds almost like a trumpet. The noise is much diminished by glass shades, and becomes almost imperceptible in the case of sinusoidal currents.

The temperature of the carbon points, and hence also the luminosity, is essentially determined by the energy consumed in the arc. With high frequencies the amount of light is probably independent of the form of the curve. But with the frequencies actually employed the luminosity, as has been shown in detail by Prof. Wedding and Dr. Rössler, increases with the flatness of the curves.

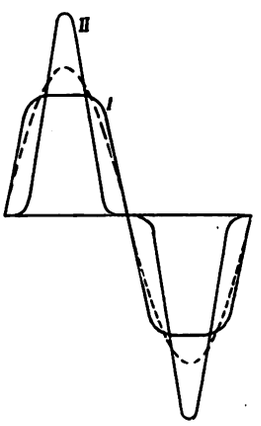

FIG. 2.

Our own measurements bear out this result. We found for a 12-ampere lamp, with a frequency of 50 per second, for a flat and a pointed curve respectively,

—	Flat curve.	Pointed curve
Mean pressure	33·5 volts.	25·7 volts.
Maximum for 1 volt mean pressure	1·19 „	1·93 „
Maximum for 33·5 volts mean pressure	40 „	...
Maximum for 25·7 volts mean pressure	...	49·2 „
Displacement of phase between current and lamp pressure	19deg.	19deg.
Mean length of arc	2·9mm.	3·1mm.
Mean spherical intensity per watt	0·960 Hefner units.	0·796 Hefner units.

The higher efficiency of the flatter curves may be accounted for in two ways. With pointed curves a short period of large current is followed by a longer time of small current. During the latter period the carbons will cool considerably. But with decreasing temperature the luminous radiation also rapidly diminishes. The intervals of small current will therefore have little influence on the luminous output. But quite a different explanation may be given. The eye perceives a mean luminous intensity when the frequency is high enough. If we imagine the light curves really traced in a system of co-ordinates, the mean algebraic value may be the same for flat and pointed curves. But perhaps the eye measures another mean value, just as the dynamometer does not measure the algebraic mean of the current intensity.

To obtain an objective record of these luminosities, a disc covered with sensitive paper was attached to a motor, and covered with a stationary disc provided with a radial slit. The result was a photographic tracing of the variations of luminosity during each revolution of the shaft. It was found that the sensitive paper is capable of recording as many as 300 alternations of light per second, where the eye sees nothing but a steady glow. Several of the traces thus obtained are reproduced in the Paper.

* Abstract of address delivered before the Elektrotechnische Verein.

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By a somewhat similar arrangement the experimenters were also able to apply the photometer direct to the light caught intermittently at a certain phase, and to determine the curves of current and pressure at the same time. The results of these measurements

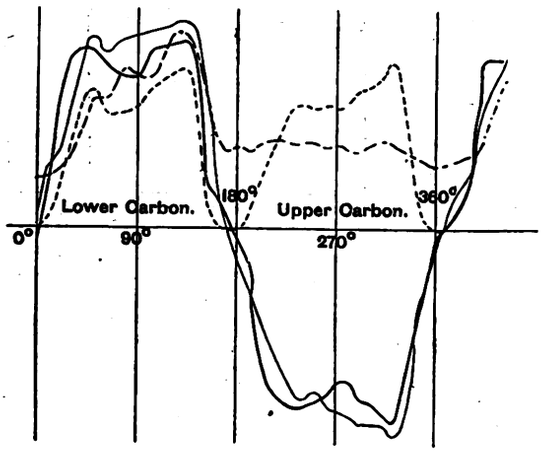

Fig. 3.—Current ——— Pressure ——— Light —.—.— Energy — — — —

are shown in Figs. 3, 4 and 5. The rays measured are those projected at an angle of 35deg. below the horizontal. During the period of large current an accumulation of heat takes place, which

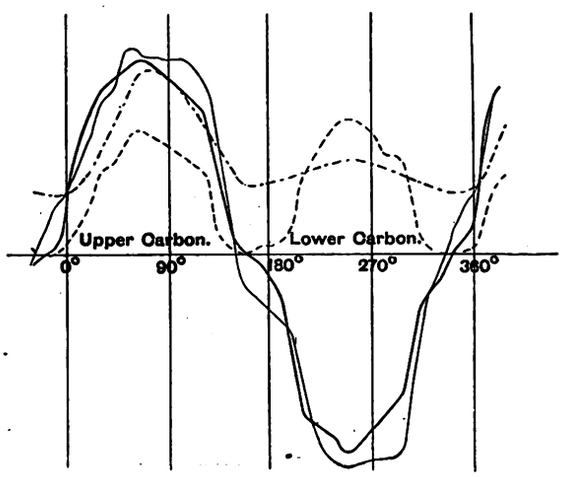

Fig. 4.

is expressed by an increase of temperature and light. This is especially seen in the flat curve (Fig. 3), but not in the pointed curve, as the current falls too rapidly. As regards the displacement

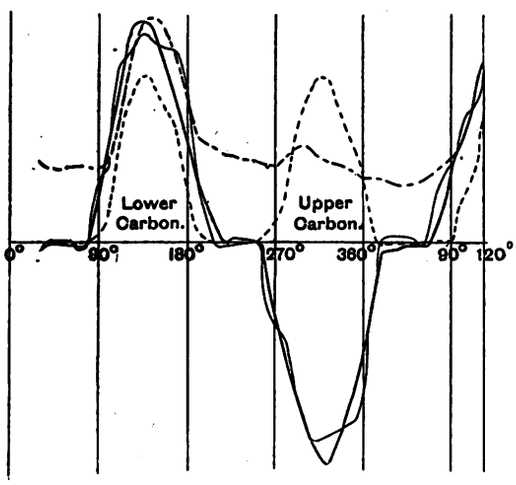

Fig. 5.

of phase between volts and current, it is decidedly positive near the zero line, *i.e.*, like that produced by self-induction. It is also seen that when the current has a high value the current suffers a negative displacement. The curves of current and light in Fig. 3 are decidedly pushed to the left with reference to the pressure. This is easily explained on the assumption of a thermo-electric counter E.M.F. in the arc. We assume that at each carbon point there is a thermo-electric force between the carbon and the atmosphere directed towards the carbon. Since the two minima are approximately equal, the thermo-electric forces must also be approximately equal, and must neutralise each other. Hence the slight self-inductance in the mechanism of the lamp and in the carbons is brought into play, and displaces the current curve towards the right. At times of large current there is a great difference of temperature between the carbon points; the thermo-electric force at the positive carbon is in excess, and produces a counter E.M.F., which reduces the current. Owing to the accumulation of heat the temperature on the right-hand side of the crest of the current must be highest, and must reduce the current more on this than on the left side. Hence the crest looks as if pressed towards the left. A similar effect may be noticed in the other curves.

REMARKS ON STEAM PIPES.*

BY J. T. MILTON.

With regard to material, by far the greater number of steam pipes have been and are being made of copper, but of late wrought iron has in a few cases been used.†

Steam pipes have to withstand considerable changes of temperature, and their length is consequently liable to continual alterations. Their attachment to the engine may be liable to slight alteration in position, owing to the working or vibration of the engines or vessel; while those to the boilers are also liable to small displacements, due to the contraction or expansion of the boilers from variations of temperatures. All these changes are generally taken up or provided for by the deformation of easy bends in the pipes, or by expansion stuffing boxes where the pipes are straight.

It must be remembered that the advance of engineering of late has not only increased the steam pressures used—and, therefore, the temperatures also—but engines are, in general, of much greater size and power than those used years ago. The steam pipes now, therefore, are, as a rule, larger in diameter, much thicker, and are subject to greater changes of temperature and expansion, &c., than formerly. These all make the pipes so much stiffer, or more rigid, that with many pipes, even when made of copper, their rigidity is so great that their yielding or altering form cannot be relied upon to relieve expansion strains, which have, therefore, to be provided for in the same way as they would need to be if the pipes were made of cast iron. Concurrently with the trouble of providing for expansion, &c., with thick and large pipes, there arises also a difficulty in manufacturing them. The usual method of making pipes of large diameter is to make them, both bends and straights, from copper sheets, the straights, except in very large pipes, having one seam along the entire length, the bends having two seams along the sides, the saddle and back pieces being each worked up from one sheet. The seams are invariably brazed, the edges of the copper being thinned down to form a scarph. Now, the difficulty of satisfactorily brazing a joint of this description increases rapidly with the thickness. The heat has necessarily to be applied from the outside, and has to pass through the thickness of the metal to reach the brazing solder, and thus the risk of overheating the copper on the outside, and consequently burning it, is much greater with thick than with fairly thin copper. There is also a further danger of deoxidising the copper, both in the brazing and also in the previous annealings to which the copper has to be subjected. To this further reference will presently be made. All these considerations have made some of our prominent engineers look with disfavour upon copper as a material for large steam pipes, and to turn their attention to iron or steel. Endeavours have been made to introduce seamless pipes of large size for these purposes to avoid the risk of brazing. These are made by several firms, and lately, I believe, with a certain amount of success; but amongst some of the earliest of those made some serious longitudinal defects, probably arising from a local defect in the original ingot being drawn out lengthwise in the manufacture of the pipe, caused them to be looked upon with a certain amount of suspicion, besides which the great difficulty of making satisfactory bends with these large pipes has, no doubt, had some influence in preventing their more general use.

The method of manufacturing the Elmore copper pipes has been publicly described, and it has been claimed that it renders the probability of their containing any latent defect very remote. The following results of tests made by the Elmore Copper Company upon two tubes made by themselves, and on one seamless tube and

* Abstract of a Paper read before the Institution of Naval Architects.

† The author here refers to marine practice.—[Ed. *E.*]

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three brazed tubes which they procured from other makers, will be of interest :—

TABLE I.

Description of pipe.	Diameter inside.	Thickness.	Pressure at which pipe burst.	Stress in tons per sq. in. produced by this pressure.	Remarks.
	In.	In.	Lbs. per sq. in.		
Elmore deposited	12·039	0·121	930	20·5	Pipe commenced to stretch at about 800lb. per sq. in.
Ditto ...	9·05	0·118	1,100	18·8	Fractured at flange only.
Seamless drawn	7·25	0·125	1,520	19·3	...
Brazed ...	12·52	From 0·104 to 0·144	580	15·58	On thinnest section
				12·66	On mean section.
Ditto ...	9·23	From 0·125 to 0·143	750	12·36	On thinnest section
				11·27	On mean section.
Ditto ...	7·38	From 0·116 to 0·126	750	10·65	On thinnest section
				10·00	On mean section.

NOTE.—All the brazed pipes burst by tearing at the edge of the brazing.

It will be observed that the seamless drawn, and also the Elmore tubes, showed a high degree of strength, which indicated that they were *hard*, or *unannealed*, a condition in which they would not be used in practice, as steam pipes are always left annealed, or very slightly hardened, by planishing. To show the actual strengths of the copper in an annealed condition, 28 test pieces were cut from these pipes, and tested in an ordinary tensile testing machine, some of them being annealed, others unannealed. The results of these tests are given in Table II. :—

TABLE II.—*Showing the Results of Tests of Strips of Copper from the Seamless Drawn, Elmore Deposited, and Brazed Copper.*

Dimensions of test piece.				Fractured area.	Extension.	Stress at which permanent elongation was first observed.	Maximum stress.	Remarks.
Length.	Breadth.	Thickness.	Area.					
In.	In.	In.	Sq. in.	Sq. in.	Per cent.	Tons per sq. in.	Tons per Sq. in.	
Tests from Seamless Drawn.								
7½	1·496	0·127	0·190	0·172	0·8	10·5	21·6	Not annealed.
„	1·494	0·123	0·184	0·165	2·5	13·06	23·4	„
„	1·497	0·125	0·187	0·151	19·8	4·4	14·7	Annealed.
„	1·495	0·125	0·187	0·144	20·7	4·28	15·3	„
Tests from Elmore Deposited Copper Pipe.								
9	1·491	0·118	0·176	0·094	22·9	2·39	21·1	Not annealed.
„	1·496	0·113	0·169	0·082	25·6	2·25	21·2	„
„	1·493	0·112	0·167	0·088	43·0	1·20	15·6	Annealed.
„	1·496	0·115	0·172	0·092	43·0	3·00	15·1	„
„	1·496	0·113	0·169	0·084	25·0	2·48	20·9	Not annealed.
„	1·496	0·120	0·179	0·097	25·0	2·78	20·4	„
„	1·495	0·117	0·175	0·084	43·0	1·49	15·5	Annealed.
„	1·495	0·120	0·179	0·091	41·6	1·40	16 2	„
7½	1·495	0·084	0·126	0·078	21·1	3·60	24·3	Not annealed.
„	1·499	0·085	0·127	0·077	20·0	2·70	24·1	„
„	1·494	0·085	0·127	0·068	43·5	2·90	16·5	Annealed.
„	1·498	0·088	0·132	0·066	45·6	2·40	16·2	„
Tests from the Copper from which the Brazed Pipes were made.								
9	1·494	0·135	0·200	0·178	19·4	3 90	17·4	Unannealed.
„	1·492	0·133	0·198	0·124	29·8	5·90	17·8	„
7½	1·496	0·121	0·181	0·141	28·9	4·14	16·5	„
9	1·495	0·136	0·200	0·151	32·6	2·25	16·9	Annealed.
„	1·490	0·135	0·198	0·117	38·8	4·10	17·2	„
7½	1·496	0·123	0·184	0·137	31·8	3·80	15·5	„
Tests from Brazed Pipes Cut across the Joints.								
9	1·488	0·110	0·164	0·175	2·4	3·30	14·0	Unannealed.
„	1·490	0·135	0·200	0·126	13·9	3·75	15·35	„
7½	1·492	0·121	0·180	0·144	2·4	3·33	13·06	„
9	1·492	0·112	0·167	0·163	2·8	2·09	14·10	„
„	1·490	0·134	0·199	0·146	20·1	2·56	14·5	Annealed.
7½	1·496	0·120	0·179	0·134	12·9	3·65	12·6	„

All but last test broke at edge of brazing. The last test broke partly at edge and partly through the brazing

Mean Results.

—	Tensile strength.	Tons per square inch.	Extension per cent.
Elmore copper.....	Annealed	15·85	43·3
Ditto.....	Unannealed	21·0	23·3
Seamless drawn	Annealed	15·0	20·07
Ditto...	Unannealed	22 5	1·65
Ordinary copper	Annealed	16 53	31·4
Ditto	Unannealed	17·23	26·0
Brazed joint	Annealed	13·55	...
Ditto.....	Unannealed	14·10	...

From these tensile tests it will appear that Elmore copper even when hard has much extension, but that it commences to elongate at much less stress than annealed ordinary copper; while, when annealed, its behaviour as to ultimate strength and extension is very similar to that of good commercial copper, but it appears to commence to elongate at somewhat lower stresses than the latter.

While treating of copper pipes it may be well to say a few words as to the qualities of copper. Engineers generally purchase their copper sheets or tubes without subjecting them to rigid tests, relying upon the reputation of the makers for supplying a good article, and not troubling about the chemical composition, &c., so long as it is found to work well. In view of the great ductility of copper, the working of even an indifferent sample of copper may not be sufficient to detect its quality, especially when made into straight pipes. Commercial copper is practically never pure, the amount of different impurities found in it being probably greater than in the case of any other metal commonly used. Information on this question can be found in the *Transactions* of Mechanical Engineers, No. 2. 1893, where two Papers will be found on the subject, by Prof. W. C. Roberts-Austen and Mr. W. Dean respectively. An opinion is generally held by locomotive engineers, coppersmiths, and many others, that the commercial copper of the present day, although chemically purer than that of years ago, is inferior in respect to its lasting qualities, both as regards ability to resist corrosive influences and also to withstand fatigue without cracking. Accordingly, for some purposes, what may be termed impurities are added to the copper for the purpose of improving some of its properties. The Papers referred to and the discussion on them appear to show that arsenic up to a proportion of ½ per cent. is certainly not injurious, and is probably beneficial, improving both the tensile strength and ductility of the copper. On the other hand, bismuth is objectionable, even small quantities, such as 0·1 per cent., being sufficient to make the metal absolutely unreliable when heated above the boiling point of water. The following figures, extracted from the Paper by Prof. Roberts-Austen, show these points. Particulars are given in the following table for comparison of pure copper and of copper containing arsenic or bismuth, in all cases the copper being as cast, not hammered :—

—	Temperature of copper.	Tensile strength per sq. in.	Percentage of elongation.
	Deg. Fahr.	Lbs.	
Pure copper ...	64	18,450	20
	64	19,740	35
Copper containing 1·2 per cent. of arsenic.	68	24,840	20
	266	20,470	16·6
	435	16,460	15
	511	14,340	4
	655	14,860	10
Copper containing 1·5 per cent. of arsenic.	59	26,460	20
	64	25,400	25 to 50
	241	23,460	26
	419	19,460	37
	500	18,360	Irregular.
	586	15,030	0
			Percentage of elongation in 4in.
Copper containing 0·1 per cent. of bismuth.	59	18,020	20
	214	11,510	15
	324	5,620	0
	390	3,860	0
	525	4,940	0
	558	2,770	0

A small quantity of lead, say under 0·1 per cent., does not appear to be objectionable, but large quantities are not desirable. On the other hand, it appears that nickel and silver are not detrimental, the samples quoted by Mr. Dean as containing the largest proportions of these elements having given satisfactory results in use. It has been stated that the tensile strength and ductility of copper vary according to its composition, but with the same mixture of metal they vary very much more with the mechanical treatment it undergoes. If properly annealed its tensile strength is compara-

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tively low, and its ductility is high. In comparing the qualities of copper, therefore, it is necessary to fix the standard as being thoroughly annealed. To show the effect of annealing and of work, the following tests recently made may be quoted. A copper tube was drawn in one operation from 3 W.G. to 11 W.G. (a very excessive draw, more than doubling its length). Its tensile strength when drawn was 24·38 tons per square inch, but its elongation was only 3·1 per cent. in 4in. After annealing (or possibly only partial annealing) its tensile strength was 18·66 tons per square inch, and its elongation was 44 per cent. in 4in. A good average result with annealed copper is 14 tons per square inch, and 40 to 45 per cent. elongation in 4in.

While treating on annealing it is interesting to compare the difference in the methods adopted in tube works and in ordinary coppersmiths' shops. In the former the tubes are annealed after every draw. They are raised to a temperature of from 800°C. to 900°C., say from 1,500°F. to 1,650°F., and are kept at that temperature for some little time, after which they are quenched in water. The tubes are uniformly heated over their whole length, care being taken that the flame is clear and contains an excess of oxygen. In the coppersmiths' shop both sheets and pipes are heated over open coke fires; the flame may possibly be reducing—that is, may have a deficiency of oxygen—if the fire is a thick one. The sheet or pipe is moved about over the fire, spot after spot being heated, generally to a dull red, and after the whole surface has been thus treated the copper is either quenched or allowed to cool, and is considered to be annealed. It thus depends upon the workman's care and judgment to ensure that every part has been heated, and there is considerable probability that some small part may escape full heating. Further, the heating cannot be uniform, nor can any part in general be retained at the red heat for any considerable time, nor is the temperature at any part raised to the same degree as is usual in tube works. The influence of time upon annealing has, so far as I know, not been much experimented upon, neither has that of the various impurities; but I am informed by Dr. Watson that annealing may be efficiently carried out at lower temperatures than 800°C., but that it requires longer time at the lower temperatures than at the higher.

To show the influence of temperature upon annealing, the following experiments are deserving of notice. A sample of copper was found to be abnormal in its behaviour, being brittle instead of ductile. Its composition was as follows:—

Copper	99·693
Nickel	0·260
Iron	0·027
Arsenic	Trace
Silver	0·020
	100·000

Six test pieces were cut off it, one was tested unannealed, and five were annealed at different temperatures. The following were the results:—

Temperature at which annealing was performed.	Tensile strength, tons, per sq. in.	Extension per cent. in 4in.	Fracture.
Unannealed	14·9	0·0	Granular.
Faintly visible red, about 525°C.	12·13	6·2	"
Dull red, about 700°C.	11·78	3·1	"
Cherry red, about 850°C.	13·89	4·7	"
Bright red, about 900°C.	14·2	14·0	Silky.
Approaching yellow, 1,000°C.	15·64	25·0	"

I am not able to say what caused the abnormal brittleness in this case, but after annealing at the high temperature the material regained a fair amount of ductility; and, after subsequent drawing or cold rolling, behaved in a perfectly normal manner. Annealing, however, at red heats left the material brittle. In this case very little time was allowed for annealing, the test pieces having been heated in an open fire and then quenched, the influence of time on annealing not having been so fully appreciated as it should have been.

Turning our attention to other materials suitable for steam pipes, we find, practically, only three, viz., cast iron, wrought iron, and mild steel. Cast iron has the advantage that it can be made in any shape, straight or bent, and that tees or junctions can be made of it. On the other hand, if the pipes are of the same strength as wrought iron or steel, they are much heavier. Wrought iron and steel may both be made with a lap-welded joint, but, whereas welds in iron are apparently looked upon as trustworthy after a severe hydraulic test, those in steel do not appear to have the same confidence reposed in them, as they generally have a riveted butt strap fitted over them. Apparently, therefore, iron pipes are preferable to steel, unless the latter are made seamless. With pipes of either iron or steel, manufacturing conditions appear to require them to be of such a thickness that either has a very large margin of strength compared with the pressures now being used, or even with those higher pressures to which marine engineering appears to be tending, so that there is no advantage in this respect in using steel rather than iron.

The question of flanges for iron pipes is important. Most of those hitherto used have had forged iron flanges screwed on, riveted over on the face of the flange, but flanges are now being electrically welded to the pipes in some cases, and welded by machine hammers in others, these plans apparently giving sound results without the chance of leakage, which screwed flanges might develop.

Regarding provision for expansion of pipes, whether of copper, iron, or steel, a point sometimes lost sight of is that it is not sufficient to provide a faucet joint in a straight length of pipe, but provision must also be made to anchor the ends of the length of pipe for the expansion of which provision has to be made, and so compel the movement of expansion to take place in the part provided for it, otherwise the end pressure on the pipes, amounting to several tons in all but the smallest pipes, will cause the joint to slide in the wrong direction. This has occasionally been overlooked in pipe designs. It is always difficult to provide for the expansion of large bends without producing excessive strains, so that, as far as possible, pipes should be made straight.

The only other point to which reference will be drawn is that of providing means of draining steam pipes. More than one fatal accident has been thought to be due to the presence of water in the pipes. In cases where it is the practice to always raise steam in all the boilers simultaneously, the stop valves on the boilers, if opened before steam is raised, may be the best possible drains for the pipes; but where there is more than one boiler it may often happen that, even if all the boilers are invariably used for steaming purposes, one only may be used in port for auxiliary purposes, and in this case leakage from its main stop valve will find the steam pipes leading to the other boilers receptacles for the condensed steam, which, if not drained, may be dangerous when opening the stop valves when raising steam in the other boilers. It is noteworthy that more than one of the serious accidents with pipes has occurred at the moment when stop valves were being opened. Too much attention cannot be paid to the provision for draining steam pipes, and it is considered that it is preferable that these should be automatic, or such as not to require personal attention.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November 30, 1895.*

The Standard Telephone Company.—An enterprise heralded some months ago in the manner of earlier electrical promotion days seems coming to a crisis. We refer to the Standard Telephone Company, which last April announced with a great flourish its entry into the field as a rival of the Bell monopoly. A capitalisation of no less than $160,000,000 was claimed, and a list published of its supporters, which comprised some of the most prominent names in the United States. Mysterious allusions were made to wondrous telephonic patents which in due time would be disclosed, and a telephonic service at a merely nominal price was promised. Thus far, however, the Company has made no installations and has given no evidence whatever of the possession of any telephone patents beyond claiming to control some old ones well known in telephone circles, and which have never been supposed to possess any practical value. At present the Company is being vigorously attacked, the charge being made that it was merely formed to obtain money from the numerous branch companies which were organised through false representation as to non-infringing apparatus, by means of which it was asserted successful competition with the Bell Company could be undertaken. No satisfactory answer has been made to these charges, and the very respectable gentlemen whose names have been the sole stock-in-trade of the Company are beginning to recognise that they may have been used as decoys in a rather disreputable scheme.

"Motocycle" Contest.—A contest of motocycles, for four prizes offered by a Chicago newspaper, ranging in value from $2,000 to $500, was announced several months ago, the time for the trial being set for the commencement of the present month. Sixty-three entries were made, and it was confidently asserted that 25 vehicles at least would participate in the race. After various postponements the contest came off on Novem-

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ber 26th, at Chicago, but with only six motocycles in the race. The length of the course was 54 miles in all, and on the day of the trial the ground was covered with slush and snow, the latter being 12in. deep in some places. Two of the six starters were electrical carriages, one of which ran only 12 miles, and the other 16. Only two motocycles, both American gasoline vehicles, covered the entire distance—one in 10 hours and 23min. and the other in one hour and 35min. additional time. A French motocycle, from the manufacturer of the vehicle which recently won the Paris-Bordeaux prize, broke down after covering about half the course.

CORRESPONDENCE.

THE COST OF LIGHTING BY GAS AND BY ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a subscriber to *The Electrician*, I have for the first time in your issue of this week seen a report by Mr. Trotter on the cost of gas and electricity at Hastings, and I would ask by your courtesy to be allowed to make a few remarks thereon.

All engineers who are engaged in the lighting industries, whether gas or electrical, must recognise that there are two sides to every question, and nothing is gained in the long run by erroneous statements made to damage one another. Having had an extended experience in both systems of lighting I have recognised the superior advantages and convenience of electric light for certain purposes, and we have ourselves put down a complete installation on our gas works for special uses, and so are fully acquainted with the possibilities of electricity for lighting purposes. I am also conversant with the admirable work done by Mr. Trotter in the measurement of outdoor illumination; but that is a very different thing to the photometrical examinations of the real value of different descriptions of light, and as a photometrist I should take serious objection to many of the arrangements made for the tests described in this report as not being conducive to that strict accuracy without which the results recorded have little real value, and this, I think, Mr. Trotter practically admits, but seeks to confirm his tests by certain tests made by others and used for the purposes of showing exaggerated comparisons. How inefficient some gas burners are under certain conditions has nothing to do with the real lighting value of the gas.

As regards the results given for the electric lamps, they are certainly taken to their very best advantage, whilst the gas burners are taken at their very worst, and show how gas can be wasted, which is equally possible with electricity. In either case the results are not obtained in actual practice. The statement that the burners tested are similar to those usually in use in the town is incorrect. The "Christiania" burner is an admirable one, but unfortunately its price is rather high, which makes its use somewhat prohibitory to all but a few; whilst the cheap burners (costing about ½d. each) are comparatively little used now, and not in the manner described. It is very certain that the "Christiania" burner used by Mr. Trotter must have been defective in some way, as it is provided with a governor which makes burners of this description unaffected by pressure, as that remains constant at the point of ignition under pressures varying from 10 tenths to 40 tenths. It is also a well-recorded fact by different experts that this burner with 16-candle gas develops a lighting value of quite 8 candles per cubic ft. of gas consumed. The question of globes should not be taken into consideration, as the same results will follow the use of obscured or unsuitable ones whichever source of light is used.

The real question is: What is the initial value of the light in each case for a certain consumption, irrespective of how badly people may misuse it or waste it?

The Parliamentary standard for gas in Hastings is 15 candles by the standard burner consuming 5 cubic ft. per hour, which has to be tested on a photometer with all the standards and accessories stipulated by the gas referees appointed by the Board of Trade. In order to comply with the Act the gas is sent out nearer 16 candles than 15, in order to be on the safe side. On October 11th, when Mr. Trotter made his tests, the recorded illuminating power of the gas going into the town was 15·93 candles. The generality of people here use governor burners of some description (costing about 1s. each), speaking only of the ordinary way of using gas, and these will easily and do develop a lighting value of quite 8 candles per cubic ft. of gas consumed. Mr. Trotter evidently does not quite appreciate the conditions which are necessary for gas distribution over large areas as regards "pressure," especially in a district like Hastings and St. Leonards. Suffice it to say that all pressure beyond that necessary to give to fulfil statutory requirements, is to the great disadvantage of the gas suppliers more than the consumers, as they can simply and easily control it, whilst extra pressure in the mains means loss by leakage.

In conclusion, the broad fact remains that in actual practice a good ordinary gas burner consuming (say) 5 cubic ft. per hour of 16-candle gas, and an ordinary 16-candle power (56 watts) electric glow lamp, both used under similar conditions, have the same useful lighting effect, and their relative cost can be easily calculated without any elaborate formulæ. Assuredly no one acquainted with the possibilities of both gas and electricity would be deceived by the "assumptions" in Mr. Trotter's report.—Yours, &c.,

CHAS. E. BOTLEY, Assoc.M.Inst.C.E., &c., &c.,
Engineer, Hastings and St. Leonards Gas Company.

Hastings, December 9, 1895.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In an article in your issue of December 6, 1895, in which you evidently refer to a recent correspondence in the local Press between the engineer of the local Electric Light Company and myself, you reproduce two of his statements—viz., that "a local critic was persuading the Hastings public that electric lighting cost three times as much as gas lighting," and that "the Hastings gasophiles have good reason to regret that they ever made exaggerated charges against glow-lamp lighting," both of which statements I have already refuted.

My statement was "that gas at 3s. a 1,000 is as cheap again as electricity at 6d. per unit," and this I substantiated, *not* by adducing the words of those interested in gas, but by the testimony and experiments of electricians themselves, taken from their own works or from the *Electrical Review*. To my mind there is a difference, which your informant cannot see, between twice and three times; whilst to talk of electric lighting as costing three, or any other number of times as much as gas lighting, without stating the actual cost of each, appears to me nonsense.

The second statement is one easily and, it is doubtless considered, safely made, because it is difficult to meet. I can only say that the alleged exaggerations by gasophiles are pure assumption, and my local opponent has *not* produced or named one single person connected with the Gas Company to support his statement, simply because the assumption is baseless; and, if fact is as valuable as assumption, it is a fact that £20 shares in the local Gas Company have, since this alleged occasion for regret, sold for £48. 5s., the highest amount they have ever fetched, whilst shares in the Electric Light Company failed to obtain a purchaser.—Yours, &c.,

December 12, 1895. GEO. G. GRAY.

BOOKS RECEIVED.

"The Electrical Transmission of Energy." By A. V. Abbott. (London: Sampson Low, Marston and Co., Limited.)

"Dynamo Attendants and their Dynamos." By Alfred H. Gibbings. Second Edition. (London: Sidney Rentall.) Price 1s.

"Kalender fur Elektrotechniker." By F. Uppenborn. (Leipzig: R. Oldenbourg. 1896.)

"Recettes de L'Électricien." By E. Hospitalier. (Paris: G. Masson.)

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LEGAL INTELLIGENCE.

Sandon and others v. the Chelsea Electricity Supply Company (Limited).

This case again came on for hearing before Mr. Justice North in the Chancery Division on Friday last, on a motion for a sequestration order against the defendants for non-compliance with an order of the Court made on June 21st last, but the operation of which was suspended until October 31st.

Mr. Warmington, Q.C., and Mr. Badcock appeared for the plaintiffs, Robert Frederic Sandon, the landlord of certain flats in Cadogan-gardens, and two of his tenants; and Mr. Fletcher Moulton, Q.C., Mr. Vernon Smith, Q.C., and Lord Robert Cecil for the defendants.

Mr. WARMINGTON said that on May 24th an order was made that the writ should be treated as the statement of claim, and that the defendants should put in a statement of defence within 14 days. Leave was also given to the plaintiffs to expedite the trial of the action. After the defence had been delivered the plaintiffs moved to expedite the trial. The defendants then said they would treat this motion to expedite as the trial of the action, and submitted to the injunction of June 21st. The order was to the effect that the defendants, their servants or workmen, should be perpetually restrained on and after October 31, 1895, from so working their engines and so carrying on their works in Cadogan-gardens, Chelsea, as to cause a noise, vibration, or otherwise to interfere with the enjoyment of the occupants of residential flats at 21, Cadogan-gardens. Mr. Warmington said that since October 31st the plaintiffs still suffered from this nuisance of vibration and noise, and therefore they had come to the Court for a sequestration order against the defendants for not complying with his Lordship's order.

In reply to his Lordship, Mr. MOULTON said he did not suggest that his clients had a statutory right to create a nuisance. He should argue that his clients had reduced the interference with the plaintiffs' property to such a pitch that it was no longer a substantial interference with the enjoyment of the property, and was no longer a nuisance. He should rely on two points: first that there was no nuisance, and secondly that his clients had done all they could, and all that it was reasonable to expect them to do, during the period that had been allowed to remove all interference, and they had succeeded to a very great extent.

Mr. Justice NORTH: Your first point is no nuisance; your second point is that, although you have not completely removed the nuisance, you have done your best and done all you could in the time, and if you have a little more time you will get rid of all nuisance?

Mr. MOULTON: Yes, my Lord. We have spent £10,000 in changing the type of machines and in altering our building.

Mr. WARMINGTON then read a number of affidavits from the plaintiffs, several residents in the flats, and visitors to the residents. All testified to the great vibration created by the defendants' machinery, causing water bottles, lamps, glasses, ferns, &c., to shake and rattle. One affidavit stated that the noise was like that experienced when next to the engine room on board a large steamship; another that the noise was like that of a screw of a steamship whilst in motion; another compared the noise to an earthquake; and other witnesses said their health had suffered by the noise, and that they could not read or write.

Mr. VERNON SMITH said that the electrical energy was now generated three-quarters of a mile away from the station in Cadogan-gardens.

Mr. MOULTON said that, shortly, what had been done was this:—The engine room had been cut in two. The portion next to the plaintiffs' premises had been made a separate room, and a brick wall had been erected right across the engine room. In this separate room were placed three transformers but no engines. These transformers could not possibly cause any vibration. They were worked from energy supplied by a distant engine with transformers. With regard to the other portions the defendants had reduced the number of large engines to two instead of three, and the number of small engines to four instead of eight. They had tried to do more than that; they had tried to obtain a class of engines which were less liable to cause vibration, and they had done their best to get them, but they had not yet been delivered.

Affidavits in support of the defendants' case were also read from General Webber, Deputy Chairman of the Company, Sir Frederick Bramwell, Prof. Perry and others.

Mr. MOULTON said that to prove how absolutely dominant the imagination of some people might be, he would mention that, on the occasion when one witness said the vibration was so great that the fireirons rattled, there were no engines working at all.

His LORDSHIP said that after hearing the evidence his impression was that the defendants should have longer time to complete the alterations which he was satisfied had to some extent been made. If the Court were now considering finally whether a sequestration order should be made or not, he would have to do what had been done in another case—namely, to employ an expert to go and see the premises and report to him. One case in which there was a question of nuisance, and in which there were strong affidavits on both sides by witnesses who were quite honest, he was pressed to go and see the place himself. He did not care to go when everything was put nice and clean, but he went himself one night without telling anybody, and he found that two or three witnesses on one side had described what he found to be the case with wonderful accuracy. His Lordship said that although his impression upon the evidence was that the defendants should have more time, his mind was quite open to conviction one way or the other.

Mr. MOULTON said the defendants were going to make very large further changes, and, after consulting his clients, he proposed that they should continue with all diligence to make these changes, he undertaking on their behalf that no machines should work after eleven at night; after that hour only the batteries and the transformers should work, and, as far as the defendants could, they would remove all the vibration before eleven. That would, at all events, preclude any possibility of any disturbance or any vibration late at night. In doing this he (Mr. Moulton) must not be taken as making any admission against his clients. The delay was only wanted for the purpose of carrying out the order in obedience to his Lordship. Mr. Moulton also said he was perfectly willing that his Lordship should name some expert to examine the premises.

Mr. SWINFEN EADY (for the Rev. M. Fowler, another complainant), Mr. WARMINGTON and Mr. BADCOCK then addressed his Lordship, the last-named gentleman arguing that it was not a question of diminution of the nuisance, but a question of nuisance or not. If there was still a nuisance the plaintiffs should succeed, and the defendants were not entitled to any further indulgence.

After some further discussion his Lordship, in giving judgment, said that he had come to the conclusion upon the evidence in the case that he ought to give further time to the defendants. He did not think that the nuisance, which the judgment showed did exist at the time it was pronounced, had been entirely removed. The defendants had done a great deal of work which had cost them much money. Of course, if the works could not be carried on without a nuisance to the plaintiffs, the defendants would have to close them altogether, no matter what inconvenience or pecuniary loss resulted to them from it. He was satisfied that they had not spent this large sum of money without some expectation that they would be able to leave the works where they were. Then there were certain other facts which had influenced him in the view which he took. It was clear that the engine power of the defendants had been reduced by one-half, and he could not believe that there was the same noise or vibration from engines with half the power that there was when there was double the power. No explanation had been offered about that. He was satisfied that there had been a *bonâ fide* attempt on the part of the defendants to comply with the order of the Court. Getting new machinery in must necessarily take some time, and delay must be caused by it. The judgment that was given and consented to by the plaintiffs showed that some time was necessary for the defendants to make the necessary alterations and improvements, and looking at what the defendants had done, he was inclined to say that the time had not been enough, and he would therefore grant them three months' longer time from that day in which to complete the alterations. The only question remaining was as to what terms he must impose on the defendants. He would require, and would accept, the undertaking of Mr. Moulton that the defendants would not work any steam engine after 11 p.m., and would complete their alterations then in progress as early as possible.

Some question was then raised as to whether the plaintiffs would wish an expert to inspect the defendants' premises periodically, to see if the alterations were being carried out satisfactorily.

Mr. WARMINGTON stated that the parties between them could probably agree on some gentleman to do so, but if not an application would have to be made to the Court.

Boyes v. Wellington and Co.

In the City of London Court, before Mr. Commissioner Kerr, was heard an action brought by Mr. Stephen Boyes, of Margate, to recover the return of £6. 10s. from the defendants, Messrs. Wellington and Co., electrical engineers, 73A, Queen Victoria-street, E.C., the price of one of their National Combination Chucks, with reversible jaw. The plaintiff had purchased the chuck of the defendants, they guaranteeing that it would work perfectly, to use in connection with certain electrical machinery. The defendants assured the plaintiff that the chuck was "dead true," and gave the plaintiff a printed description, in which the special virtues of this particular device were enumerated. When he took the chuck home he put it in a lathe, and, he alleged, found it was not true, and was therefore useless. The work produced by it was defective and of a useless character, and he therefore asked to have returned to him the £6 he had paid and 10s. by way of damages. It was tried in a new lathe.

For the defendants it was said that they made similar chucks by the thousand, and had never before had a similar complaint. It was simply impossible for the chuck to be untrue. The plaintiff did not return the chuck for three months and a-half, and they then, not unnaturally, refused to take it back.

Mr. Commissioner KERR said the proper course was to have the chuck honestly tested by an engineer, the cost to fall upon the person who was in the wrong. He was surprised at any difficulty being made about such a matter by a man who carried on business in the City of London, except that morality in trade was not what it should be.

The case was then referred to an expert, he to report to the Court.

Mitchell and Co. v. Nicholls.

In the Westminster County Court on Tuesday an action was brought by the plaintiffs, a firm of electrical engineers, to recover a balance of account of five guineas in respect of electric lighting work done.

Mr. DAVID MITCHELL said that in November of last year he had a conversation with the defendant, who was desirous of having the electric light fitted up at his house at Hampstead. Witness offered to give a price for the work, but the defendant said it did not matter, as he wanted it got on with without delay. Acting upon those instructions he (plaintiff) carried out the order in accordance with the defendant's wishes, and in due course an account for £15. 5s. 4d. was rendered, and various sums were paid on account from time to time; but when the balance was pressed for the defendant set up the contention that he was not liable on the ground

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that there was a verbal contract to do the work for a fixed sum of £9. There was no truth in that suggestion, however, and the present action was to recover the balance due.

The DEFENDANT appeared in person, and swore most positively that the plaintiff told him the cost of the work should not exceed £9, and it was upon that understanding that the order was given.

His HONOUR said that if such a bargain was ever made it was strange that it was not put into writing.

The jury found for the plaintiffs, with costs.

Judgment was entered accordingly, and his Honour refused the defendant's application for time in which to pay.

POLICE INTELLIGENCE.

Alleged Fraudulent Marking.

At Clerkenwell Police Court on Wednesday Alfred Attride, of Richmond-road, Kingsland; Edward Ingold, electrical engineer, of Woodlands-road, Leytonstone; and George Cosgrave, electrician, of Church-street, Putney, were charged on a warrant with unlawfully applying to certain lamp-holders marks which resemble the trademark of the Edison and Swan United Electric Light Company (Limited).

Mr. WONTNER, who represented the Company, said the defendants would be charged with conspiring to defraud the Edison and Swan Company, who carry on business as manufacturing electricians and electric supplies dealers at Queen-street, London, E.C., and also with infringing the Merchandise Marks Act. Ingold was formerly in the employment of the Company as a clerk, and was the head and front of the conspiracy. He was discharged in 1892, and since then, it would be shown, had, with the aid of the other defendants, been carrying on a fraudulent business by forging the name of the Edison-Swan Company upon lamp-holders resembling those manufactured by the Company. Attride was accused of having had a circular stamp made, at the instigation of Ingold, and Cosgrave would be shown to have used a stamp belonging to Messrs. Paterson and Cooper, electrical engineers, of Pownall-road, Dalston, E. Cosgrave had been employed by Paterson and Cooper (who were licensed by the Edison and Swan Company to stamp lamps and sell them), and he had taken the stamp home and used it. In addition to this stamp, which had been used in these fraudulent transactions, there was the stamp which was made for Attride by a stampcutter at St. Luke's. Ingold had a number of incandescent electric lamps made in Germany, and after these had been stamped they were sold at less than half the price at which such lamps were sold by the Edison and Swan Company. After the opening statement of counsel, the evidence of Walter Finlay, an electrician, formerly in the employment of the Edison and Swan Company, was taken. He said he left the Company's service in 1892. He had since then, at Ingold's request, obtained consignments of lampholders from a maker at Cologne, and Ingold paid him for acting as agent.

The further hearing was then adjourned.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HAND-BOOK is in active preparation, and orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. The usual circulars, &c., are now being sent out. Full particulars post free on application.

TENDERS INVITED.—The Corporation of Durban invite tenders for the supply, and for delivery and fixing at Durban, of steam and electrical plant (high-speed steam engines, dynamos, cables, arc and other lamps, accumulators, &c.). Specifications and plans can be obtained from the consulting engineer to the Corporation, Mr. W. H. Radford, Angel-row, Nottingham, and tenders (in duplicate) must be delivered at the offices of Messrs. Webster, Steel and Co. (agents to the Corporation), 5, East India-avenue, London, E.C., by the 28th inst. Further particulars appear in our advertisement columns.

——— The Leyton Urban District Council require tenders for electric lighting works, including central station buildings, gas engines, travelling cranes, piping, &c., dynamos, switchboards, &c., storage batteries, and five miles of mains, including laying. Tenders to Mr. R. Vincent, clerk, Town Hall, Leyton, Essex, before 6 o'clock on *Tuesday next*.

——— The Guardians of St. Luke, Chelsea, require tenders for the fitting up of an electrical wiring installation, including fittings, in the Chelsea Infirmary extension, Cale-street, Chelsea. The specification and form of tender can be obtained from the 17th to the 28th inst., inclusive, from the architects, Messrs. Lansdell and Harrison, 12, Compton-terrace, Highbury, London, N., and tenders must be sent in to Mr. Wm. Miller, Clerk to the Guardians, at the offices, 250, Kings-road, Chelsea, S.W., by noon of December 31st. Some further particulars are given in our advertisement columns.

TENDERS INVITED.—Particulars may be obtained at the Brazilian Consulate in London, Liverpool, Manchester or Glasgow of tenders required for lighting the city of Pernambuco by electricity, which are invited by the Government of the State of Pernambuco, Brazil. Some particulars are given in our advertisement columns.

——— The City Council of Aussig-a.-d.-Elbe invite proposals for the construction of about 11 kilometres of tramways. Tenderers may provide for electric or other motive power in their schemes. Tenders to the Bürgermeister, Aussig, Germany, by January 31st.

——— The Manchester City Council invite tenders for wiring, and for the supply and erection of accumulators, columns and lamps for the electric lighting of the Foreign Animals Wharf, Mode Wheel. Tenders, addressed to the Chairman of the Markets Committee, must be delivered at the Town Hall, Manchester, by 10 a.m. on the 20th instant.

——— The Cleator Moor Co-operative Society require tenders for an electric light installation at their central stores. Particulars from the Secretary, Mr. J. C. Teasdale, Cleator Moor, Cumberland.

——— Tenders are being invited by the Wallassey District Council for installing the electric light at the Seacombe, Egremont and New Brighton Ferries. Tenders to the Chairman of the Ferry Committee, Public Offices, Egremont, by 4 p.m. on Monday next.

——— The Municipality of Ploesti invite tenders for lighting 46 of the principal streets in the centre of the town by electricity. Particulars from La Mairie de Ploesti, Roumania.

——— The Belgian Minister of War invites tenders for the electric lighting of the new military school in the Avenue de la Renaissance, Brussels. Tenders to the Ministère de la Guerre by January 15th.

——— The General Direction of the Belgian Posts and Telegraphs invites tenders for the supply of 11,692 telegraph poles. Tenders to the Direction Générale des Postes et Telegraphes, Brussels.

——— The Alsace-Lorraine State Railway authorities are inviting tenders for the supply of 1,010 telegraph poles. Tenders to the Betriebs-Direktor der Reichs Eisenbahnen, Strasburg.

——— The Prussian State Railway telegraph authorities at Saarbrücken invite tenders for the supply of 28 normal sets of Morse telegraph apparatus. Tenders to the Eisenbahn Telegraphen Inspektion, Saarbrücken, Germany, by the 16th instant.

——— The Mayor of Charkow (Russia) invites tenders for the supply of steam engines and electrical machinery and apparatus necessary for an electric light installation capable of supplying current to 6,000 incandescents and 500 arcs.

——— The General Consul of the South African Republic invites tenders for the delivery of 5,000kg. 2mm. hard drawn copper wire for the Telegraph Department of the Republic. Conditions, &c., from Messrs. Belinfante Bros., Paveljoensgracht, The Hague, and tenders must be sent in to the Consul, at the American Hotel, Leidsche Plein, Amsterdam, by December 20th.

TENDERS ACCEPTED.—The Eccles Town Council have decided to accept the tender of the Manchester Edison-Swan Company for the supply of machinery, &c., in connection with their electric lighting scheme for £13,792.

——— At the last meeting of the Metropolitan Asylums Board the South-Western Committee reported that they had accepted the tender of the Private Wire and Telephone Installation Company for fixing fire alarms and electric bells at the new administrative block for £71. 6s.

——— The Electric Lighting Committee of the Belfast Corporation have accepted the tender of Messrs. J. H. Holmes & Co. for the supply of electrical instruments, and of Messrs. Gill and Russell for iron pipes for their electricity works.

——— The Improvement Committee of the Sheffield Corporation have accepted the tender of the Sheffield Electric Light and Power Company for wiring the Town Hall for the electric light at £720. The tender of Messrs. W. Singer & Sons, of Frome, for supplying and fixing the electroliers at £1,028, has also been accepted.

——— The contract for wiring and fitting up Messrs. Metcalf and Kirkpatrick's premises, Wellington-place, and also the Kentish Hotel, Tunbridge Wells, has been given to Mr. F. Bruce, Hastings.

——— The Stafford Town Council have accepted the tender of the Stanton Ironworks Company for laying steam piping between the boiler houses at the electricity works and the neighbouring gas works for £65 12s. 6d. The tender of the Smethwick Boiler Covering Company, for covering the pipes with non-conducting composition at £38, has also been accepted.

TENDER RECEIVED.—Three tenders received by the Dundee Town Council for wiring and fitting up the Lochee Free Library and Baths for the electric light have been referred to the Lord Provost and the architect of the buildings for consideration.

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EXPERT SERVICES REQUIRED.—The Guardians of Mile End Old Town contemplate lighting their municipal establishments by electricity, and are open to receive from consulting electrical engineers proposals for supervising the work, including the preparation of specifications, plans, &c. Some further particulars are given in our advertisement columns, and proposals must be sent in before the 19th inst. to Mr. W. Thacker, Clerk, Guardians Offices, Bancroft-road, London, E.

APPOINTMENT.—Mr. Francis G. Baily, M.A., Cantab., for some time Lecturer in Electrotechnics at University College, Liverpool, has been appointed to succeed Prof. R. Mullineux Walmsley at Heriot-Watt College, Edinburgh.

VACANT APPOINTMENTS.—As will be seen from our advertisement columns the Vestry of St. Mary, Islington, have vacancies for three electricians (salary £2 per week), one foreman fitter, and a number of workmen in connection with their electricity supply scheme. Written applications have to be sent in addressed to the Electrical Engineer, Electricity Department, 50, Eden-grove, Holloway, London, N., by twelve o'clock noon of Monday, the 16th inst.

CHANGE OF ADDRESS.—The North of England branch office of the General Electric Company (Limited) is removed from 21, Grainger-street West, to 13, Westgate-road, Newcastle-on-Tyne.

REMOVAL.—Messrs. W. F. Dennis and Co., the well-known agents for Messrs. Felten and Guilleaume and for the Antwerp Telephone Works, are removing from No. 11 to No. 23, Billiter-street, London, E.C.

DISSOLUTION OF PARTNERSHIP.—Messrs. R. L. and S. L. Baxter and D. J. Macdonald, hitherto trading as mica merchants at 81, Murraygate, Dundee, have dissolved partnership. Debts by Messrs. R. L. and S. L. Baxter.

THE "DOVETAIL" DYNAMO AND MOTOR BRUSH.—Messrs. F. W. Potter and Co. send us illustrated particulars of the "Dovetail" copper gauze brush for dynamos and motors made under Soar's patent, for which, it is claimed that they are not stitched, do not

FIG. 1.

wear oval at the commutator, do not turn up at the points, and require a minimum of attention. The "Dovetail" brush is so folded that the part intended to face the commutator consists of plain layers of gauze to the extent of about one-half of the thickness

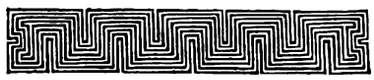

FIG. 2.

of the brush, backed by about an equal quantity of gauze folded or corrugated at or nearly at a right angles to the plain layers as shown in Fig. 1, or without the plain layers as in Fig. 2, and the degree of stiffness given to the brush can be varied to almost the rigidity of metal.

TIME-CHECKING CLOCKS.—We have received particulars from Messrs. F. Brook and Co., of Huddersfield, of Brook's patent "Paragon" automatic time-checking clock, which consists of mechanism for recording the arrival and departure of workpeople by means of the automatic disposal of workpeople's checks according to their punctual or late arrival and departure from the works. These clocks can be worked either by electricity or clockwork. If by electricity, the clock can be fixed in the office, or at any conspicuous part of the works, and any number of time-checkers can be accommodated from it. This arrangement is specially devised for large works, where there are several workpeople's entrances.

"CASSIER'S MAGAZINE."—An excellent number of this popular American magazine is issued for December. The articles include "The Evolution of the Portable Engine," "Electric Power in Collieries," "Power Consumption on Electric Railways," "Some American Vertical Boilers," "False Economy in Foundry Equipment," and some interesting reviews under the heading of Current Topics. Several of the articles are well illustrated, and the magazine is, as usual, well printed on good paper.

CALENDAR.—We have received from the Direct United States Cable Company a useful hanging pad calendar for 1896.

TOBIN BRONZE.—This elegant and artistic name is given by the Ansonia Brass and Copper Company, of New York, to an alloy which they manufacture for engineering purposes. The merits of this material are set forth in a tobin-bronze-coloured pamphlet, a copy of which we have recently received. The alloy appears to possess great tensile, crushing and torsional strength; and in addition those properties of elasticity, &c., which are essential to a material intended for use in engineering constructive work. Among other things, tobin bronze has been found useful for making drop-forged commutator segments.

HEATHMAN'S LADDERS.—A new catalogue just issued by Messrs. Heathman and Co., of Endell-street, Shaftesbury-avenue, W.C., will be found to contain useful information for companies and local authorities engaged in public lighting. Ladders manufactured by this firm are largely used in the cleaning and tending of public lamps in London and several towns in the provinces.

ABERDEEN.—The offices of the Northern Assurance Company in Union-terrace have just been fitted up for the electric light. About 100 incandescents are employed, and the fittings throughout the building are of artistic design. The other tenements in the building are also wired, the entire contract having been entrusted to Messrs. Shirras, Laing and Co.——Experiments are being made with a view to the adoption of suspended overhead street arcs in the principal thoroughfares of this city. It has been arranged that several lamps shall be suspended at distances of about 60 yards as a trial.

ADELAIDE (SOUTH AUSTRALIA).—Some time back the Corporation of this city decided to make experiments in electric lighting in the public streets, and early in November practical effect was given to this resolve. The arc lamps are Crompton's make, and have been erected by Messrs. R. W. Thomson and Co., of Leigh-street, Adelaide, current being supplied from the same firm's supply station at Bank-street, from which the theatre, a number of hotels and many of the principal shops in the city are now supplied with current.

BATH.—At the last meeting of the Urban Council it was decided to form a special Electric Lighting Committee.

BURSLEM.—The North Staffordshire Tramways Company have entered into an undertaking with the Burslem Town Council to make extensions to their tramway system in different districts within two years.

BUXTON.—At the meeting of the District Council on Friday the Electric Lighting Committee's report stated that it was undesirable to instal the electric light in Buxton at present. The Council obtained a Provisional Order in 1894, and the Committee have been considering the electric lighting question for some time past. Evidently it is intended to proceed leisurely in the matter, and to do nothing "rash or injudicious."

CHELTENHAM.—The Electric Lighting Committee report that applications for current are coming in in a very satisfactory way from all parts of the town. Some extensions will shortly have to be made—notably to Leckhampton, from which district an offer has come from Mr. Harold Webb, who agrees to wire for the electric light a number of workmen's houses he is building if the Committee will put in prepayment meters. Mr. Norman, in referring to this offer, stated that this was the first indication of a change which the Committee were very anxious to adopt, and which will, he anticipates, lead to a considerable increase in the consumption of current amongst tenants of the smaller houses. A number of Brush-Vienna arc lamps and transformers have been ordered by the Committee. The number of lamps applied for equals 5,120 8 c.p., and of these 4,300 are wired. It was originally anticipated that 5,000 lamps would be connected up by Christmas. It is now estimated that this number will be 6,000.

CHINESE TELEGRAPH CABLES.—The Chinese Telegraph Administration has recently laid a cable from Yangtse to Tsungming, and communication with that important island is shortly to be opened.

COLWYN BAY.—At the last meeting of the District Council Mr. W. Davies moved that the Council oppose the Dissolution and Re-incorporation Bill of the local gas company, and that the Council's application to the Board of Trade for a Provisional Electric Lighting Order be proceeded with. Mr. J. Roberts moved that the Council ascertain the views of the ratepayers as to the purchase of the gas undertaking, and that no opposition be made to the Company's application to Parliament. After a long and acrimonious debate the amendment was carried by five votes to three.

DEVONPORT.—The County Council, at a special meeting yesterday, decided to apply to the Board of Trade for a Provisional Electric Lighting Order.

DUBLIN.—It will be remembered that the Dalkey Town Commissioners decided to oppose the application of the Dublin Southern District Electric Tramway Company for powers to extend the electric tramways to Dalkey. After a discussion with Mr. J. Clifton Robinson, C.E., the Managing Director of the Company, the Commissioners, without rescinding the resolution to oppose, have agreed to receive a deputation to again discuss the matter.

ECCLES.—The Property Owners' Association has decided to oppose the Town Council's proposal to spend £20,000 in carrying out their electric lighting scheme.

EDINBURGH.—Prof. A. B. W. Kennedy has just presented a report on the proposed extension of the electric light system in

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Edinburgh. The report, which recommended considerable additions to the generating plant and mains, was considered and approved by the Electric Light Committee at their last meeting. The Town Council will consider the matter at their next meeting. The Committee report that they have now an equivalent of 46,000 8 c.p. lamps connected, the total number of units sold during the thirty-four weeks' period of supply being no less than 285,000, generated at a cost of 1·56d. per unit sold. Thus, in the first 37 weeks' working all working expenses have been paid and nearly all charges for interest and sinking fund. The total capital expenditure has worked out a little less than Prof. Kennedy's estimates. Considerable additions have, however, been made, both in the station buildings and the mains, which have caused additional expenditure. Prof. Kennedy says: "The result seems to me to have been the best possible justification of the policy adopted by the Town Council in making these extensions. From Mr. Monkhouse's statements to me, and from my own observation of what has been going on in Edinburgh, I can hardly doubt that you must be prepared to supply current to an additional 40,000 or 50,000 lamps at least (beyond those now connected) by next winter. The smallest addition to the plant which would meet the case would be four more machines, each of 225 kilowatts. These, together could provide for 26,400 lamps alight at once, or say 53,000 lamps wired beyond those at present on the circuit. The station could therefore safely supply current for 90,000 to 95,000 lamps wired, including the equivalent of the arc lamps, which number will, no doubt, be reached by the end of 1896; and I think the only question now is whether you should put down four or six new sets at once. These additions are to the continuous current plant. The proposed lamps in Clerk-street and in Leith-walk will be high tension lamps, and if these are sanctioned, two more rectifiers will be required, which will be sufficient for 25 or 30 additional lamps for still further extensions. An additional alternator will be required, and I think ought to be of a capacity about double that of the present ones, or say 160 kilowatts. It would further conduce to economical working if a motor-alternator were provided to be driven by the battery in the day-time, so as to avoid the necessity of always keeping an engine (with boiler) actually at work. The boiler-house is large enough for many more new boilers, of which it is recommended that five be added of the existing type (the Droyback marine). As to mains—the existing feeders, which contain, of course, the heaviest copper, have been laid large enough for about 75 per cent. beyond their present load, so far as they are laid in armoured cable. Those portions of them which consist of bare strip can be nearly doubled in section without moving the roadway or pavement, and at a very moderate cost." Prof. Kennedy then refers to the question of high-voltage lamps, and says that the supply of these has come sooner than was expected. The report proceeds:—"The system which I recommended to you and which you have carried out was chosen so that full advantage could be taken of these new lamps whenever they came on the market. They are already to be had, of satisfactory quality, up to 200 and even 250 volts. I hope, therefore, that before long your system may be changed into a three-wire system, at just double its present voltage, a change which will quadruple the present carrying capacity of the mains, and will involve very little change in the station plant, engines and dynamos." In this connection the question of the existing lamps is a formidable one, and Prof. Kennedy makes the following suggestion:—Let the undertakers give notice (*a*) than on and after a certain date (say February 1st, or, perhaps, May, 1896), their standard voltage will be 230 in respect to all consumers connected after that date; (*b*) that on and after another certain date (say August 1, 1897), the new voltage will be standard over their whole system, new and old; and (*c*) that at any time between those dates the undertakers will supply any existing consumers with new lamps (for 230 volts) at the price of 6d. each, the old lamps becoming the property of the undertakers. The effect of this last clause would be that each consumer would run his existing set of lamps as long as possible, and then buy a new set very cheaply from the undertakers. The undertakers would probably lose about 8d. per lamp on the transaction. Prof. Kennedy estimates the total cost of this change to the Edinburgh Corporation at about £670, plus the wages of men employed in changing the lamps, &c. There are no electrical difficulties in the way of making the change. There are some difficulties in detail as to shops which at present use not more than two arcs, and as to a few motors, but these are small matters which can be easily arranged. After referring to the fact that, owing to savings effected in the estimated cost of previous extensions, additional extensions can be safely sanctioned, the report concludes with a recommendation that a substantial reduction either in the nominal price or in the scale of discounts should take effect from the new year. The Committee, after careful consideration of the foregoing report, recommend that four engines and dynamos low-tension, one engine and dynamo high-tension, two rectifiers, five boilers, and all necessary apparatus be added to the existing plant.

ELECTRICALLY-DRIVEN VENTILATING FANS FOR THE NAVY.—It is stated that experiments are about to be made by the Admiralty as to equipment of vessels with electric fans for ventilating purposes.

ELECTRIC PLANT FOR GOLD MINES.—The Directors of the Sheba Gold Mine Company have recently issued their report to the shareholders, in which reference is made to the extensive plant recently sent out by Messrs. Johnson and Phillips. The Directors state that the laying down of the plant by which power generated at the Queen's River has been transmitted seven miles, was a great experiment, and that the Directors, on the whole, are well satisfied with the result. The first electric plant ran 25 stamps, but was gradually developed to 50 stamps, and motors are now being sent out to deal with a remaining 10 stamps. In addition to this plant electrical machinery is to be erected to supply power for working the new air-compressing plant for ten drills. Arrangements have been made to provide adequate water power to secure the continuous working of the electrical machinery.

FAREHAM.—At the meeting of the District Council on Friday last the result of the recent action at law between the Council and the Fareham Electric Light Company, which was fully reported in our columns, was discussed. A number of ratepayers attended, and the meeting was a very noisy one, which is not unusual at Fareham when the electric lighting subject is discussed. The Chairman of the Council (Mr. W. Pankhurst) now proposes to take a poll of the ratepayers to ascertain their views as to the action to be taken with regard to an appeal. It was decided that before paying the damages awarded, or accepting the offer made in Court by the Company to complete the purchase of the undertaking, that a poll should be taken on December 21st.

FIRE.—A fire broke out on the premises of the Automatic Electric Sign Company, in Swaine-street, Bradford, on Sunday last. The damage was very slight.

FOUNDRY LIGHTING.—The works and offices of Messrs. Dobbie, Forbes and Co., of Larbert, have been fitted up for the electric light. The offices and pattern shops are lighted by means of incandescents, while arcs are employed for lighting the main arteries of the moulding shops and furnace, thus allowing the somewhat dangerous process of running the bogie ladles with less risk of accident. A very ingenious arrangement has been applied in part of the moulding shops, the invention of Mr. T. Laurie, whereby each moulder can traverse his lamp from end to end of his "row," move it up or down, and bring it to project the light on any part of his work. The installation has been carried out by Messrs. T. Laurie and Co., of Falkirk.

FULHAM (LONDON).—A special meeting of the Vestry was held last week to consider the advisability of applying to the Board of Trade for a Provisional Order. Mr. Sayer (the Chairman of the Electric Lighting Committee) said that, while he was prepared to move that the Vestry apply for a Provisional Order, they could not take action until November or December next. They had engaged an electrical expert to advise them, and had decided to oppose the Capital and Counties Electricity Supply Company's application for an Order. Under the circumstances he thought it would be unwise to proceed to a vote, and he moved that the question be adjourned for three months. The matter could be considered when they had received their electrical engineer's report, and they would not prejudice their position by adopting this course. An amendment to adjourn the matter for six months was moved by Mr. Marks, and after some discussion was carried.

GREAT YARMOUTH.—The Town Council have unanimously decided to increase the salary of their electrical engineer (Mr. A. W. Ranken) to £200 per annum. The surveyor's report, presented at the last meeting of the Council, gives evidence of the continued progress of the electric light undertaking, and of the steady increase in the demand for current. During the past month there were fresh applications for 580 8 c.p. lamps, bringing the total number of lamps applied for up to 6,369. The income for the month was £308. 8s., and the working expenses £164. 14s. 2d., a gross profit of £143. 13s. 10d., from which, however, £90 has to be deducted for repayment of capital, interest, depreciation, &c. Arrangements are being made for supplying current during daytime.

HACKNEY (LONDON).—On Tuesday the reports of the Electric Lighting Committee appointed some months ago, and of the consulting engineer to the Vestry, Mr. F. H. Medhurst, were considered. The Committee advised strongly in favour of a combined scheme of electric lighting and refuse destruction, such as is proposed by Mr. Medhurst, and are convinced of the accuracy of Mr. Medhurst's estimate for the work. Mr. Medhurst's Report is very exhaustive, and goes with great detail into the scheme, under which it is proposed that current should be sold at 5d. per unit, this low figure being based upon the expectation that Hackney will be able to produce and distribute electric current on a more economical scale than any of its metropolitan predecessors. The dust destructor scheme enters largely into that of the proposed electric light undertaking, as this is estimated to give an output of steam equal to 480 H.P. for the

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full 24 hours, and although a considerably larger output would be necessary for a small portion of the time, this could be secured by an admixture of coal with the ashbin refuse burnt in the destructors, or, as an alternative, the scheme provides for a battery of accumulators to be charged during the day. Mr. Medhurst's scheme is for an initial installation equivalent to 16,000 8-c.p. lamps, and 140 1,000-c.p. arcs for lighting the main thoroughfares of the district. The high-tension alternating-current system is recommended as the cheapest for Hackney. The area included in the Vestry's order obtained in 1893 represents about four miles of streets, which it is estimated the 140 arcs would efficiently illuminate. For the public electric lighting an allowance of £1,800 per annum is estimated, this being three times the cost of the existing gas lamps, but for this increased outlay a light 16 times greater than the present will be given from dusk to midnight, and eight times greater from midnight to dawn. This increased cost, it is calculated, will be saved several times over by the decreased cost of dealing with the refuse of the district, the saving on 40,000 tons being estimated at £3,500 a year. This and the income from private and public lighting give a total revenue of £10,685. 13s. 4d., against which are set working expenses £5,357, plus a bye-product in the shape of mortar "to be economically manufactured from the waste clinker from the destructors," and such income as could be derived from the supply of current on a day load for motive power purposes, which it is proposed should be sold at 2½d. per unit. The interest and sinking fund account is credited with £4,000 per annum, leaving an estimated clear profit for relief of the rates of £1,328 per annum. The capital outlay in Mr. Medhurst's scheme is limited to £80,000.

HANLEY.—The Local Government Board have sanctioned the borrowing by the Town Council of a further sum of £19,000 for electric lighting purposes.

HARROGATE.—A Local Government Board inquiry will be held on Tuesday next into the application of the Town Council to borrow £27,000 for electric lighting purposes.

HORSELESS VEHICLES *v.* LIGHT RAILWAYS.—At a meeting at the Cannon-street Hotel, on Tuesday, an association was formed to be called the Self-Propelled Traffic Association, to be incorporated under the Companies Act. Sir David Salomons, who presided, stated that the Association had for its objects the encouragement of a new industry in England, "and the conferring of benefits upon the agricultural classes and the struggling professional man." The benefit to the agricultural classes is to be the adoption of the horseless vehicle in place of light railways in bringing garden produce to the distributing centres; the benefit to the struggling professional man was not particularly specified. It is proposed to limit the liability of members to the amount of their £1 shares. Mr. H. J. Lawson, "the inventor of the bicycle," described how he and his friends had scoured the Continent buying up patent rights in connection with the manufacture of the horseless carriage at an expenditure of £100,000, which he urged as evidence that no stone would be left unturned to secure success for the new industry.

HUDDERSFIELD.—At last week's meeting of the Borough Council the Council's Improvement Bill was discussed. The first subject dealt with was the proposed application to the Board of Trade for a Provisional Order to supply electric current to the Longwood district by extending the area of supply regulated by the Huddersfield Order of 1890. This proposal met with the approval of the Council. Although, so far as the electric lighting section of the Improvement Bill is concerned, the feeling of the Council and the ratepayers is favourable, a largely-attended meeting of the Ratepayers' Association had previously met and passed a resolution demanding the withdrawal of the Bill, and after a lengthy discussion the Council decided to adjourn the further consideration of the matter to a future meeting.

ISLINGTON (LONDON).—At the last meeting of the Vestry, Mr. Lambert (the Chairman of the Electric Light Committee) stated that they hoped to be in a position to supply electric current by January 31st next.

KIDDERMINSTER.—Messrs. A. Dickinson and Co., engineers, of Birmingham, have applied to the Worcestershire County Council for permission to construct electric tramways between Kidderminster and Stourport Bridge and between Short Heath and Kidderminster.——The General Purposes Committee of the Town Council have instructed the Borough Surveyor to prepare a written report upon the proposed electric tramway scheme, by which a line is to run through Kidderminster on to Stourport. The necessity of engaging the services of an expert adviser is also to be considered.

KINGSWOOD (BRISTOL).—The District Council had before them at their meeting on Wednesday the proposals of the Great Western Electric Light and Power Company for the electric lighting of the district. The Great Western Company have notified their intention of applying for a Provisional Order. The proposals were discussed at some length, but the Council finally adjourned the matter until their next meeting.

LEEDS.—Mr. Arthur John Vinall, Postmaster at Portsmouth, has been appointed to the Postmastership at Leeds, vacant by the transfer of Mr. Salisbury to Liverpool. The salary is £800 per annum.

LEYTON.—Mr. Rienzi Walton, M.I.C.E., held a Local Government Board inquiry last week into the application of the Council for permission to borrow, amongst other sums, £16,200 for electric lighting purposes. The Council were represented by Mr. R. Vincent (the Clerk) and Prof. H. Robinson, while the application was also supported by Mr. Sutton, Chairman of the Local Tradesmen's Association. Prof. Robinson explained that the generating station would be situated at the back of St. Patrick's Cemetery, Harrow Green, and submitted plans showing the various streets in which it is proposed to lay the mains.

LIVERPOOL.—It is anticipated that before the beginning of the new year the heading of the tunnel at the South end for the extension of the Liverpool Overhead Railway will be driven through from the Herculaneum Dock to the Dingle Terminus, as only about 60 yards have now to be pierced. This extension will widely differ from the original portion of the line. This is carried upon an iron viaduct a good height above the level of the street, but the extension burrows all the way through soft red sandstone rock, and the Dingle Terminus, at which the extension ends, will, with the exception of the ticket and station offices, be below the level of the ground. A new station is to be built upon the existing line opposite the Wellington foot bridge, the end of the existing line being used as a carriage shed. The new station will be conveniently placed for residents in the Toxteth district, as a footbridge is to be erected. When the extension is completed, the northern and southern parts of the populous district along the line of docks will be connected by the electric railway. It is anticipated that the extension will be in full work early in the coming summer.

MADRAS.—Trial trips are now being made on the Madras tramways by Mr. Gadsby, the Company's electrician, on those portions of the new sections which are to be worked by electricity on the overhead system. For some distance (from the power station to Chintaripet) the electric cable is taken underground and joins the main line at the latter place; from thence it is carried overhead. The cars running on this section are to be lighted by electricity. Portions of the line are ready for working at once, but will not be worked until the lightning arresters are fitted.

MARGATE.—At their last meeting the Town Council, on the motion of the Mayor, decided to apply to the Board of Trade for a Provisional Electric Lighting Order.

MEVAGISSEY.—At the last meeting of the District Council a Committee of the whole Council was appointed to confer with the engineer of the Mevagissey Electric Lighting Company as to the most suitable positions for the street lamps.

NEWPORT (SALOP).—The District Council have appointed a committee to consider and report upon the question of adopting an improved system of lighting.

NEW PREMISES.—The Lighting Corporation (Limited) have secured Bedford Chapel, New Oxford-street, W.C., so well known in connection with the preaching of Mr. Bellew and of the Rev. Stopford Brooke, on an 80 years' lease from the Duke of Bedford.

OLDHAM.—The Oldham Corporation have decided to increase the salary of their electrical engineer (Mr. S. Wilmott Newington) from £160 to £200 per annum.

PAISLEY.—The Electric Lighting Committee of the Town Council have had under their consideration the advisability of either proceeding with the electric lighting of the town in terms of their Provisional Order, or of entering into an agreement with the Caledonian Electric Supply Company for a transfer of the Order. At the last meeting of the Committee the Provost stated that, so far as he was able to ascertain, there was at present no demand in the town for the electric light, and this view being concurred in by the Council, it was decided not to proceed further in the matter.

PERTH.—The Police Commission have some spare power at their disposal, and notice of motion has been given for the next meeting of the Commission that it be remitted to a Special Committee to consider and report as to how this power could be best utilised, and especially with a view to the electric lighting of the Corporation Buildings.

QUEENSTOWN.—At a special meeting of the Town Commissioners a resolution that application be at once made to the Board of Trade for a Provisional Order was carried with only one dissentient. This means business, as, in addition, the Commissioners gave instructions to the Clerk to draw a cheque for £50 for the statutory fee.

ROYAL ALBERT AGED MERCHANT SEAMEN'S INSTITUTION.—An earnest appeal is made on behalf of the funds of this Institution, in which the late Sir James Anderson took so great an interest. There are many members of the cable fleet stationed throughout the world who may read these lines, and if they, or any of our readers, can spare a contribution to the funds, grateful acknowledgment will

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be made by the Secretary, Mr. W. E. Denny, 58, Fenchurch-street, London, E.C.

SHREWSBURY.—The formal opening of the Shropshire Electric Light and Power Company's electricity station took place on Tuesday last. The station has been equipped by Messrs. Edmundsons (Limited) to the plans of Mr. A. H. Preece, the Company's consulting engineer. The plant consists of three 60 I.H.P. Babcock-Wilcox boilers, three Belliss engines, and three continuous-current Parker dynamos. A battery of D.P. accumulators has also been put in, and the mains have been supplied by the Callender Company.

SMITHFIELD CLUB SHOW.—As usual, the attendance at this Show during the week has been enormous, and the opportunity of bringing electrical appliances of a domestic nature before this immense number of visitors has, also as usual, not been made the most of. It is estimated that not far short of 150,000 persons visit the Agricultural Hall during the "Cattle Show" week, and amongst this number must be hundreds to whom the possibilities of small electric light and power plants are practically unknown. We were surprised not to find Messrs. Crompton and Co. at the Hall with their heating and cooking apparatus, and there are several firms who could be mentioned whose artistic fittings and electrical novelties might have been effectively, and doubtless remuneratively, displayed. Although electrical exhibits were noticeable by their absence, the same cannot be said of the exhibits of the leading engine and implement builders, whose displays gave the Show an attractive and busy appearance. Traction engines, threshing machines, and similar machinery can have but little interest for a fair proportion of the visitors to the Agricultural Hall, but it is always interesting to watch the crowds which congregate wherever these machines are displayed, and who are evidently impressed when inspecting a more than usually imposing specimen of the engine builder's work. In this respect the centres of attraction at this year's Show were the exhibits of Messrs. Robey and Co.; Ransomes, Sims and Jefferies; Marshall, Sons and Co.; Clayton and Shuttleworth; John Fowler and Co.; E. S. Hindley; and Crossley Bros. At the stands of these well-known firms a splendid array of engines, agricultural machinery, &c. were on view. Messrs. W. H. Willcox and Co. displayed a great variety of engineers' stores, belting, &c.

SOUTHPORT.—At the last meeting of the Town Council Mr. W. H. Herford brought forward an electric light extension scheme, but after discussion it was agreed to postpone the matter for a month.

SOUTH SHIELDS.—Alderman Rennoldson, in presenting the report of the Electric Lighting Committee to the Town Council at its last meeting, made reference to certain deviations which had been made from the original scheme, but which had not entailed any additional expense, owing to savings in other directions. He referred to the low price at which it was proposed to supply current—6d. per unit—and the advantage which would accrue to large consumers, who would be able to reduce the cost of their electric current by 15 to 20 per cent. Notwithstanding a very determined opposition to the Committee's report, it was voted by a large majority, the Committee being complimented upon the results of their labours.

SOUTH STAFFORDSHIRE TRAMWAYS.—The South Staffordshire Tramways Company have been notified by the Electric Construction Company that the agreement between the two companies for the working of the electrical portion of the tramway lines at Walsall will not be renewed after the end of the current year unless the road bed is put in reasonably good repair. The Construction Company provide the motive power, the cars and drivers, and own the generating station and machinery. The matter is one of great importance to residents in the Wednesbury, Darlaston, Walsall, and Bloxwich districts, and the travelling public generally will hope that satisfactory arrangements will be come to before the expiration of the time stated. The Construction Company wish it to be distinctly understood that they have no desire to stop the running electric cars if arrangements can be come to for their continuation, and that it is not they who are putting obstacles in the way. The Company undertook to run the electric cars at a certain price per mile, the roads to be kept in a satisfactory state by the tramway company. The roads are now in a most unsatisfactory condition, indeed, are so bad that unnecessary wear and tear to the cars and machinery are caused. During the last year or two the cars have been run with great regularity and punctuality.

ST. AUSTELL.—At the last meeting of the District Council the Lighting Committee were instructed to prepare a specification on which the local electric light and gas companies might be invited to tender for the lighting of the principal streets.

ST. PANCRAS (LONDON).—At the last meeting of the Vestry it was decided to reduce the price of current for churches and chapels to 5d. per unit. Mr. Bangs, a governor of University College Hospital, stated that the authorities of that institution desired to substitute electric lighting for gas, and asked that they might have the current at the reduced charge. The matter was referred to the Electricity Committee.

SUNDERLAND.—At the last meeting of the Highways Committee Mr. C. S. Vesey Brown's report on the proposed electric lighting extensions was considered and approved. These extensions are rendered necessary by the increasing demands for current, and are estimated to cost about £13,750. Mr. Vesey Brown estimates, when these extensions have been carried out, the entire cost of generating current, &c., will be 4·20d. per unit, and the probable average charge 5d., showing a profit of 0·8d. per unit, which on an output of 250,000 units amounts to about £835. The capital expenditure to September 30th was £29,483. A loss of £900 has been made on the first year's working, but this is partly owing to the fact that the generating machinery has not been worked to its utmost capacity, and also because the interest and sinking fund charges were somewhat higher than was at first anticipated.

THE BRAZILS.—A considerable extension of the State telegraphs from Maranhao to the town of Palma, in the State of Govaz, has been decided upon, and a credit of $200,000 has been approved.

WALLASEY.—At the last meeting of the Urban District Council the Gas and Water Committee's minutes stated that the engineer had submitted his report on the electric light question. The cost of the buildings, machinery, mains, &c., is estimated at £12,500.

WELLS.—Last week we chronicled the fact that the City Council had decided by the casting vote of the Mayor to offer £14,000 for the local gas company's works, and a special meeting of the Council was held on Wednesday last to receive the Company's reply. The Company, however, declined to accept £14,000, but offered to sell their undertaking for £15,000. The Council have now decided to increase their offer to £14,700 on condition that it is accepted by Monday next. This spirit of compromise is refreshing, and should be rewarded by success.

WEST AUSTRALIA.—The work of duplicating the telegraph line between Perth and Kalgoorlie is now almost complete. The wire passes through the Coo'gardie gold district.

WEYBRIDGE.—At the last meeting of the District Council it was reported that the Weybridge Electric Supply Company had agreed to transfer their Provisional Order to the Council for £100. The Council, however, desire to obtain an assurance from the Board of Trade as to the exclusion of competitors before they make any payment. A committee of the Council are to again confer with the Company on the matter.

WOLVERHAMPTON.—The Town Council have received the formal sanction of the Local Government Board to borrow £5,000 for electric lighting extensions.

YEADON.—The District Council have decided to make a canvass of the ratepayers in order to ascertain the amount of support likely to be given to their proposed electric lighting scheme.

MUSICAL.—Mr. T. E. Gatehouse gives a violin recital at the South London Institute of Music, Camberwell New-road, London, S.E., on Tuesday evening next. An excellent programme is provided, and the concert will doubtless prove as great a success as so many of its predecessors have done under Mr. Gatehouse's direction.

ELECTRIC LIGHTING IN RAILWAY CARRIAGES.

On Tuesday last a meeting of the Preference stockholders of the Great Eastern Railway Company was held at the Cannon-street Hotel, when, amongst other matters, power was asked to raise £250,000 additional capital, of which it was proposed to spend £20,000 for electric lighting.

Lord CLAUDE HAMILTON, who presided, explained that the money to be expended for electric lighting was for the lighting of Bethnal Green Junction and Spitalfields Market. As they were aware, they could work goods traffic much more expeditiously by means of the electric light than by the old system of gas.

Mr. CUSTANCE asked if the electric lighting was to be applied to the carriages, as there was also an expenditure of £20,000 asked for gas.

The CHAIRMAN explained that they had no electric lighting in their carriages.

Mr. CUSTANCE said there were several lines which had electric light in their carriages, and it seemed to him that if they put gas in the carriages now they would be called upon hereafter to construct them for electricity. He would like to know if the matter had been considered by the Board in order to save expense hereafter.

The CHAIRMAN said that for some years they had very carefully considered the question of electric lighting in carriages as against gas, and they found the expense of the electric light far too great for them to attempt to undertake it. There was another objection to electricity for their line. Electrically lighted trains were all very well if the train was made up at the commencement of the journey and in no way dissevered throughout the journey, but, owing to the large number of junctions on their system, their trains were being constantly taken to pieces, and that would interfere with the electric light. Another matter was that the consensus of opinion of the great railway companies was, so far, in favour of gas rather than electric light for carriages.

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NEW COMPANIES, STATUTORY RETURNS, &c

In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1895, *pages 304-332, &c., &c.*

BRITISH TUBE COMPANY (LIMITED).—This Company has been registered, with a capital of £250,000, in £10 shares, to acquire the business of the British Seamless Steel Tube Company (Limited), Smethwick Works, Birmingham, and to carry on business as iron and steel tube manufacturers, engineers and metal founders.

ELECTRIC INSTALLATION SYNDICATE (LIMITED).—This Company was registered on December 5th with a nominal capital of £5,000, in shares of £10 each, to carry into effect an agreement between Alfred J. P. Whitaker, accountant, and Frederick G. Treharne, analyst, both of Cardiff, and George P. Tutcher (acting for the Company) for the acquisition of the benefit of certain existing inventions, particulars of which do not transpire, and to use, exercise, develop, grant licences in respect of, sell, deal with or otherwise turn to account any such patents, licences, concessions, &c. The first subscribers, with one share each, include: The Duchess of Marlborough, Lord William Beresford, V.C., John W. Palmer, W. Thomas Lewis, Alfred J. P. Whitaker, W. H. Mathias and Frederick G. Treharne. The first Directors are: Lord William Beresford, V.C., Edward Davies, William H. Mathias, Frederick G. Treharne and Alfred J. P. Whitaker.

IMPROVED PATENT FORCED DRAUGHT FURNACE SYNDICATE (LIMITED).—This Company was registered on December 3rd with a capital of £2,000, in £1 shares, to deal with certain letters patent relating to an invention of an improved device for equalising the forced draught for destructor and other furnaces. The first directors are Robert Gosling and James F. Colyer.

WINDSOR ELECTRICAL INSTALLATION COMPANY (LIMITED).—This Company was registered on December 5th with a capital of £10,000, in £1 shares, to acquire and take over as a going concern the business of the Windsor Electrical Installation Company, now carried on at Windsor and the neighbourhood, and to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity for light, heat, and motive power, electrical contractors, electric lamp arch builders, electrical carriage builders and fitters, and the general business of an electric light, heat and power supply company. The first subscribers, with a share each, are local tradesmen.

WOKING ELECTRIC SUPPLY COMPANY (LIMITED).—This Company was registered on December 5th with a nominal capital of £20,000, in £1 shares, to carry into effect an agreement between Anthony G. New and Arthur J. Mayne, electrical contractors, and the Company, to carry on in the parish of Woking and the neighbouring parishes the business of an electric lighting company in all its branches, to construct, lay, establish, fix and carry out all necessary wires, lines, accumulators, lamps and works, and to carry on the business of electricians, electrical and mechanical engineers and contractors, suppliers of electricity for the purposes of light, heat, motive power and otherwise, and manufacturers of and dealers in all kinds of electrical apparatus and appliances. The first subscribers, with one share each, are: Edward Mann, electrical engineer; Charles E. Masterman civil engineer; William J. Rundle, electrical engineer; Charles G. Bromfield, electrical engineer; Frank Wright, clerk; W. W Norman; Arthur Branch, electrical engineer; and Arthur E. D.

ALUMINIUM COMPANY (LIMITED).—The annual return to November 11th, has been filed. Nominal capital £80,000, in 60,000 "A" and 20,000 "B" shares of £1. The latter have been issued as fully paid, and the former paid for in full.

AMAZON TELEGRAPH COMPANY (LIMITED).—The statutory return to November 14th has been filed. The whole nominal capital of £250,000, in £10, shares has been subscribed, and calls amounting to £8 per share have been made. The calls paid (including calls paid in advance on 984 shares) amount to £145,368, leaving £56,600 still in arrears.

G. E. BELLISS AND COMPANY (LIMITED).—This Company's annual return has been filed. The nominal capital is £150,000, divided into 5,000. Preference and 10,000 Ordinary shares, all of £10 each. 4,100 of the former and 6,270 of the latter have been taken up, and 4,098 Preference have been issued as fully paid. The full amount has been called on the two Preference, and a call of £5 per share has been made on the Ordinary shares, resulting in the receipt of £31,370.

ELECTRICAL COAL-CUTTING CONTRACT CORPORATION (LIMITED).—The annual return to November 12th has been filed. The capital is £402,000 in 60,000 Ordinary and 20,000 Deferred shares of £5 each, and 2,000 Founders' shares of £1 each. 9,531 Ordinary and all the Deferred and Founders' shares have been taken up, and 4,000 Ordinary and the Deferred shares have been issued as fully paid. The full amount has been called on the remaining 5,531 Ordinary and the Founders' shares, and £28,375 paid thereon, leaving £1,280 in arrears.

GENERAL ELECTROLYTIC PARENT COMPANY (LIMITED).—The annual return to November 6th has been filed. The nominal capital is £30,000, in £1 shares, and 24,458 of these have been taken up; 18,000 have been issued as fully paid, and the full amount has been paid on the remaining 6,458 shares.

HARROW ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The statutory return to November 19th has been filed; 1,686 shares have been subscribed for out of a capital of £225,000, in £5 shares, and £2 per share has been paid.

LIGHTING CORPORATION (LIMITED).—The statutory return has been filed. The nominal capital is £275,000, divided into 250,000 Ordinary shares of £1 each and 25,000 Preference shares of similar value. Seven Ordinary shares have been subscribed for, and £7 has been paid.

MONTE VIDEO TELEPHONE COMPANY (LIMITED).—The annual return to November 14th has been filed. The capital is £220,000, in 29,000 Preferred and 15,000 Ordinary shares, of £5 each. 28,000 Preferred and all the Ordinary have been taken up, and 3,000 of each class have been issued as fully paid. Full amount called on remaining 25,000 Preferred and 12,000 Ordinary, and £185,000 paid.

WESTINGHOUSE ELECTRIC COMPANY (LIMITED).—The annual return to October 29th, has been filed. The capital is £600,000, divided into 30,000 Preferred and 30,000 Ordinary shares, of £10 each. 18,955 of the former and 27,500 of the latter have been taken up, and 15,000 Preferred and all the Ordinary have been issued as fully paid. Full amount called on 1,835 Preferred, and a call of 10s. per share has been made on the remaining 1,320 Preferred, resulting in the payment of £19,010.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30d. per oz. (Dec. 12th). Consols (2¾ per cent.) 106⅜ - 106⅞ for money, 106 13/16—106 15/16 for account; 2½ per cent. 104—104¼ (Dec. 12th). Stock Exchange Settling Days: Consols, Jan. 3rd; Stocks and Shares Continuation Day, Dec. 13th and 27th; Ticket Day, Dec. 14th and 28th; Pay Day, Dec. 16th and 30th. Mining Share Carry-over Day, Dec. 24th.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended December 8th were £977, against £941 in the corresponding week of 1894, an increase of £36. The total receipts for the half-year amount to £20,527, against £20,518 for the corresponding period of 1894, an increase of £9.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment on January 14th next of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum, on the Preference shares for the quarter ending December 31, 1895, and the usual interim dividend of 2s. 6d. per share on the Ordinary shares, free of income tax, in respect of profits for the quarter ended September last. The transfer books will be closed from the 7th to 14th January inclusive.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend for the quarter ended September 30th last, of 2s. 6d. per share, free of income-tax, payable on the 15th prox. The share register will be closed from the 7th to the 14th prox., both days inclusive. The coupons on the Company's Five per Cent. Australian Government Subsidy Debentures, due on January 1st next, will be paid on and after that date at Messrs. Barclay, Bevan and Co.'s bank, 54, Lombard-street, E.C. Coupons must be left three clear days for examination.

ELECTRIC CONSTRUCTION COMPANY (LIMITED).—The numbers are published of 134 Six per Cent. Second Mortgage Debentures of this Company, which were drawn on the 6th inst., and will be paid on January 1st at the offices of the Electric and General Investment Company, 1 and 2, Great Winchester-street, E.C. Coupons must be left four clear days for examination.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—The transfer books and register of members of this Company will be closed from the 16th to the 28th inst. inclusive, in order that warrants may be prepared for the interim dividend on the Ordinary shares. The Directors have declared an interim dividend on the capital paid up on the Ordinary shares of the Company at the rate of 10 per cent. per annum for the six months ended November 30th, payable on and after the 23rd inst.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 8th inst. amounted to £1,042. The amount for the corresponding week last year was £855, an increase of £187.

"MOTOR" AKTIEN-GESELLSCHAFT FUR ANGEWANDTE ELEKTRICITAT. This is the title of a Company which was recently formed in Baden, Switzerland, by the Allgemeine Deutsche Kreditanstalt of Leipzig; Brown, Boveri and Co., of Baden; the Aktiengesellschaft Leu and Co., of Zurich, and other Continental firms. The nominal capital of the Company is 3,000,000fr., of which 20 per cent. is paid up. The Company is established to financially assist electrical undertakings, and will also undertake the exploitation of electrical or electro-chemical works in any part of the world, in the execution of which the Company are to have the assistance and co-operation of Brown, Boveri and Co.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have ordered 25,000 shares (Nos. 1 to 25,000) of the Amazon Telegraph Company (Limited), and the further issue of 3,723 Ordinary Shares (Nos. 10,278 to 14,000) of the Chelsea Electricity Supply Company (Limited), to be quoted in the official list.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ending December 6th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,978.

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).—At the adjourned ordinary general meeting of the shareholders of this Company, held at Eccleston-place on Wednesday (Mr. J. H. Powell, in the absence of Lord Suffield, owing to illness, presiding), it was resolved: "That, in order to save the trouble and expense of a double yearly audit, it be, and is hereby, resolved that the auditor appointed by the Board of Trade for the official audit should also act as the shareholders' auditor."

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Dec. 4.	Price Wednesday, Dec. 11.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 7. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	10/0	Anglo-American	44 41	44 46	4 17 10	Jan., Apr., July, Oct.	45	44
£2,993,560	Stock	20 0	Do. Preferred	84 85	84 85	5 5 11	" "	85	84½
£2,993,560	Stock	5/0	Do. Deferred	6½ 6¾	6½ 6¾	.. ..	.. ..	—	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	101 105	101 105	3 17 6	January and July	..	..
180,000	£10	5/0	Brazilian Submarine	18 18½	18 18¼	5 3 8	Mar., June, Oct., Dec.	18 7/16	18 5/16
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111 115	111 115	4 8 6	June and December	..	..
16,000,000	$100	$1½	Commercial Cable Capital Stock	164 168	164 168	4 3 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	13 14	13 14	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 13 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	3½ 4½	3½ 4½	4 8 11	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104% 107%	104% 107%	4 5 9	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½ 8¾	8½ 8¾	4 11 5	Jan., Apr., July, Oct.	8½	8¾
400,000	10	2/6	Eastern	16 16½	16 16½	3 18 9	" "	17¼	16½
70,000	10	6%	Do. 6 per Cent. Preference	17½ 18	17½ 18	3 6 8	" "	17¾	17¾
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	125 128	125 128	3 2 6	May and November	127½	126¾
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107 110	107 109	4 13 3	February & August	..	..
250,000	10	2/6	Eastern Extension	17 17½	17 17½	4 0 0	Jan., Apr., July, Oct.	17 7/16	17½
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	126 129	126 129	3 2 6	February & August	128	126
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	102 106	102 106	4 16 5	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	102 106	102 106	4 16 5	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108 111	108 111	3 12 11	February & August	103	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 115%	3 9 9	May and November	..	..
180,227	10	1/3	Globe Telegraph and Trust	9½ 10	9½ 10	4 5 0	Jan., Apr., July, Oct.	9¾	9 7/16
180,042	10	6%	Do 6 per Cent. Preference	16½ 17	16½ 17	3 10 7	" "	16¾	17 1/16
150,000	10	5/0	Great Northern	21½ 22	21½ 22	3 17 8	Jan., April, and July	..	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	104 107	104 107	4 14 7	March & September	..	..
37,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	..	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	.. ..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 110	106 110	5 10 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	109 112	109 112	3 19 10	.. ..	..	..
11,839	8	4/0	Reuter's	5 6	4 5	.. ..	April and October	..	..
3,381	£100 Cert.	83/0	*Submarine Cables Trust 6 per Cent.	127 132	127 132	4 10 11	" "	..	..
15,609	10	2/0	West African Telegraph	6½ 6¾	5½ 6¼	.. ..	January and July	..	..
£233,300	100	5%	* Do. 5 per Cent. Debentures (red.)	103 105	102 105	4 16 5	March & September	—	..
30,000	10	2/0	West Coast of America	1 2	1 2	.. ..	January and July	1½	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	98 103	93 103	8 0 0	June and December	..	..
88,321	10	1/3	West India and Panama	⅞ 1⅛	⅞ 1⅛	.. ..	.. ..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½ 9½	8½ 9½	6 6 4	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	111 114	111 114	4 9 6	June and December	..	..
64,242	15	8/9	Western and Brazilian xd	9½ 10	9¾ 10	4 17 6	May and November	9¾	..
33,129	7½	8/9	Do. 5 per Cent. Cumulative Preferred xd	6½ 6¾	6½ 6¾	.. ..	—	6½	..
33,129	7½	1/6	Do. 5 per Cent. Deferred	3¾ 3¾	3 3¼	.. ..	—	3 7/16	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 14 3	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 14 3	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	110 115	113 118	5 13 2	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100 103	100 103	5 18 3	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3½ 3¾	3½ 3¾	.. ..	.. ..	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16 3/16	1/16 3/16	.. ..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	1/16 1/8	1/16 1/8	.. ..	Yearly	5/16	..
484,597	5	2/6	National	6 6¼	6¼ 6⅜	3 18 5	June and December	6 1/16	6 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	17 7/16	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15½ 16½	15½ 16½	3 12 9	" "	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6¼ 6⅜	6¼ 6⅜	3 18 5	—	6 7/16	6⅜
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	105 107	106 108	3 5 9	January and July	107	106½
58,000	5	3/0	United River Plate	2½ 3	2¾ 3	.. ..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	92 97	92 97	5 5 6	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	13 13½	12¾ 13¼	1 17 9	—	13½	13 3/16
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15¾ 16¼	15¾ 16¼	3 13 10	—	16	15 15/16
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	132 136	132 136	3 14 9	June and December	13 ⅛	133
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	.. ..	—	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½ 5¾	5½ 5¾	.. ..	—	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	— —	— —	.. ..	—	..	..
8,322	£5	..	House-to-House Electric	— —	— —	.. ..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	— —	— —	.. ..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	.. ..	January and July	..	..
£5,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 8⅛	7⅞ 8⅛	.. ..	—	..	..
111,000	5	..	London Electric Supply	.. ..	.. ..	.. ..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	10½ 11½	10½ 11½	2 12 2	..	..	..
159,000	Stock	4½%	* Do. 4½% Debs.	117 120	117 120	3 16 3	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9	8½ 9	.. ..	—	8 7/16	8½
..	..	..	Rand Electric	1/16 ⅛ prem	1/16 ⅛ prem	.. ..	—	..	..
19,980	£5	2/0	St. James and Pall Mall	8 8¼	8 8¼	.. ..	—	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	9 10	9 10	3 10 0	—	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8 8¼	8 8¼	3 2 10	—	8¼	8 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	2	1/6	Brush Electrical Engineering	1½ 1¾	1½ 1¾	10 0 0	—	..	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2½ 2¾	2½ 2¾	5 12 11	—	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 19 0	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2 2½	2 2½	.. ..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1¾ 2¼	1¾ 2¼	.. ..	.. ..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 5 9	.. ..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	— —	— —	.. ..	.. ..	..	..
110,000	2	..	Electric Construction	⅝ ¾	⅝ ¾	.. ..	.. ..	..	..
12,845	2	2/9½	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 11 0	.. ..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	¼ ⅜	¼ ⅜	.. ..	.. ..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¼ ⅜	¼ ⅜	.. ..	.. ..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	18 19	18 19	3 18 11	February & August	18½	18
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101 103	101 103	4 8 0	March & September	..	..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	.. ..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	— —	— —	.. ..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	.. ⅜	.. ⅜	.. ..	.. ..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	39 41	39 41	5 17 0	March and July	40½	..
£150,000	100	5%	* Do. 5 per Cent. Bonds	104 107	104 107	4 15 6	January and July	..	..
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	.. ..	.. ..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	.. ..	.. ..	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	13½ 14½	13½ 14½	4 2 9	..	14½	..
£80,000	10	7/0	Do. 7 per Cent. Preference	15½ 16½	15½ 16½	4 4 0	—	..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108 111	108 111	4 1 11	—	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway	40 42	40 42	2 19 6	May and November	..	..
7,650	10	5%	Do. 5% Perpetual Preference	14¾ 15¼	14¾ 15¼	3 5 7	.. ..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130 132	130 132	3 0 9	May and November	..	..
£7,500	£10	2½%	Liverpool Overhead Railway	11⅜ 11¾	11⅜ 11¾	1 18 4	—	..	..
10,000	10	5%	Do. 5% Preference	15½ 15¾	15½ 15¾	3 3 6	..	..	..
101,000	Stock	4%	Do. 4% Debenture	113 115	114 116	3 9 0	January and July	—	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

THE breaking of eggs is essential to the making of omelettes, and courage, foresight, organisation, and tact are no less essential to the success of a revolutionary resolution such as that brought forward by Mr. RAWORTH at the Annual General Meeting of the Institution of Electrical Engineers last week. There is an evident desire among the members of the Institution that means should be devised to make the Council as representative of the youth and energy of the electrical profession as it admittedly is of its eminence and dignity; and there appears also to be a general consensus of opinion that the best way to obtain this end is to veto the voting power of of the past presidents, and tomake it a rule that the Council list shall be sent out in sufficient time to enable counter proposals to be made, and effectually made. Recent events have amply justified the existence of this hankering after reform, and the devices just mentioned seem likely to meet the case and—the wishes of the great majority of those concerned.

ALL this was easily ascertainable prior to the Annual General Meeting. Nevertheless, it was thought advisable, without any warning to the general body of members, and without any attempt to obtain their views, to move the appointment of a cut-and-dried Advisory Committee with names complete, the mover leaving his hearers in doubt whether this Council of Twelve was to be a temporary expedient or a permanent feature of the constitution. The proposal, at any rate, had the merit of audacity as it stood, involving as it did nothing less than the resignation of a superseded Council. Subsequent exegesis of the text of the proposer's speech has, however, entirely whittled away this single virtue; nothing in the nature of a resolution or of a vote of censure upon Council was intended. Even so, a carefully arranged plan of campaign, and an avoidance of any appearance of snatching a surprise vote, would have contributed to success and prevented the fiasco that followed, which may possibly wreck a movement having both right and might on its side. It behoves the advocates of reform to take counsel together before the next general meeting, to make sure of their ground, to settle their plan of attack, and above all, to pull together. If the thing is worth doing at all it is worth doing well.

Two series of researches on alternate-current arcs, as yet incomplete, but even now affording useful information, are sketched by Dr. FLEMING and Mr. PETAVEL in our columns this week. The first of these researches relates to the comparative spherical candle-powers of alternating and continuous arcs, when equal amounts of power are expended in them. As the authors observe, the final determination of this question would probably possess only an academic interest, and they have wisely confined their researches to a condition of affairs most commonly occurring in practical lighting. In this case it was found that the mean spherical candle-power for the continuous arc was nearly twice that of the alternating arc. This is a severe handicap in the race for public lighting by these two sources of light; and it would be interesting to know how alternate current lamp makers propose to bring about a more equal efficiency, and what effect, say, a rectifier would have upon the practical relative efficiencies. The second line of research deals with a matter of more analytical and theoretical importance—viz., the space and time distributions of the luminous intensity in an alternating arc. The useful light emitted by the carbons and the purple light of the intra-carbon vapour have been differentiated by a most ingenious arrangement of mechanism. As might have been predicted, the light from the true vapour is intermittent, and falls to zero every cycle. The light from the carbon ends does not, but varies in a complex wavy function between a minimum value and two alternating maxima of widely different values. This complicated variation of the useful light of an alternating arc points to at least one of the causes of its relative inefficiency.

SUNDERLAND is in the enviable position of having an electric light station of 6,000 lamps capacity, and applications from customers for 6,925 lights; and this condition of affairs has been reached within eight months of the starting of the concern. Accordingly the cry is for extension of the plant; and that deus ex Westminster, Prof. A. B. W. KENNEDY, has presented a report showing what should be done. He recommends the addition of two dynamos and steam engines to the low-pressure section, together with one steam-driven set for the high-pressure section. His decision is therefore in favour of steam power; and some of the Sunderland folk, who use gas engines in their local industries, are up in arms. The "local engineers, who knew more about the matter than Prof. KENNEDY," so the County Council was informed, "knew that the modern gas engine was the cheapest motive power extant." A little knowledge, even

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of local engineering, is a dangerous thing; and the opposition is evidently badly informed as to at least two facts. The first fact is that Prof. KENNEDY's advice may be relied on in regard to much more than the essentially electrical part of the scheme, being as expert in gas and steam engines as in dynamos and cables. Secondly, that it is a dangerous half-truth to state that the gas engine is the cheapest power extant. Prof. KENNEDY himself has shown the Sunderland authorities that what is true of a small station, or of a private plant, is not true of a station where an annual output of 300,000 units is contemplated; and that whatever saving there might be in costs with gas plant would disappear with the extension of the works. Nevertheless, Sunderland has decided to wait.

IT might be thought that a small gas engine would be useful in helping the station through the uncomfortable hours; but it must be remembered that the low-pressure section of the Sunderland system is already well equipped with storage batteries, which render auxiliary gas plant superfluous. In this connection it is interesting to note a Paper on "The Storage Battery or the Gas Engine as an Auxiliary," which Mr. NELSON W. PERRY has recently read before the American Institute of Electrical Engineers. The author endeavours to show that "the gas engine, with fuel gas, would prove a much more economical auxiliary to the central station for taking the peak of the load, and the loads amounting to a fraction of a unit (of plant), than the storage battery." We ourselves do not care to be so dogmatic as this, for the value of both gas power and storage plant is liable to be largely influenced by local considerations; but we believe that circumstances might very well exist, in many stations, which would give the balance of favour to gas engines rather than to secondary batteries.

RUMOUR of a wonderfully light and powerful oil engine, in which an electric spark was made to act in an entirely novel manner, came to us from over the Atlantic a short time ago; and now we hear that the motor, the invention of Messrs. KANE and PENNINGTON, has followed. It is said that, in the form specially constructed for cycle propulsion, 2 effective horse-power can be obtained from a gross weight of engine of about 20lb., the engine shaft making 500 revolutions per minute. This, in itself, is a sufficiently astonishing claim; and we look forward with curiosity to the trials which no doubt shortly will be made by competent English engineers. But a still more surprising feature is the apparent action of what has been termed an electric "mixing" spark. The engine works on the ordinary Otto cycle, and towards the end of the compression stroke an electric non-igniting spark is passed through the charge. It is claimed that the effect of this spark is to complete the vapourisation of the oil, and thoroughly to mix the vapour with the air. A second spark, at the commencement of the working stroke, serves to ignite the explosive mixture. We confess this effect of an electric spark, in accelerating the admixture of the gases, is quite new to us; and until we are better informed as to the manner in which the "mixing" spark is applied we must reserve judgment as to its probable efficacy. It is conceivable that a brush discharge might, by means of the so-called "electric wind," accelerate the mixture of two gases in which it took place; but we are not aware that anything analogous occurs around the electrode of an induction coil, unless the potential is very much greater than is usual in such coils when used for gas or oil engines. The phenomenon is at present enveloped in a certain amount of obscuring vapours which might with advantage be satisfactorily cleared up.

Cable Interruptions :—

	Date of Interruption.
Maranham-Para	Dec. 18, 1895.
Puerto Plata-Martinique	Dec. 19, 1895.

The Arc Lamp and the Meteor.—Some correspondents of *Nature* describe a brilliant meteor which was seen at Isleworth, Lewes, Dover and other places, on November 22nd. At Dover, it seems, the light emitted was said to have been "sufficiently brilliant to have thrown the electric light into shadow." The meteor, however, only lasted between one and two seconds; so the rivalry was short-lived.

Disastrous Hurricane.—The *Manchester Courier* of Saturday last publishes the following despatch from their correspondent at New York: "News of a disastrous hurricane along the Newfoundland coast is contained in despatches from St. John's. Among a considerable number of vessels that have been stranded is the French telegraph steamer "Pouyer Quertier," which it is feared will become a total loss.

Horseless Carriages.—The following interesting announcement appears this week in the columns of the *Engineer* :—

"Our readers will be interested to hear that the Memorial to the President of the Local Government Board which we prepared has now been presented to Mr. Chaplin. It bears upwards of 1,700 signatures, amongst which are the names of most of the principal firms of manufacturing engineers in the country, and many of the engineering societies, and county and other local officers. It was intended that a small deputation of leading firms should submit the Memorial, but Mr. Chaplin expressed himself to us as so entirely in sympathy with the movement that he did not think it necessary to trouble the deputation to attend."

Electric Motors in Furnace Work.—A new application of electric motors has been made in a German furnace plant. The Martin furnace at the Lauchhammer works, near Riesa, has to be charged eight times daily with about 13 tons of iron. This has hitherto been done by hand at a great expense of time and money, but with the new feeding apparatus one man can do in a tenth of the time the work of four men who have hitherto been necessary, and is not subjected to anything like the same temperature.

Expiry of a Sellon Secondary Battery Patent.—On Monday next, December 23rd, the Sellon patent, No. 5,631, for secondary battery plates, will expire. The patent claimed: "The construction of terminal plates, supports, retainers, or frames employed in secondary batteries of a material or materials not readily subjected to the destructive influence of oxidation in the manner and for the purposes herein described." Amongst the materials mentioned are carbon, asbestos, wood, *papier maché*, cellulose and platinum.

Effect of Magnetisation on Engine Governors.—Some time ago we mentioned the case of an engine governor which failed to perform its duty on account of magnetisation of its parts. The engine drove a dynamo, and it was thought that the stray field passing through the iron of the engine caused the trouble. It may be interesting to know that this trouble has been overcome by the ingenious expedient of fitting a non-magnetic cap of micanite between the eccentric and the hub of the wheel to which the eccentric is fastened, phosphor-bronze studs being used for fastening the parts together.

Philadelphia Tramway Strike.—A strike was entered upon last Tuesday afternoon at Philadelphia by some 4,500 drivers and conductors employed by the Union Traction Company, who suddenly abandoned their cars, owing to a difference in reference to wages. Within an hour, and practically without warning, 55 per cent. of the Company's cars were at a standstill; and,

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as though the more effectually to prevent other men taking the vacant places, the strikers cut the trolley wires in all directions, and in this way largely blocked the tracks.

Another Pacific Cable.—In the United States Senate on Monday Senator Carter introduced a Bill authorising the Pacific Cable Company of New York to co-operate in the laying of a Pacific cable to Japan by way of Hawaii, the United States agreeing to pay an annual subsidy for 20 years at the rate of $25 per mile on a distance not exceeding 7,250 miles. The Bill also provides that United States Government messages shall be given the preference, that they shall be carried free for 20 years, and that in case of war the line shall be placed in possession of the United States.

The Brighton and Rottingdean Seashore Electric Railway.—The General Purposes Committee of the Brighton Town Council have resolved, on an application on behalf of the Brighton and Rottingdean Electric Tramroad Company, that the Company shall be released from the requirement that they shall provide sureties to join in the bond for £1,000 to be given by the Company for the removal of the poles about to be erected by them for carrying electric cables, and also that security for the removal of the railway in certain contingencies shall not be included in the bond.

Obituary.—We regret to announce the death, at Cape Town, on the 24th ult., of Mr. Philip Henry Bell, at the comparatively early age of 30. Mr. Bell was one of the first to be engaged in electric lighting by incandescent lamps, being connected with the Swan Company at Newcastle-on-Tyne almost from its commencement, and for many years held an important position with the Edison and Swan Company at Ponder's End. In the year 1894 he removed to Cape Town, where he has acted as manager of the electrical department for Messrs. George Findlay and Co. The news of his death from peritonitis, after a very short illness, has come as a great shock to a large circle of friends.

Development of Telephony in Austria.—The official statistics just published show the following figures for the year 1894. Figures printed in parentheses refer to 1893. The total number of telephones was 17,404 (14,941); of these the State controlled 9,295 (7,850), and a private company 8,109 (7,071). There were 121 (85) town systems with 8,365 (7,280) miles of conductor, 47 (40) interurban lines with 5,246 (4,155) miles of conductor, 112 (86) exchanges, 210 (177) public call offices, 8,723 (7,499) subscribers, and 223 (155) switchboards under State control. In private hands there was only the Vienna exchange, with 26,443 (26,170) miles of conductor, and one other exchange, 16 public call offices, 7,924 (6,902) subscribers, and 168 (152) switchboards.

Fatality at Cheltenham.—A fatal accident occurred on Monday last to a man at work in a sub-station of the Cheltenham electric supply system. The transformer station, 10ft. by 7ft. area, by 7ft. 6in. high, is below the footpath. The high-pressure mains in this chamber are at 2,000 volts. While working with other men, without insulating gloves, near the high-pressure switchboard, a man named John Pugh accidentally placed his arm, some inches above the wrist, in contact with a bare terminal on the high-pressure board. Death was almost, if not quite, instantaneous. Another workman, who was slightly in contact with Pugh at the time, received a severe but not injurious shock. The jury at the inquest have exonerated everyone from blame.

Damage by Lightning.—During the recent storm Devenish Round Tower, the most perfect of its kind in Ireland, was struck by lightning, and two of the stones fell from the summit, the caretaker on the island being a spectator of the occurrence. Some time ago much damage was done the old belfry by the lightning, and on the suggestion of Mr. Thomas Plunkett the Enniskillen Board of Guardians communicated with the Board of Works, and it was then understood that lightning conductors would be attached, certainly to the belfry, and probably to the tower. However, for so far nothing has been done. It is somewhat remarkable that two occurrences of this kind should have taken place within such a short period, seeing that for centuries these ancient buildings have stood unaffected by "time's effacing finger."

Swansea Electric Tramways.—The Swansea County Borough Council, at a meeting held last Tuesday, completed the negotiations for the purchase of the tramways, their conversion into electric tramways, and the supply to the lessee Company of electric energy at a rate depending upon the annual consumption. According to the agreement which has now been made it was settled that the Corporation was to pay £10,600 down to pay off debentures now held in the property of the Tramways Company; also to advance a sum of £21,600 to enable them to buy motor cars to work the tramways by electricity. That sum of money was to be repaid, firstly, by the interest, and, secondly, by a sinking charge over 30 years. The Corporation were to expend money in extending and doubling the lines, on which the Company were to pay interest equal to ½ per cent. more than what the Corporation paid for the loan. The Company were to take a minimum quantity of 400,000 units, at 2d. per unit; if 600,000 units, at 1¾d. per unit; and if 750,000, at 1½d. per unit. Any interest accruing during construction was to be added to the capital cost.

The "Low Pressure" Report.—The following extracts from some remarks in the *Builder* on the recommendations of the Board of Trade Committee on "low pressure" will be read with interest, coming as they do from a singularly well-informed journal, and representing therefore the opinion of the intelligent public:—"The report is certainly favourable to the electric lighting companies, and we think that the limit has been fixed at a higher value than the educated consumer will altogether appreciate. It is amusing to hear low-pressure electrical engineers declaring now that a pressure of 600 volts is quite safe; not so long ago they considered it deadly. It merely shows how easy it is to convince oneself when it is to one's interest to do so. From the consumers' point of view a 100-volt electric supply current is far preferable to a 200-volt supply. Anyone who has heard a fuse on a 200-volt circuit go off like a pistol shot needs little technical knowledge to understand that the danger of arcing across the terminals of cut-outs is far greater with the higher pressure. It depends now on the makers of electrical fittings and the wiremen to guard against this greatly-increased danger. . . . Electrical engineers are hastening on too quickly in their agitation for higher pressures. In time, when people know more about electric supply, it may be safe to use higher pressures, but at present it most decidedly is not. A few accidents due to this cause would do far more harm to the industry than the expense of a few tons more copper in their mains."

Steam Pipes and Elmore Copper.—We have been asked to publish the following Note, which Mr. J. T. Milton has appended to his "Remarks on Steam Pipes," an abstract of which appeared in our columns last week:—

"Since the reading of the above Paper Messrs. Elmore's Patent Copper Depositing Company (Limited) have communicated with me, expressing surprise and some doubt as to the accuracy of the figures given as representing the elastic limit of their material. Being anxious to get to the truth in this matter, I invited Messrs. Elmore to cut some additional strips from tubes, and to arrange to have a representative present at the tests. This invitation was promptly accepted, and Mr. Stanley Elmore attended with myself at the Central Technical College, when Prof. W. C. Unwin tested six specimen, two of them being annealed. The results are fully set out in the accompanying report. It will be seen that Messrs. Elmore's claim to an exceedingly high ratio of elastic limit to ultimate strength, in the copper supplied by them, is fully supported by the results of these tests."

Copy of Report made by Prof. W. C. Unwin on Specimens of Copper received from Mr. W. Elmore.

Marks on specimen.*	Dimensions.		Section in sq. in.	Stress at elastic limit in tons per sq. in.	Maximum stress in tons per sq. in.	Elongation in 8in. per cent.
	Width, in.	Thick, in.				
C‡	1·469	0·187	0·2747	2·275	13·09	45·88
C	1·485	0·1895	0·2814	15·10	15·48	13·13
C	1·503	0·185	0·2781	15·28	15·91	14·75
L	1·500	0·1935	0·2903	15·07	15·67	21·25
L	1·498	0·193	0·2891	15·56	16·03	17·88
L‡	1·503	0·188	0·2826	1·769	13·13	48·13

* C signifies that tests were cut circumferentially from the pipe. L signifies that tests were cut longitudinally from the pipe. ‡ Annealed.

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The Murphy-Pierce Sectional Conductor System of Electric Traction.—A new electrical railway system, invented by John M. Murphy and Albert F. Pierce, of Danbury, Conn., dispenses with the overhead wires and the conduit underneath the car. The surface only of the road is used, says the *Electrical Engineer* of New York, and the car takes the power from the section of rail directly beneath it. Between the rails on which the car runs is a third rail, laid in short sections, each section being perfectly insulated from every other section. The car, in passing, automatically engages the section of this third rail directly beneath it, and from it takes its power. This is done by one wheel of the car, which touches a push-pin, thus operating mechanism placed underneath the rail which in turn makes the connection with and charges the section of rail over which the car is passing. As the car moves forward and touches another pin, the section in the rear is cut out the same instant the one forward is charged. The main or feed wire insulated, is buried along the outside of the track. From this feed wire, insulated wires run to each section of the rail from which the car derives its power. These wires pass to the section through the mechanism by which the connection is both made and broken. The mechanism is simple, consisting of a lever, a pawl, a wheel, a shaft, and an electrical switch. All of this mechanism is encased in a box cast especially for it, water-tight as well as dust-proof. There is a fuse box between the wire and every section of rail, which makes it impossible to charge the rail up to the danger point. Any more than the required voltage burns the fuse and makes the rail dead. The charged rail is never exposed from underneath the car. All the mechanism used is cast in the foundry, making it comparatively inexpensive, and also possible to replace any part at a moment's notice. The electrical connection is made and broken by mechanical means. There is no magnetic switch device. An experimental section has been laid at Westport, Conn.

Fires and Electric Lighting.—Under the above alarming heading Major Flood-Page contributed a lengthy letter to Tuesday's *Times*, from which we take the following extracts:—

". . . Captain Simonds has been kind enough to furnish me with his reports for the years 1892, 1893, 1894, which show that, within the metropolitan area, fires have taken place, caused by candles, gas, lamps, and electricity, as follows:—

	1892.	1893.	1894.
Candles	175	235	157
Gas	265	284	284
Lamps	373	456	476
Electricity	1	5	3

These facts will surely allay any feeling of anxiety in the minds of users of electric light as to there being any practical danger from electric light properly installed in their houses. . . . I must, however, confess that I view with some alarm the efforts of some electrical engineers who are advocating an increase and in some instances actually increasing the pressure at which they deliver the current of electricity to 220 volts, while the ordinary current has been 100 to 110 volts. It is supposed by some that a difficulty has arisen in the manufacture of incandescent lamps to meet this demand. Permit me to say that the lamp presents the smallest difficulty in connection therewith. A far more serious question, and one which touches very closely upon fire insurance, is whether houses wired with fittings and switches manufactured for 100 volts can safely carry 220 volts. It stands to reason that before this change can be made every house must be inspected—switches, wiring, and fittings thoroughly tested and examined. I have no hesitation in expressing my own opinion that it is far better that we should, for many a day yet at any rate, be content with the useful safe pressure under which we have obtained the most satisfactory reports which these figures of the Metropolitan Fire Brigade show in connection with fire risks and electric light. I have said, and I repeat, that the lamp is probably the least difficult part of the whole question; but the question itself merits the most serious and earnest attention alike of those who supply and those who are using electric light for domestic purposes. Incidentally, I should like to remark that it is very doubtful whether the engineers who are advocating this increased pressure are entitled to do so, for the Electric Lighting Act, under which they are all working, provides that the undertaker shall not exercise any influence whatever as to the lamp which the customer is to use. The words of the Act are as follows:—'Electric Lighting Act, 1882. —The undertakers shall not be entitled to prescribe any special form of lamp or burner to be used by any company or person, or in any way control or interfere with the manner in which electricity supplied by them under this Act and any licence or special Act is used.' The primary sense of these words is probably that the undertakers shall not recommend the lamp of any particular maker; but I think it cannot be denied that they also bear the interpretation that the undertakers may not arbitrarily compel customers to change their lamps, which they must necessarily do if the current is supplied to them at 220 instead of 100 volts. In all seriousness, apart altogether from any legal question, this increase of voltage must exercise so important an influence upon that of safety that I trust the most careful consideration will be given by all users of electricity before they will submit to such increase, no matter what inducement may be held out by those who advise them to make the change. . . ."

The Boston "West End" Electric System.—The eighth annual report of the West End Street Railway Company, of Boston (U.S.A.), shows a handsome increase in both gross and net earnings. The gross earnings for the year ending September 30, 1895, were $7,746,170, compared with $6,823,879 the year before, an increase of $922,292. Operating expenses were $5,633,163, compared with $4,807,083 in 1894, an increase of $826,080. This reduced the net earnings to $2,113,007, an increase of $96,211 for the year. In his general remarks, which are more extended than those of last year, President Samuel Little outlines what has been accomplished by the West End in the past twelve months, and says:—"The act of the Legislature compelling the placing of electric wires underground in a certain defined district of the city, affected this Company to the extent of requiring all of its wires to be buried in the district named, except the trolley wires. The act of the Legislature required the Commissioner of Wires to designate the sections of this district upon which work should be accomplished each year, which section could not be more than one-fourth nor less than one-sixth of the whole district. The work already completed exceeds the requirements of the Commissioner for the first two years; 2·24 miles of conduits, containing 41·07 miles of duct, have been constructed, in which have been placed 23·31 miles of feeder cables and 13·93 miles of return feeders. The construction of the conduit and cable system takes the place of the overhead feeder wires. A contract has been made for electric heater equipments for the balance of the entire box car equipment of the road, which will all be installed and in operation the coming winter." The present equipment is as follows: Box cars, horse, 371; open cars, horse, 170; box cars, electric, 16-foot bodies, 92; box cars, electric, 20-foot bodies, 336; box cars, electric, 25-foot bodies, 445; open cars, electric, seven or eight benches, 582; open cars, electric, nine benches, 212; open cars, electric, ten benches, 47; mail cars, electric, 11; motor cars, electric, 2; horses, 857; electric motors, 2,108; snow ploughs, horse, 83; snow ploughs, electric, 115; snow sleds, 388; miscellaneous vehicles, 482.

Contemporary Electrical Science.—In the December number of the *Philosophical Magazine*, Prof. Holman, of the Massachusetts Institute of Technology, corrects the statement made five years ago by Messrs. Ayrton, Mather and Sumpner, that in the coil of a sensitive (Thomson) galvanometer the current in a portion of the central turns affects the needle in opposition to the remaining major portion of the turns; so that this portion should be left out or connected in reverse direction. The space containing these turns was pointed out as being nearly "an oblate spheroid with a polar axis about 0·72 of its equatorial diameter, the latter being, of course, slightly larger than the length of the needle." As a matter of fact, this volume is about one-quarter to one-eighth of that indicated, and the error arose from the fallacy of considering the deflective moment upon the needle as due to the field at the poles merely, and not over the remainder of the needle. The space inside the null surface is approximately a sphere whose diameter is about half the length of the needle. Hence it is practically useless to wind turns within a distance of one-quarter of the needle from the centre. To increase sensitiveness, the needle must be made as short as is consistent with torsion of suspension.——In the same number, Prof. J. J. Thomson has a very interesting Paper on the relation between the atom and the charge of electricity carried by it, which will amply repay a careful perusal. In the electrolysis of solutions, the hydrogen ion always carries a positive charge, the chlorine ion a negative one. But in the electrolysis of gases, both of these atoms are capable of carrying either positive or negative charges. The author elucidates these properties by reference to gyrostatic and hydro-dynamical analogies, and propounds a new electrical theory of chemical combination. At no stage of this process are any atoms set free, and this has been proved by the absence of conductivity. An electrified plate when immersed in a gas by which it is attacked does not lose its charge.

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NOTES ON AN INVESTIGATION OF THE ALTERNATING-CURRENT ARC.

BY J. A. FLEMING, D.SC., F.R.S., AND J. E. PETAVEL.

During the last six months investigations have been carried on by us in the electrical laboratory of University College, London, with the assistance of some of the senior students, which form part of an analytical study of the alternating-current arc as yet not quite complete. Results, however, have been obtained which it will probably be of interest to the readers of *The Electrician* to put on record, pending a complete publication of the details of the investigation. A short communication was sent by one of us last year to the pages of a contemporary journal,* containing an account of preliminary experiments carried out some time ago, in which a comparison was made between an alternating-current and a continuous-current arc in respect of the total spherical candle-power yielded for the same expenditure of power in the two arcs. These experiments have since been continued and repeated with greater care. They form the first portion of the above-mentioned investigation. The general description of the arrangements employed in their conduct was as follows :—

Two arc lamps were selected of well-known types—one of them suitable for working with continuous current and the other with alternating current, the lamps being chosen with a view to good regulation and steady working over wide limits of power consumption. The particular types of lamp employed were of no consequence except in so far as they were lamps capable of being used with alternating and continuous currents throughout the limits required.

The first portion of the experimental work consisted in the construction of an inspectional reflecting wattmeter, intended to enable the observers to measure and to regulate with great accuracy the power taken up in the arc itself, neglecting altogether the power absorbed in the mechanism of the arc lamp. Briefly speaking, this wattmeter consisted, as usual, of a fixed coil, which was the current coil of the instrument, and through which the current of the arc passed, and a movable coil hung by a bifilar suspension, the two suspending wires being exceedingly fine silver wires. In series with the suspended coil was a non-inductive resistance, capable of being varied in magnitude within certain limits. The suspended coil had affixed to it a plane mirror, and an image of a wire illuminated by an auxiliary arc lamp was thrown by it on to a fixed scale. The suspended coil consisted of 33 turns of wire, and the fixed coil of 10 turns of thicker wire. The non-inductive resistance, in series with the suspended coil, had a resistance of 1,200 ohms, the resistance of the shunt coil of the wattmeter being 3·67 ohms, and that of the fixed coil 0·01 ohm. The wattmeter was fixed firmly to a wall, and the scale carried at a fixed distance opposite to it. The wattmeter was calibrated by means of continuous currents and by means of an interpellation curve the power reckoned in watts passing through the wattmeter could be read off from the position of the image of the wire thrown upon the fixed scale. The terminals of the fine wire coil were connected to the arc carbons. In all the experiments the wattmeter readings were subsequently reduced so as to give the true power taken up in the arc, neglecting the power required to actuate the arc lamp mechanism and the power taken up in the voltmeter and wattmeter itself.

In addition to the wattmeter measurements, the current through the arc, as well as the potential difference between the carbons, was taken by properly corrected instruments, and the length of the arc was also measured at the same time by projecting its image upon a screen. The photometric measurements were made with a Sugg's star disc photometer, the light from the arc lamp being compared by this means with that of an incandescent lamp, which was worked at a sufficient voltage to bring it up to about 2½ watts per candle, the incandescent lamp being compared at frequent intervals with a primary standard incandescent lamp.

The colour difference in the two lights to be compared gives rise to a certain difficulty in making the photometric measurements, which can only be overcome by an observer whose eye is sufficiently well trained to detect minute differences of brightness and neglect the existing colour difference of the two images in the photometer. It was found that by focussing the eye for a point rather nearer to the eye than the images of the photometric disc, the colour difference between the two images became less distracting, and in this manner the observations that were made are all taken in terms of a white-light standard, no measurements made in terms of red or green light having any practical value. The experiments consisted in taking a series of observations of the photometric intensity of the arc in different angular directions to the horizontal plane through the arc in the usual manner, the power supplied to the arc being kept perfectly constant by a regulating carbon resistance in series with the arc. The use of the bifilar reflecting wattmeter enabled this to be done with the greatest ease and accuracy. A complete series of observations was taken with the continuous-current arc when supplied with power of from 200 to 600 watts. For each complete set of observations the wattage in the arc was kept perfectly constant, and from the photometric observations the ordinary illumination curve of the arc could be plotted out, and the mean spherical candle-power calculated in the usual way by means of Rousseau's diagram. In the case of the alternating-current arc, owing to the circumstance that there is a slow periodic rotation or change of place of the arc, quite independent of the fact that the current or the wattage in the arc is maintained perfectly constant, the photometric measurements become particularly troublesome. In this case it was necessary to take a series of photometric observations rapidly in different azimuths for each particular inclination angle, and to take the mean of these observations. Carrying out this process, a series of illumination curves was obtained for the continuous and the alternating-current arc, which had the usual characteristic form. In both cases these experiments and measurements of the mean spherical candle-power were repeated for different expenditures of power in the arc varying from 200 to 600 watts. The alternating-current experiments were made at two frequencies—viz., 50 ∿ and 83·3 ∿. The carbons used in the case of the alternating-current experiments were both 15mm. cored carbons of the best quality, and in the case of the continuous-current arc experiments two sets of observations were made, one with both carbons cored and 15mm. in diameter, the other set with the positive or upper carbon cored and 15mm. in diameter, and the lower or negative carbon solid and 9mm. in diameter. When all the necessary reductions of the hundreds of observations were made by the integration of the illumination curves to give the mean spherical candle-power, and the reduction of the wattmeter scale readings to give the true power in watts expended in the arc itself, apart from anything taken up in the mechanism or instruments, the results were embodied in a series of curves as shown in Fig. 1, in which the horizontal distances represent the power in watts taken up in the arc, and the vertical ordinates the mean spherical candle-power. The four curves there shown show the variation of mean spherical candle-power for the particular carbons used for the various powers employed in the case of

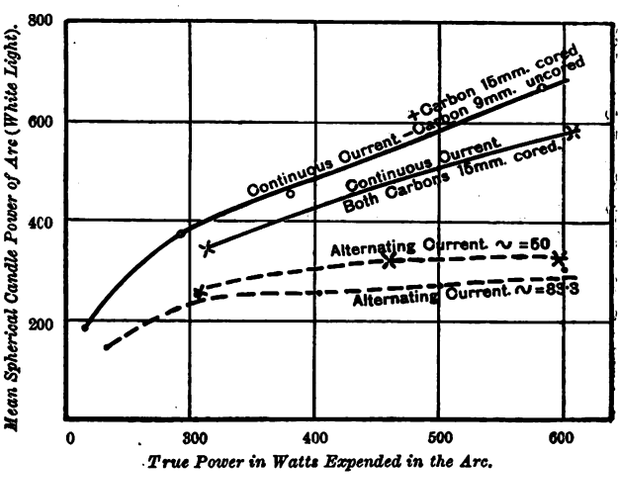

FIG. 1.

* See *Lightning*, October 25, November 8, 15 and 29, 1894.

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	Continuous-current arc.						Alternating-current arc. Both carbons 15mm. cored.							
	+ Carbon 15mm. cored. − Carbon 9mm. solid.				Both carbons 15mm. cored.		Frequency 83·3 ∿.					Frequency 50 ∿.		
Power expended in the arc in watts	582	380	292	*215	607	313	601	501	404	305	*233	596	459	308
Mean spherical candle-power	675	455	372	181	582	344	307	274	256	250	144	326	322	254
Potential difference of carbons in volts	56	44	36	26	60	40	37·5	34	28	21	15·3	39	31	22
Current through arc in amperes	10·6	8·7	8·1	8·2	10·2	8	16·2	15·1	15·1	15·5	15·4	16	15·1	14·6
Length of arc in centimetres	0·715	0·25	0·07	0	0·807	0·061	0·628	...	0·125	0·016	0·01	0·7	...	...
Power factor	1·0	1·0	1·0	1·0	1·0	1·0	...	...	0·96	0·96	0·99	0·97	0·99	0·97

* In these observations the arc was hissing during the whole of the time.

In reading the above Table it must be noted that it was the power, measured in watts, taken up in the arc which was kept constant. The current and difference of potential of the carbons were allowed to take care of themselves. The current and volts were approximately constant, and had the mean values given in the Table, but the product of these mean values does not quite agree with the true mean power measured in watts taken up in the arc.

both arcs, the details of the observations being given in the table above.

The general result of the above described experiments therefore confirms the conclusions reached by one of us in 1894, and which indicated that for a given amount of power expended in the arc under the conditions under which these experiments were carried out, the mean spherical candle-power for continuous current was nearly double that for the alternating current. It is now well understood from the experiments of Messrs. Wedding and Roessler and others that the mean

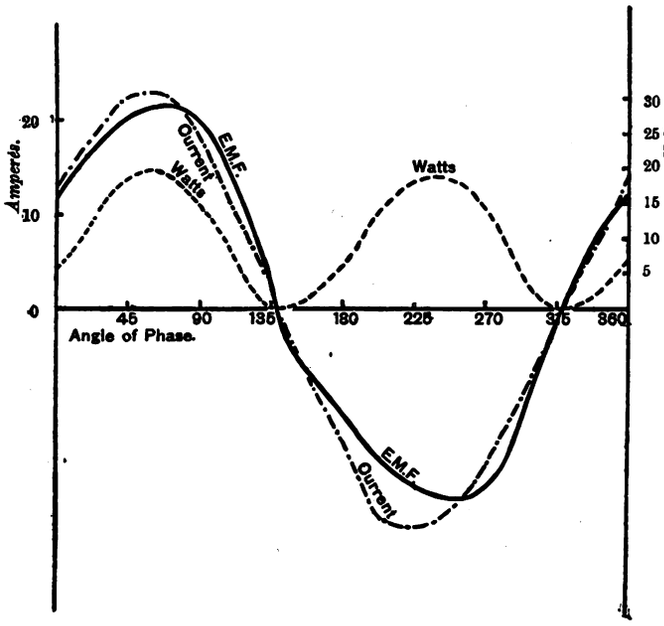

FIG. 2.—The curve marked E.M.F. is the curve of variation of potential difference of the carbon poles for an alternating current arc. The dotted curves are curves of current and power. ∿ =83·3; amperes=15; volts=18; watts=260.

spherical candle-power in the case of the alternating-current arc for a given amount of power expended in the arc, depends, amongst other things, upon the form of the carbon potential difference curve. A set of current and electromotive-force curves was in all cases taken for the alternating-current arcs employed by us, for the various powers of from 200 to 600 watts, and for both frequencies of 83·3 ∿ and 50 ∿, which curves showed the form of the variation of the current and electromotive force. One set of these curves is shown in Fig. 2, as an illustration of the kind of curve found.

The above described experiments do not, of course, by any means exhaust the subject. The question whether continuous-current arcs *per se* are more efficient than alternating-current arcs in regard to mean spherical candle-power produced per watt is a large question to consider, and perhaps cannot be answered in a general sense, but it is capable of being settled for any particular instances which occur in practice. It is for this reason that we selected the two typical cases of an alternating-current arc worked with 15mm. cored carbons worked at frequencies 83·3 ∿ and 50 ∿, and compared it with a continuous-current arc worked with 15mm. and 9mm. carbons as commonly employed. The experiments, of course, do not settle whether any particular form of alternating-current arc can be produced which shall give the same mean spherical candle-power for a given expenditure of power as a continuous-current arc with the same carbons, and such a question has, perhaps, too purely an academic interest to make it worth while to spend time upon it.

These experiments amply justify generally the opinion which has been held as to the relative inefficiency of alternating-current arcs in mean spherical candle-power, apart from any question as to differences in the distribution of the light, and show the correctness of the opinion which dictates the employment of continuous current or rectified alternating current for public arc lighting purposes.

The second part of the investigation was concerned with an analytical examination of the periodic variation of light coming from various parts of an alternating-current arc. For this purpose an alternating-current arc was formed with currents of frequencies of about 83 ∿, 50 ∿, and 25 ∿. The synchronising motor curve-tracer described by one of us in *The Electrician* for 1895, Vol. XXXIV., p. 460, was employed in the following manner to examine these arcs:—

A disc of aluminium of about 27cm. in diameter had four small radial slits cut in it 90deg. apart, the length of each slit being 4·5cm., and mean width about 0·5cm.; this disc was

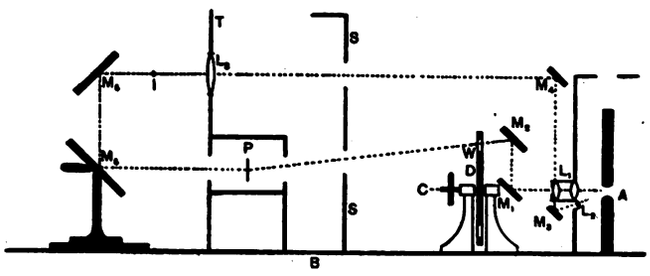

FIG. 3.

attached to the shaft of the synchronising motor, and driven from the same circuit which supplied current for the alternating arc. The disc was therefore driven synchronously with the arc. The motor has eight field poles, so that the disc turned through 90° in each complete period of the alternating current. In Fig. 3 a diagram is shown representing in outline the arrangement for obtaining the variation of illuminating power of any part of the arc during the complete phase. Owing to the slow variation in the total illumination of the arc, it is impossible to photometer the instantaneous value of the light of the arc against any fixed-light standard with any chance of securing accurate results; but the difficulty was overcome by using the *arc itself* as a standard, and photometering the mean value of the light emitted from any part of the arc against the instantaneous value of the light from the same part of the arc, taken at any instant during the phase. In Fig. 3, A represents the alternating-current arc; the light from this arc passed through a lens, L_1, in a horizontal direction, and fell upon a mirror, M_1, placed at an angle of 45deg., and capable of being rotated round a horizontal axis in line with the axis of the revolving disc. D represents a section of the revolving

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disc, W being one of the radial slits. The motor shaft was attached to the disc axis C. The ray, reflected from M, was then reflected upwards to a mirror, M_2, and passed through one of the windows W in the revolving disc, finally falling upon the photometric disc P. The lens L_1 thus formed an image of the arc on the disc P. Another ray, proceeding from the arc in the same horizontal plane, but in a direction slightly inclined to the first ray, passed through a lens, L_2, and fell upon another mirror, M_3, which, in the diagram, for diagrammatic purposes, is represented as below the lens L_1, although really its centre is on the same horizontal plane with it. This second ray was reflected up to the mirror M_4, passed through an aperture in a screen, S, and fell upon a lens, L_3, the lens L_2 forming a rather blurred image of the arc upon the lens L_3, so that by slightly moving the mirror M_4 any part of the image of the arc or the incandescent carbons could be made to cover the lens L_3. After passing through the lens L_3 the beam was brought to a focus at I, and then fell upon two mirrors M_5 and M_6, fixed together on a vertical stand at angles of 45deg. so as to reverse the direction of the beam and cause it to fall upon the other side of the photometric disc P. The lens L_3 formed a real image of any required part of the arc at some point I between L_3 and M_5. By moving the two mirrors M_5 and M_6 together to or from the photometric disc, the length of the path from the image I to the photometric disc could be varied, and therefore the light falling upon the star disc of the photometer which came along the path $M_4 M_5 M_6$, and which was selected from any part of the arc or the incandescent carbons, could be varied in intensity. When the disc D is set in rotation the light passes intermittently through the windows W, and the lens L_1 forms a sharp image on the disc P, which is apparently continuous, but really interrupted, and any part of this image could be made to fall on the disc P by moving slightly the mirror M_2. The right-hand side of the photometric disc is illuminated therefore by an intermittent stream of light which is always selected in the same phase when considered as belonging to a periodically varying illuminating beam, in consequence of the fact that the rotation of the disc is synchronous with the period of the arc. On the other hand, the light which falls on the left-hand side of the disc is a uniformly illuminating beam coming from the same part of the arc, the intensity of which at the point P depends upon the square of the length of the path I M_5 M_6 P. By moving the mirrors M_5 M_6 to or from the disc P, a balance could be obtained between the right and left-hand illuminations, and therefore the instantaneous value of the light coming from any part of the arc or carbons could be photometered against the mean value of the light coming from the same part of the arc or carbons, the length of the arc and the current through the arc being kept perfectly constant through the experiment. At the same time the motor alternator driving the revolving disc was employed to make the intermittent contact by which, in the usual manner, the current and electromotive force curves of the arc were delineated, and the diagram Fig. 4 shows a complete set of observations giving the current through the arc, the potential difference between the carbons, the power expended in the arc, and the variation of the light in the centre of the true arc, excluding any light coming from the incandescent carbons. The firm line curve in Fig. 4 therefore represents, by its ordinates, the periodic variation of the light coming from the purple arc discharge lying in between the carbons, but does not include any light coming from the carbons themselves. The light is selected for measurement at particular instants during the complete phase, as follows:—The image of the arc formed by the light which comes through the windows of the revolving disc is received on the disc P, and we have an image formed there which represents the state of the alternating-current arc in some particular phase, depending upon the angular position of the axis which joins together the mirrors M_1 and M_2. The mirrors M_1 and M_2 are fixed upon a radial arm, which connects them together, and which is capable of being moved round in a vertical plane, so that the line $M_1 M_2$ revolves round a centre, M_1, and is capable of being placed in any angular position within certain limits with respect to the vertical line through M_1. By rocking round this arm the light which passes through the window W is that which is taken from the arc at a particular instant during its complete periodic change. Under these circumstances the image that is seen formed upon the screen can be made to exhibit any of the conditions which exist in the arc during the complete period by moving the rocking arm carrying the mirrors M_1 and M_2 through a certain angle. It is thus found that the blue or purple light forming the true arc in between the carbons undergoes a periodic variation in intensity, completely vanishing at a certain instant during the phase, but at the same time there is outside this true arc a dim halo of golden light which is persistent, and it is on account of this persistent aureole of faint light that the ordinates of the firm line curve in Fig. 4, which represent the variation of light in the true arc, never

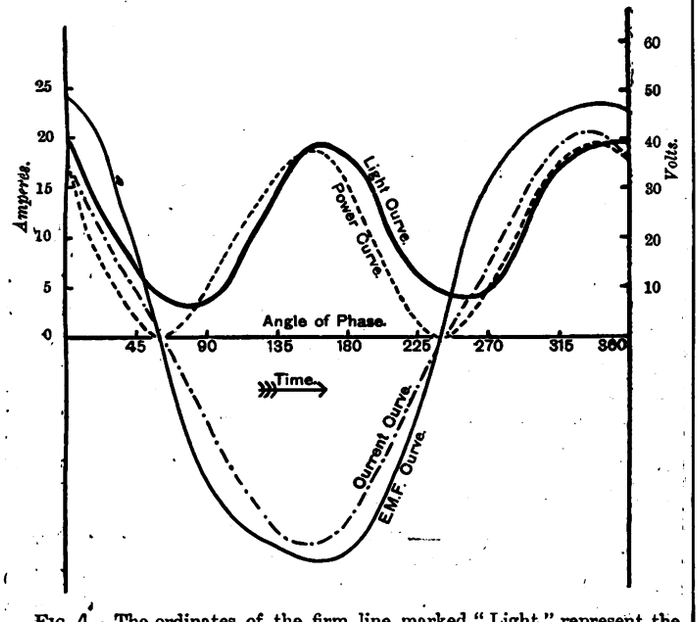

FIG. 4.—The ordinates of the firm line marked "Light" represent the periodic variation of illuminating power of the centre of the *true arc* of an alternating-current arc. The other curves marked E.M.F., current and power represent the variation of potential difference of the carbons, current and power in the arc. Carbons, 15mm. cored; $\sim$ = 83·3; amperes = 14; volts = 39; length of arc, 0·55cm.; volts at alternator terminals = 104.

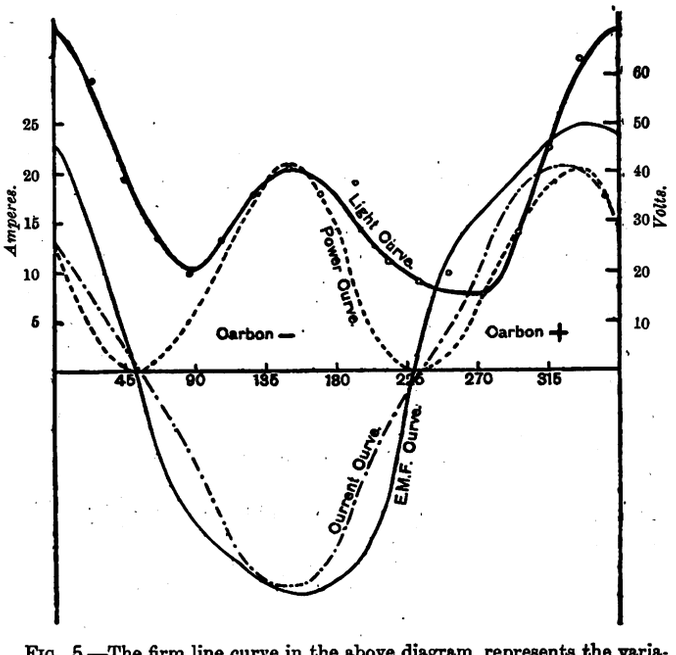

FIG. 5.—The firm line curve in the above diagram represents the variation in illuminating power of the *crater* of the lower carbon during one complete phase of an alternating-current arc. Carbons, 15mm. cored; $\sim$ = 83·3; amperes = 14; volts = 36; length of arc, 0·42cm.; volts at alternator terminals = 98.

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become zero, but there is always an outstanding constant amount of light. In order to select as far as possible merely the blue or purple-coloured light from the true arc, irrespective of any admixture of white light coming from the aureole, a blue gelatine transparent screen was employed to select a certain group of rays. By shifting the position of the mirrors M_2 and M_4 slightly, it was possible to measure the periodic variation of light coming from any part of the incandescent carbons. The diagram in Fig. 5 represents the periodic variation of light coming from the centre of the crater of the lower carbon, the other curves of the same diagram representing the variation of current through the arc, potential difference between the carbons, and power expended in the arc. It must be noted that the scale to which the light curve in Fig. 5 is drawn is very different from that of the light curve in Fig. 4, as the crater is, of course, far more brilliant than the true arc. The interesting point to notice is that during the time when the lower carbon is negative, the maximum light emitted from the centre of the crater of the lower carbon does not reach such a maximum value as it does when the same carbon is positive. For a frequency of 83 it is not much more than one-half as great—that is to say, the brilliancy of the crater on the carbon undergoes a periodic variation, but at the instant when the carbon is negative and when the maximum power is being expended in the arc, the brilliancy of that part of the carbon is not much more than one-half that which it is when the same carbon is positive and receiving its maximum power expenditure. The lower the frequency, the greater this difference. It is easy to distinguish the part of the period during which the lower carbon is negative from that in which it is positive by holding a magnet at the back of the arc and noting which way it causes the image of the arc to be deflected, which image is formed by the lens L_1.

It is evident from the curves in Fig. 5 that there is a certain lag in the curve representing the variation of light from the carbons behind the curve representing the power; in other words, the light lingers on a little after the power has fallen to zero. It will also be noticed there is a very slight difference of phase between the current and electromotive force, which is also found in all the other curves taken with the alternating-current arc.

These investigations are as yet not quite complete, but we propose later on to publish a full account of them. The observations have necessitated an enormous number of photometric and electrical measurements, and we have in this work been very efficiently aided by Messrs. L. Birks, W. H. Grimsdale, A. M. Hanbury, E. N. Griffiths and others who have taken part in the research, and to whom our thanks are due.

SPEED-VOLTAGE CURVES.

BY J. ALFRED GRIFFITHS, B.SC., WH. SCH., &c.

The predetermination of the relations of speed and potential for a self-exciting dynamo is of direct importance when the prime mover is uncontrollable and subject to irregular fluctuations of speed of considerable extent, as in the cases of wind-power storage and of train lighting from the axles of the carriages; it is also useful in the case of constant current regulated by varying the speed, in the arrangement of compound winding, and in the design of low-speed dynamos.

When a dynamo is started with the speed slowly increasing in small steps it is noticed that at first the potential is imperceptible, or very slight, and that the dynamic building of the magnetic field does not commence until a certain critical speed is reached, at which very often a slight increase of speed causes a decided jump in potential, which afterwards increases steadily with each increment of speed. The reason for this absence of dynamic increment at low speeds is by no means obvious from text-books and published papers, attention being usually concentrated on the action of the dynamo under an ideal constant speed that is but approximately realised in practice. The following method of investigation will be useful to students, and may possibly be interesting to experienced electricians.

In the first instance, consider a continuous-current bi-polar dynamo without any external load, so that the distinctions of series, shunt, or compound-winding do not complicate the question, and in which both armature reactions and permanent magnetism are so small as to be negligible.

Let the curve O A B represent the magnetic properties under separate excitation of the dynamo carcase, including its armature *at rest* and the air gaps; the abscissæ measuring the total ampere-turns in the field coils and the ordinates the average magnetic density in the air gaps (after allowing for leakage) in C.G.S. lines per square centimetre of *effective* gap or pole area. The full line represents the induction as the ampere-turns are slowly increased, and the dotted line the induction with diminishing excitation. On the same diagram, O C (tangent, or nearly so, at O to O A B) will represent the relation between the magnetic density in the gap space and that portion of the ampere-turns required to overcome the reluctance of the air gaps alone.

The scales used in the diagram will suit a dynamo having the following dimensions:—

A = effective pole area = 1,600 sq. cm.;
B = C.G.S. lines per square centimetre in the gap;
$2l$ = total length of double gap = 3·0cm.;
C = total conductors round armature = 80;
r_a = armature resistance from brush to brush = 0·01 ohm;
E = total electromotive force in the armature;
Z = number of coils in shunt winding = 3,260;
r_s = total resistance of shunt coils = 16·93 ohms;
S = number of series coils;
r_s = resistance of series coils;
R = external resistance of working circuit;
i_a, i_z, i_s = currents in the several circuits;
n = speed in revolutions per second.

The equation to the gap-line O C will then be:—

$$\text{A.T.'s} = B \times 2l \times \frac{10}{4\pi} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$= B \times 2{\cdot}3874 \text{ for the particular dimensions.}$$

Next, consider the density in the gap, B, to be independently varied, while the armature is maintained in uniform motion. Then for each value given to B a potential will be induced in the armature capable of generating a current in the field coils, and since the speed and resistance are constants, the ampere-turns of such current will be directly proportional to the density B, and the relation may be expressed by a straight line through O, or by the equation

$$\text{A.T.'s} = \frac{E}{r_a + r_s} \times Z = \frac{B \times A \times C \times n \times Z}{10^8 \times (r_a + r_s)} \quad . \quad . \quad . \quad (2)$$

Let O A be such a line (which may be named a *speed line*) cutting the ascending magnetic curve in the point A, at which 20,840 ampere-turns are produced by the armature revolving in a field of density $B = 7{,}050$ at a speed of 12 revolutions per second; and also (on the magnetic curve) a field of $B = 7{,}050$ is generated in the gap by 20,840 ampere-turns acting in the complete magnetic circuit. Obviously there is equilibrium at A, and the dynamo will excite itself at that stage.

The same squared paper may be used for the speed-voltage diagram, measuring revolutions along Y Q and volts along X Q, the origin being still at O, by choosing suitable units. Through the point D, where the speed line of the magnetic diagram cuts the corresponding speed ordinate (in the example, for 12 revolutions per second), draw the dotted line C D E parallel to O X. This line may be called the *scale of speeds* for the particular winding of armature and field under consideration, for if a line is drawn to O from any point on the speed line, it will represent the relation of the density of field to the ampere-turns generated by the armature at the speed indicated by that point on the speed scale. If on the squared paper, p ampere-turns measure q revolutions, then from equation (2)

$$B_n = \frac{p}{q} \times \frac{10^8 (r_a + r_s)}{A \times C \times Z} \quad . \quad . \quad . \quad . \quad (3)$$

which fixes the height of the speed scale on the scale of magnetic density.

None of these speed lines O F, O G between O Y and O C cut the ascending magnetic curve O A B, showing that at speeds

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lower than that represented by O C (the gap-line) the ampere-turns generated by the armature will not excite the necessary field for self-excitation. On the other hand, if the armature be moving at any constant speed greater than O C, and the circuit (previously supposed open) be closed, then, if there is ever so little residual magnetism or other cause which will start any faint current, the ampere-turns of that current will be competent to excite a denser field than is necessary to induce the first faint current; thus the current and field will be mutually strengthened until the point is reached where the speed line and ascending magnetic curve intersect, where there will be equilibrium and the process will stop. For example, suppose the speed to be 12 revolutions per second (speed line O D) and the initial field be but 60 C.G.S. lines due to permanent magnetism; the potential in the armature will generate only 177 ampere-turns, yet these 177 ampere-turns will excite a dynamo field of about 70 C.G.S. lines, the potential from which is competent to generate 208 ampere-turns. Thus the current and field will increase until at about 4,700 C.G.S. lines the surplus ampere-turns will be about 2,000. From this point as the current increases the surplus will diminish, until the intersection of the rising magnetic curve and the speed line is reached when the surplus vanishes and a stable field is established.

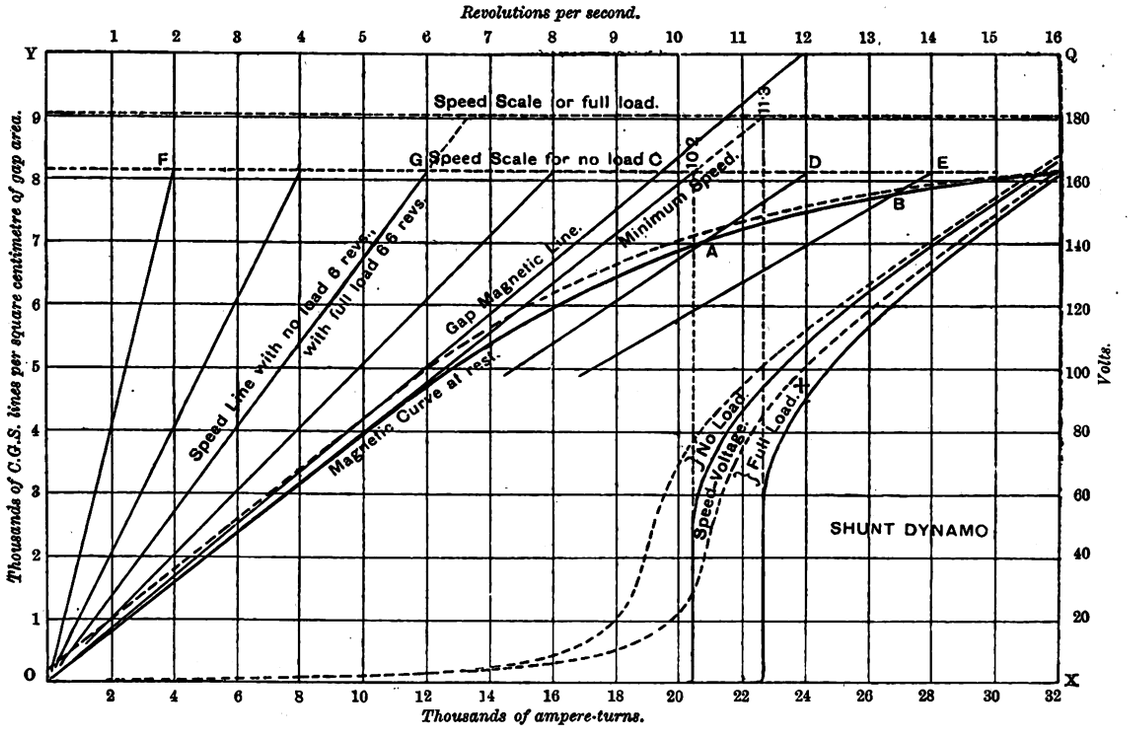
but as this is impossible, the curve may be determined graphically for any given magnetic curve. By drawing a sufficient number of speed lines, and scaling the value of **B** at the intersections with the magnetic curve, the corresponding armature potential may be calculated by the equation

$$E = \mathbf{B} \times n \times \frac{A \times C}{10^8}; \quad . \quad . \quad . \quad . \quad . \quad (5)$$

for the example in the diagram

$$\frac{A \times C}{10^8} = \frac{1{,}600 \times 80}{10^8} = 0{\cdot}00128.$$

The rising and falling branches of the magnetic curve may be separately treated as in the diagram (the measurements and calculations for which are tabulated in the appendix) or a mean magnetic curve may be used for practical convenience. When the speed is decreasing the speed-voltage curve lies above that for rising magnetism, and the excitation does not stop suddenly when that value of n is reached at which self-excitation commenced, but continues to zero speed with the low but perceptible value shown in the dotted voltage curve. The greater the residual magnetism the greater will be the space between the two curves. This property greatly helps the stability of the potential with small variations of speed,



Evidently, the minimum speed below which the self-excitation will not begin is that for which the speed line through O is coincident with the line O C, representing on the magnetic diagram the ampere-turns required for the gap-reluctance. Since only linear functions are involved, this minimum speed is easily expressed in terms of the dimensions of the dynamo by equating the ampere-turns from equations (1) and (2) thus:

$$\mathbf{B} \times 2l \times \frac{10}{4\pi} = \frac{\mathbf{B} \times A \times C \times n_0 \times Z}{10^8 \times (r_a + r_s)},$$

whence

$$n_0 = \frac{10^8}{C} \times \left(\frac{2l}{A} \times \frac{10}{4\pi}\right) \times \frac{r_a + r_s}{Z}. \quad . \quad . \quad . \quad (4)$$

Usually r_a is quite negligible compared with r_s, and then

$$n_0 \text{ varies as } \frac{\text{gap reluctance} \times \text{resistance of one field coil}}{\text{total armature conductors}}.$$

With some open-coil armatures (such as the Siemens shuttle) the minimum speed will be half of the above value (4), and with parallel-connected multipolars C will be the number of armature conductors for each pair of poles.

If the magnetic function could be algebraically expressed, the next step would be to write down the equation for the whole speed-voltage, and to trace its curve shape analytically; for a small drop in speed is not immediately followed by a drop of potential to the value for the lower speed on the rising curve, and the induction may not change until the speed has fallen to a value corresponding to that potential on the falling curve—*i.e.*, through a change of speed measured by the horizontal distance between the ordinates for the two branches of the speed-voltage curve at the one potential.

When the permeability at low stages is so nearly uniform that the magnetic curve near the origin is practically straight, then the induction through this stage is a linear function which may be added to the expression for the air-gap, and the minimum speed will be that for which the speed line coincides with the straight part of the magnetic curve. If the uniform permeability is known the minimum speed will be

$$n_0 = \frac{10^8}{C} \times \left(\frac{2l + m}{A} \times \frac{10}{4\pi}\right) \times \frac{r_a + r_s}{Z}, \quad . \quad . \quad . \quad (6)$$

m being the length of air-gap that has the same reluctance as the iron carcase at low stages of magnetisation. Usually, however, this special minimum speed is most easily obtained graphically by drawing a tangent, as in the diagram, at O H.

Having determined a speed voltage curve as in the diagram for any particular height of speed scale (say $\mathbf{B}_a = 8{,}130$), the

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curve for any other position of speed scale (say $B_n = 9{,}020$), due to different winding or to the addition of an external load, may be proportionately computed and plotted. If a speed line be drawn through any particular value of B on the magnetic curve, then the speed represented thereby will be increased in proportion to the height of the new speed scale, and the potential in proportion to the same alteration of height (and to the alterations of winding, if any). This may be done graphically or numerically. By the graphic method (when the winding is unaltered) take any corresponding points on the magnetic and potential curves; through the point on the magnetic curve draw a speed line, and from its intersection with the new speed scale drop the ordinate perpendicular to OX; through the point on the old potential curve draw a vector from the origin to cut the new ordinate in the desired point on the new potential curve. Numerically a slide rule may be set up for the ratio of the speed scale heights, and the new co-ordinates written down in tabular form, as in the appendix, and plotted.

When work is done through an external circuit, either with series or shunt connections, a greater speed is required for any particular potential than with no load. This is due to the reduction of the ampere-turns both from the alterations of the electrical circuit and by the armature disturbances. Some assumption must be made as to the nature of these disturbances, of which the most important is the demagnetising of the field by the back ampere-turns of the armature. When the external circuit is constant and only the speed varies, the variation of brush lead for sparklessness will not largely affect the result, and the back ampere-turns may be taken simply as proportional to the armature current, and expressed by $i_a \times b\,C$, b being the ratio of half the conductors in the demagnetising belt to the total number.*

Taking this approximate expression for the main armature reaction, and neglecting minor disturbances, the three main formulæ become, for a series dynamo with external circuit of resistance R :—

$$\text{A.T.'s} = i_a \times S - i_a \times b\,C = \frac{E \times (S - b\,C)}{r_a + r_s + R}, \quad . \quad . \quad (7)$$

$$B_n = \frac{p}{q} \times \frac{10^8}{A \times C} \times \frac{r_a + r_s + R}{S - b\,C}, \quad . \quad . \quad . \quad . \quad (8)$$

$$n_0 = \frac{10^8}{C} \times \left(\frac{2\,l}{A} \times \frac{10}{4\pi}\right) \times \frac{r_a + r_s + R}{S - b\,C}; \quad . \quad . \quad (9)$$

} Series

and for a shunt connection,

$$\text{A.T.'s} = i_s \times Z - i_a \times b\,C = E \times \frac{R\,Z - (r_s + R) \times b\,C}{r_a r_s + r_a R + r_s R}, \quad (10)$$

$$B_n = \frac{p}{q} \times \frac{10^8}{A \times C} \times \frac{r_a r_s + r_a R + r_s R}{R\,Z - b\,C \times (r_s + R)}$$

$$= \frac{p}{q} \times \frac{10^8}{A \times C} \times \frac{\frac{r_a r_s}{R} + r_a + r_s}{Z - b\,C \times \left(1 + \frac{r_s}{R}\right)}, \quad (11)$$

$$n_0 = \frac{10^8}{C} \times \left(\frac{2\,l}{A} \times \frac{10}{4\pi}\right) \times \frac{\frac{r_a r_s}{R} + r_a + r_s}{Z - b\,C \times \left(1 + \frac{r_s}{R}\right)}. \quad . \quad (12)$$

} Shunt.

The lowest position of the speed scale is when B_n is a minimum, which occurs with series connections when $R = 0$ and the current has a maximum value, and with shunt connections when R is infinite and the external current has vanished. This limiting value of B_n is in both cases the same, Z and S being then interchangeable,

$$\text{Minimum } B_n = \frac{p}{q} \times \frac{10^8}{A \times C} \times \frac{r_a + r_s}{Z - b\,C}. \quad . \quad . \quad (13)$$

With compound winding the series coils may be used either to oppose the demagnetising action of the armature and circuit resistances, resulting in an increased potential at any given speed, or they may be reversed; the former method being useful to obtain constant potential at approximately constant speed, and the latter to obtain a drooping external characteristic to prevent excessive current at high speeds when the prime mover is uncontrollable as to speed, as in the cases of wind power and railway carriage axles. The three formulæ for compound winding are :—

$$\text{A.T.'s} = i_s \times Z + i_s \times S - i_a \times b\,C$$

$$= E \times \frac{R\,Z + r_s\,S - b\,C \times (R + r_s)}{r_a r_s + r_a R + r_s R}, \quad . \quad . \quad . \quad . \quad (14)$$

$$B_n = \frac{p}{q} \times \frac{10^8}{A\,C} \times \frac{r_a r_s + r_a R + r_s R}{R\,Z + r_s S - b\,C\,(R + r_s)}, \quad . \quad . \quad (15)$$

$$n_0 = \frac{10^8}{C} \times \left(\frac{2\,l}{A} \times \frac{10}{4\pi}\right) \times \frac{r_a r_z + r_a R + r_z R}{R\,Z + r_z S - b\,C\,(R + r_z)}. \quad (16)$$

} Compound.

In these R includes r_s, and the sign of S is positive or negative according as the series coils help or oppose the shunt coils.

In order that the two windings shall exactly compensate, a value of S must be chosen, which, if possible, will bring the position of the speed scale to the same height with external resistance = R as the minimum height. By equating the values of B_n from equations (13) and (15),

$$\frac{r_a r + r_a R + r R}{R\,Z + r\,S - b\,C\,(R + r_z)} = \frac{r_a + r_z}{Z - b\,C},$$

hence

$$S = \frac{r_a\,Z + r_z\,b\,C}{r_a + r_z}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

The elimination of R from this value of S indicates that if the brush lead is not altered then the total armature potential will be constant at any particular speed for all external loads, when that number of series coils assists the shunt. The first part, $\frac{r_a Z}{r_a + r_s}$, represents the coils needed to compensate the drop in potential due to armature resistance, and the latter part, $\frac{r_s\,b\,C}{r_a + r_s}$, the coils needed in respect of the belt of back ampere-turns supposed to be of constant width. If further hypotheses are made concerning the variations of b, or of other disturbances of potential, the expression for S will be extended, but R may not be eliminated, as is found practically when compounding for constant external potential. But since R cannot be eliminated from the fundamental relation of total and external potential it cannot be expected that perfect compounding for external potential should follow its elimination from the total potential.

With certain chord-wound armatures, the demagnetising is insensible, and equation (17) becomes

$$\frac{S}{Z} = \frac{r_a}{r_a + r_s}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

In the diagram, the speed-voltage curve for no-load is plotted for a value of $B_n = 8{,}130$ from equation (13), assuming

APPENDIX.

Speed-voltage Ordinates for a Shunt Dynamo.

With no load, $B_n = 8{,}130$.					With full load, $B_n = 9{,}020$. Calculated values.		
	Rising magnetism.		Falling magnetism.				
Speed.	Scaled value of B.	Volts. 0·00128 B × n.	Scaled value of B.	Volts. 0·00128 B × n.	Speed.	Rising magnetism. Volts.	Falling magnetism. Volts.
0·0	...	...	200	0·0	0·00	...	0·0
2·0	...	...	220	0·6	2·22	...	0·6
4·0	...	...	300	1·5	4·44	...	1·7
6·0	...	...	450	3·5	6·66	...	3·8
8·0	...	...	900	9·2	8·88	...	10·2
9·0	...	...	1,750	20·2	9·98	...	22·4
9·7	...	...	4,600	57·1	10·76	...	63·4
10·0	0	...	5,550	71·0	11·09	0·0	78·9
10·2	4,000	52·2	5,850	76·4	11·32	57·9	84·7
10·6	5,500	74·6	6,400	86·8	11·76	82·8	96·3
11·0	6,150	86·5	6,730	94·7	12·21	96·0	105·1
11·5	6,690	98·5	7,060	103·9	12·76	109·2	115·3
12·0	7,050	108·3	7,280	111·8	13·32	120·2	124·0
12·5	7,300	116·8	7,480	119·7	13·87	129·6	132·8
13·0	7,520	125·1	7,670	127·6	14·42	138·8	141·6
14·0	7,810	140·0	7,900	141·6	15·53	155·3	157·1
15·0	8,000	153·6	8,100	155·5	16·64	170·4	172·5
16·0	8,170	167·3	8,200	168·0	17·75	185·6	186·4

* *See* Appendix.

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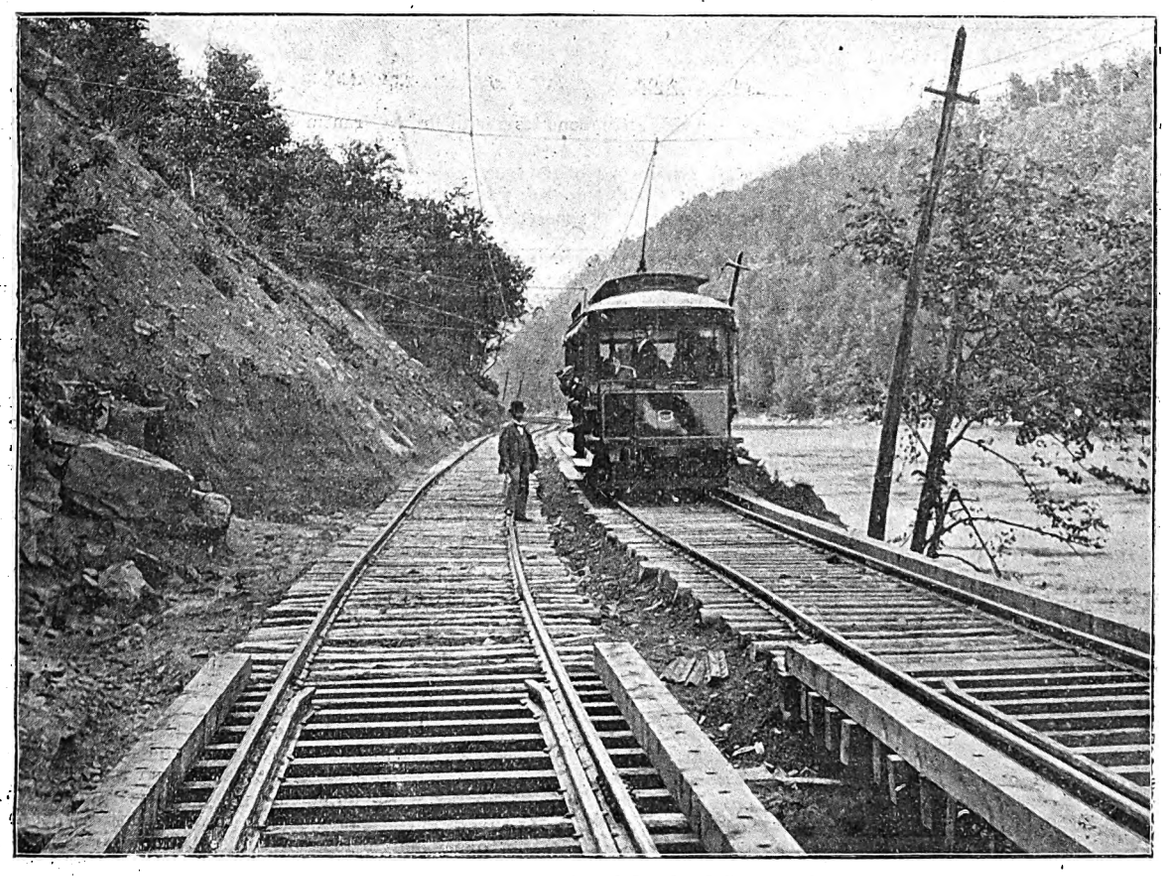
bC to have a constant value $\frac{C}{17{\cdot}8}$, and for full load a current of 320 amperes in an external resistance of 0·3281 ohm gives $B_n = 9{,}020$ from equation (11). The value of S for constant total potential, from equation (17), will be 6·4 coils.

The necessary additional series coils to give approximate constant external potential at the brushes or at the end of the main leads, and the number of reversed series coils necessary for a drooping external characteristic, are determined by considerations beyond the scope of the present study.

THE NIAGARA FALLS AND LEWISTON ELECTRIC RAILWAY.

On the New York State bank of the Niagara River, between Niagara Falls and Lewiston, a distance of seven miles, a double-track electric railway is being constructed, and for a little over half of its length has been completed and is in operation. From Lewiston, the United States town immediately opposite Queenston Heights, the road for some distance runs along the bank, about 20ft. from the water's edge. As will be seen from our illustration, the side-pole system is used, and the track is of the usual American type. The power for the operation of this road is now obtained from the plant of the Niagara Falls Hydraulic Power and Manufacturing Company, and carried to the point where the road at present begins on cables strung on poles. The cars now start close to the whirlpool rapids, and speed along past the rapids, the whirlpool and other points, affording passengers a truly magnificent view. The construction of the roadbed was a tremendous task. Dynamite was freely used in blasting a path through the rock. In some places the cliff was perpendicular, and at these points the rocky mass was blasted away from the water's edge to the top of the cliff, and the broken rock used to fill in and make a roadbed. Pieces of rock weighing hundreds of pounds were hurled—so heavy were the blasts—clear across the gorge into the Canadian town of Niagara Falls, until the danger to life and property becoming so great, the local authorities of that town made severe protest, and called the attention of the British Ambassador at Washington to the matter. The British Ambassador protested to the State Department, which, in turn, called down the New York State Government, the American local authorities finally preventing further heavy blasts by arresting some of the foremen. The fact that this road runs for miles along the swiftest current of the lower Niagara River, the Company controlling the shore line, has given rise to efforts to develop power from the current, and many men are giving the subject thought, the Company being willing to pay for a plan by which they will be able to secure sufficient power to operate their road.



Lewiston Electric Railway. View showing Track and Overhead Construction on the Niagara Falls.

TESTS OF THE BROWN TELEPHONE TRANSMITTER AND COLLIER-MARR RECEIVER.

The tests described below were made between Baltimore and various other points on the Baltimore and Ohio Railway in the United States, with the Brown loud-speaking telephone transmitter and the Collier-Marr receiver, the patents for which belong to the Single-Wire Multiple Telephone Signal Company. The wires used were the ordinary railway wires used for telegraphy, and the result is interesting as showing that the very great amount of induction present did not interfere with conversation. The same instruments were afterwards used on a railway wire between Chicago and Meadville—500 miles—with perfect success.

September 16th.—Wire in service 182-iron, gauge 9 (rather smaller than English standard gauge 11), to Washington, occupying poles as shown in diagram, distance 41 miles: conversation carried on perfectly and easily at a distance of 10ft. from the receiver during a thunderstorm.

September 17th.—Test made on a single copper wire, gauge 12 (14 English standard), wire No. 40, from Baltimore to Washington Junction, distance 86·3 miles, during a heavy storm of lightning, very heavy induction: conversation easily carried on at a distance of several feet from the receiver.

September 18th.—Raining at Baltimore and all along the line; heavy thunderstorm between Baltimore and Cumberland:—

(First Test.)—Iron wire, gauge 8 (10 English standard), Baltimored to Cumberland, 195·7 miles, earthed at each end: Cumberland could be heard by

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placing the ear close to the instrument; conversation carried on, but with difficulty, owing to storm.

(Second Test.)—Copper wire, gauge 12 (14 English standard), earthed at both ends: perfectly intelligible speech, although induction very great, the effects of storm quite apparent.

The lines used, besides being parallel or on the same poles as the lines shown in the diagram, are parallel and in proximity to electric light and street railway wires at different points along the line; tests were made when these wires were all in operation, and when the wires on a same set of poles were being used for multiplex and

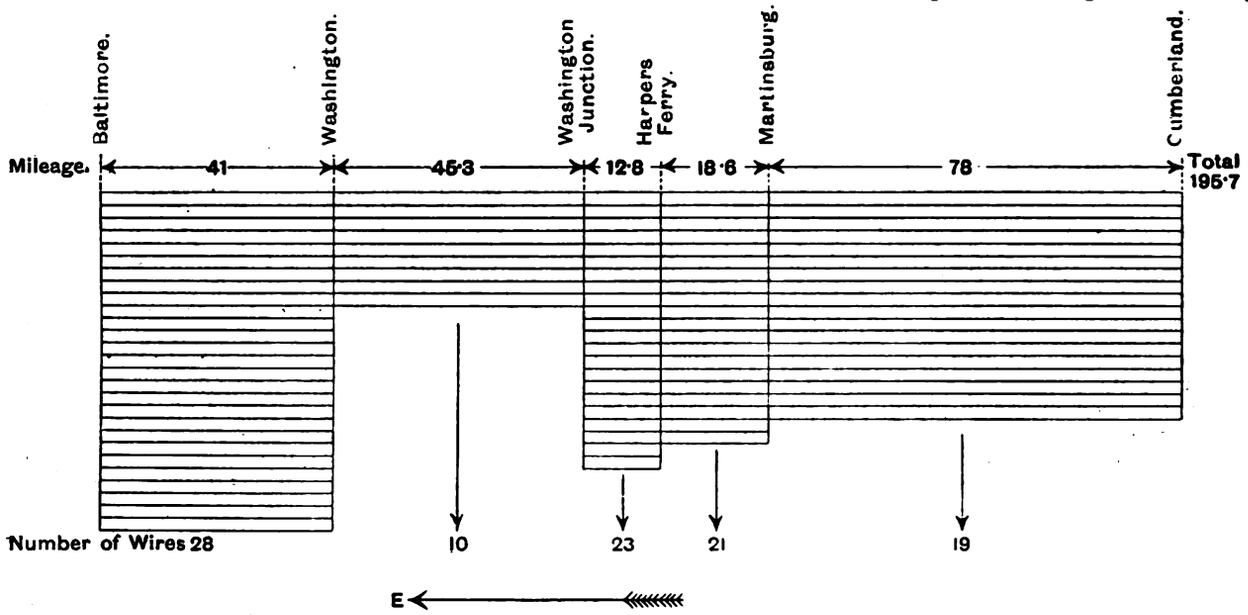

Diagram showing distance and number of wires on poles over which telephone tests with Brown Transmitter were made. (Not drawn to scale).

(Third Test.)—Copper wires, gauge 12 (14 English standard), forming a metallic circuit, Baltimore to Cumberland, distance 195·7 miles: speech perfect, and could be heard from 5ft. to 10ft. away from the receiver.

other telegraphic uses; although the induction was very great, the speech was so clear that when one stood a few feet away from the receiver noises due to induction were not audible.

THE USE OF DUST DESTRUCTORS AS STEAM PRODUCERS FOR ELECTRICITY SUPPLY STATIONS.*

BY E. MANVILLE.

I do not propose to describe all the various methods and systems on which dust destructors have been constructed, as this would involve a Paper so lengthy that it would take more time than at your disposal to read it, and I will therefore only allude to the main points in the arrangement of suitable and of unsuitable systems for the efficient generation of steam by the waste gases from the destructor furnaces, and then confine myself to a description of those two installations at present being erected for the Vestry of Shoreditch and the Corporation of Swansea on what I believe to be the most suitable lines.

The progress of the design of the dust destructor since its first days has certainly been one of slow evolution. In those times the design of the furnaces seems to have been such as to simply provide for the burning, or rather partial burning, of the refuse without much consideration as to the treatment being carried on in a scientific manner, and this, no doubt, has had a great deal to do with the prejudices that still in many places exist against the erection of such an installation within a populous town. These objections were chiefly founded on the smells that proceed from many destructors, and I may assure you that there is no need for such smells to exist. They proceed from two causes: (1) that in some destructor furnaces the design is such that all the gases produced in the heating and burning of the refuse are not thoroughly and completely burnt, and (2) that the refuse when tipped on to the tops of the hot furnaces from the dust carts, before being burnt, rapidly ferments and emits a very sour smell unless proper precautions are taken to prevent this happening.

The first of these two causes which has caused dust destructors in some cases to be regarded as nuisances is due generally to the burning of the refuse at too slow a rate of combustion, and is a fault which is inherent in most of the old forms of destructors, and more especially in nearly all those erected in the South of England. In this type of destructor the refuse is burnt under such natural draught as is attained by a chimney 150 to 180 feet in height, and under this draught the refuse as a rule burns so slowly that its temperature whilst burning rarely exceeds 1,000°F., and is generally below that temperature. When ashbin refuse, as generally composed, is heated to this temperature, gases are given off by its destructive distillation which, to ensure their thorough combustion, must be raised to a temperature of at least 1,200°F. Obviously, if the maximum temperature of the furnace is beneath 1,000deg., these gases are sent out into the atmosphere incompletely burnt and partially causing the nuisance complained of. Therefore, to ensure the complete combustion of all the gases, the mean temperature of the furnace should not be much less than 1,800°F., so that during the operations of clinkering, &c., the temperature of the interior of the furnaces may not fall below the before-mentioned minimum of 1,200°F.; and in the more modern design of destructors these temperatures are obtained through the more rapid combustion of the refuse by burning it under forced draught. In the old types of furnaces where these temperatures are not attained, a secondary urnace has to be provided, in which is burnt continuously a coke-fire, over which all the gases from the refuse furnaces have to pass, and in which their temperatures are raised to the required degree.

Of late years some of the towns in the North of England have set an example as to the use of forced draught so as to produce the requisite atmosphere within the furnaces themselves, and in your immediate neighbourhood there are several good examples of high temperature destructors which leave little to be desired. I allude to those at Warrington, Rochdale, Oldham and at Leeds, in all of which the temperatures attained are amply sufficient to completely burn and thus render completely innocuous all the gases produced by the destructive distillation of the refuse. The use of forced draught has proved itself eminently satisfactory so long as normal conditions are maintained in the quality of the refuse to be burnt; but, at the same time, it is certain that no matter what the locality may be, every single load of refuse cannot be absolutely relied upon to contain nothing of a character that might prevent the necessary high temperatures being attained, and therefore I believe that, especially in small ranges of destructor cells, means should be provided for adding a secondary fire, even if it be only used occasionally when the refuse is of a doubtful character. Proper design and provision of this kind having been made, there can be, I think, no doubt in the minds of those responsible for the erection of dust destructors as to the certainty of complete combustion of the gases taking place, and the entire absence of anything in the shape of a nuisance arising from those gases as sent out into the atmosphere through the chimney shaft. The second possible source of a nuisance—namely, the smell arising from the fermentation of the refuse when tipping within the destructor house before being burnt—is, happily enough, likewise entirely eliminated by the use of forced draught. I need hardly point out to you that the large weight of refuse that has to be burnt hourly requires the provision of a very large quantity of oxygen for its complete combustion, and if this oxygen be furnished in the shape of air provided by fans producing the forced draught, this air can be taken by the fans with the greatest facility, from above the level of the tipping floor, and the rate at which the fans draw air is such that the whole atmosphere of the destructor house is renewed

* Abstract of Paper read before Northern Society of Electrical Engineers.

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at very short intervals of time, the whole of the air so abstracted being sent by the fans through the furnaces and up the chimney shaft, and in its passage through the furnaces is rendered completely innocuous; thus, the forced draught not only provides for that temperature which is requisite to render innocuous the gases produced by the destructive distillation of the refuse, but also draws into the furnaces the outside surrounding atmosphere that may have been rendered unpleasant to the smell by the fermentation of the green refuse.

The calorific value of burning refuse has so often been called in question, and such varying statements have been made as to the results so far achieved, that there is little wonder at the incredulity of many Local Authorities as to the steam refuse having any value worth talking about from a steam-raising point of view. I am afraid I must state that many of these contradictory statements have been made from sheer ignorance on the part of those who made them and others on account of the conditions under which the steam raising has been performed.

You are no doubt aware of the extremely good radiating properties of brickwork, and you can well appreciate that if a row of furnaces are placed at one end of a long brick flue, and boilers placed at the other end of this same flue, so that the hot gases, in their passage from the furnaces to the boilers, are exposed to a great area of brickwork, a very large proportion of the useful heat of these gases is lost before ever the boilers are reached, and then, again, in most of the older types of destructors the boiler-heating surface provided, on which the gases act, is completely insufficient for the efficient utilisation of this heat. I have myself heard practical users state that but an extremely small amount of steam can be hoped to be produced with their dust destructor, and therefore with dust destructors in general. Now, of course, the calorific value of ashbin refuse varies in every district according to the season of the year and the nature of the district; but, after making all due allowance for such differences as might exist under these conditions, some of these statements set forth publicly seem to me to be quite ridiculous, and I believe this view is held by those who, like me, have taken the trouble to ascertain what may be attained in the way of steam raising with ashbin refuse. I have always endeavoured in such cases to find out the reasons that have induced the gentlemen concerned to place such discouraging figures upon the calorific value of their ashbin refuse, and I have invariably found that the cause was due to the admixture of foreign substances with the refuse collected from the ashbins. I would mention one case in particular, where a gentleman well known in connection with dust destruction has from time to time stated that in his belief no such horse-power as talked about by others could be obtained from ashbin refuse: I found that his ashbin refuse was enormously diluted with street sweepings before it was burned in his destructor. Need I say that it follows that if a matter of an entirely incombustible nature is mixed with—if I may term it—pure ashbin refuse, the calorific value of the ashbin refuse may be so reduced that it may be entirely worthless as a steam producer? But I hope now that the subject is being so largely considered that where the unusual conditions of the admixture of foreign substances with the ashbin refuse occur, those who talk of the steam-raising properties of ashbin refuse under these conditions may be more careful in the future to mention that it is so mixed. I feel strongly upon this point, since to my personal knowledge several Local Authorities who might have erected dust destructors and utilised the steam raised by the combustion of the ashbin refuse have been so discouraged by these contrary and apparently inexplicable statements that they have abandoned altogether the consideration of a destructor scheme.

I will not further take up your time by the discussion of what I may term the principles of refuse destruction, but will rather now proceed to describe to you the methods by which I am engaged in applying it to electric power production.

In the year 1892 the Vestry of St. Leonard, Shoreditch, in London, had in view the erection of a central electric supply station and at the same time of a dust destructor. I being appointed to advise the authority in relation to electric lighting, strongly recommended them to combine the two schemes. A great deal of careful investigation was carried out on their behalf to ascertain what power might reasonably be expected as obtainable from the burning of their ashbin refuse, and as a result of this investigation I felt enabled to assure them that all the steam required for the estimated electrical output likely in the first instance to be demanded from their electric light station might be obtained from a properly designed dust destructor, without the use of other fuel. In arriving at this opinion I experimented on a large scale with samples of ashbin refuse collected from various parts of Shoreditch at a season of the year when household fires were not much in use, and I found it was extremely rich in carbon.

When the unsorted refuse was burnt directly in a boiler, it evaporated as much as 3lb. of water from and at 212°F., and my opinion that the steam required could be obtained from the burning of this refuse in a properly-designed arrangement of destructor cells and boilers, was founded on the supposition that only about one-third of the calorific value of the refuse would be utilised in the boilers, after due allowance had been made for the complete and perfect combustion of the ashbin refuse and its gases.

The Vestry thereupon resolved that such a combination should be erected forthwith. Unfortunately the scheme approved of by the Vestry in the early part of 1893 did not advance with the speed one might have hoped, owing to the difficulty of obtaining a sufficiently extensive site within the area of the parish, more particularly as the Vestry wished to erect on the same site other municipal buildings. This difficulty having at last been overcome, about eight months ago I was enabled to proceed with the plans of the arrangement originally proposed by me. A number of tenders were received for carrying these plans into effect, and ultimately the contract was awarded to Messrs. Manlove, Alliott and Co., of Nottingham, on the following basis, and this firm are now actively proceeding with the construction of the works.

The destructor cells themselves are arranged a pair on each side of a Babcock and Willcox boiler, there being thus in all six boilers. Each of these boilers has a heating surface of about 1,400 sq. ft., and a pair of cells on each side of it are arranged to discharge their products of combustion under the boiler tubes immediately above the level of the fire bars, these fire-bars being left in the boiler together with the fire doors in exactly the same manner as if the boilers were being erected without the accompaniment of dust-destructor cells. Each cell is arranged with double flues, one leading to the boiler, as aforesaid, and the other direct to the main flues.

Each destructor has a grate area of 27 sq. ft. The main flues are arranged above the floor level and underneath the working floor, and are in duplicate, each boiler and cell being able to discharge its gases into either or both of the main flues. This arrangement of duplicate flues is essential in the combination of a dust destructor with an electric lighting station, as the dust carried over with the products of combustion from the cells into the main flue must be removed at moderately frequent intervals, whilst the working of the main flue can never be discontinued owing to the necessity of continuous steaming of the boilers, and this duplicate arrangement of the flues enables one flue at a time to be cleaned out, the products of combustion of all the boilers and all the cells being taken into the remaining flue during that time. At the end of the main flues is placed a chamber, which for the present will serve the purpose of a dust-depositing chamber, but may in the future be divided up to contain an economiser with its requisite by-pass flue. This chamber leads into the main chimney shaft, which is 150ft. in height from the floor level, and is provided with a circular gallery around its base, into which this chamber leads, and between which gallery and the main shaft are a number of small openings, the whole being so arranged that the products of combustion have to swirl round the gallery to enter the shaft—a provision to ensure the final depositing of any fine dust carried by the gases through the depositing chamber. The chimney shaft is lined right to the top with fire-brick, and a ventilated air-space left between the fire-brick lining and the main structure of the shaft, to avoid the outer walls being appreciably heated. In the London district this is quite desirable, since the rules of the London County Council provide for such thickness of walls in the chimney shaft that the unequal expansion and contraction of these walls would be such as to lead to the disintegration of the brickwork, the inner skin coming into contact with gases possibly at the temperature of upwards of 2,000°F.

As before mentioned, each Babcock and Willcox boiler has its proper complement of fire-grate, fire doors, &c., which are provided for the express purpose of enabling the boilers to be fired by coal alternatively or simultaneously with the absorption of heat from the waste gases of the destructor cells passing through the boilers. This arrangement fulfils a two-fold object. Firstly, the provision of the secondary fire before referred to, which is in the most desirable position for further heating the destructor gases immediately they enter under the boiler, should that operation be requisite, and having the further advantage that the heat so produced is ultimately completely absorbed by the boiler and thus turned into profitable use; secondly, to add to the steam-raising power of the boilers when the heat of the destructor gases is not sufficient to produce all the steam required, or when the destructor cells attached to a particular boiler are out of order, to enable the boiler to be entirely fired by coal or coke.

Each of the destructor cells and the boiler furnaces is fitted with two systems of forced draught, one being an air blast, the other an induced blast produced by steam jets. The air blast is produced by three sets of fans coupled to and driven by electric motors, two out of the three fans being sufficient to supply 16,000 cubic ft. of air per minute, the maximum quantity that could possibly be required, and to produce it at a pressure up to three-inch water gauge. The steam blast is derived direct from the boilers, and is arranged as a continuous system, so that cells adjoining a boiler

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not in use can still obtain their steam blast from the other boilers in use. So much divergence of opinion still exists as to the relative merits of the fan blast and induced steam blast, that the Vestry, acting under my advice, settled to instal both systems, when they will be able to use either or both in combination as may be found desirable in practice.

Ten out of the twelve dust destructor cells are capable of burning with ease the 20,000 tons of ashbin refuse which have to be dealt with by the Vestry annually. The charging of the cells with refuse is to be effected in a manner which, though not novel, will perhaps be more effective than heretofore. The space available for the construction of an inclined roadway involved the use of a gradient of one in fifteen—not an unusual gradient for such purposes, but at the same time decidedly detrimental to the longevity of the horses drawing the carts, and it was decided to replace the elevated roadway with two electric lifts. Either of these lifts is capable of lifting a full load of, say, three tons of refuse, and being in duplicate, no hindrance can happen to the delivery of refuse should one of them be put out of order. The refuse is tipped from the carts into a tipping wagon, sinking below ground level, and raised by the lifts afterwards to a floor considerably above the level of the tops of the dust destructor furnaces. These tipping wagons are then hauled by mechanical means into any desired position along the range of furnaces, and the refuse tipped from them into storage bins reaching from this floor to the level of the tops of the destructor furnaces. From these storage bins the refuse is discharged as required into charging trucks made after Messrs. Bulnois and Brodie's patents. These charging trucks are divided into compartments so arranged that the charging truck being brought over a horizontal door in the top of and at the back of the destructor cells, doors in the bottom of the truck corresponding with each compartment may be opened simultaneously with the door at the top of the cell, and the exact charge of refuse dropped through in to the cell. There it falls upon an inclined hearth at the back of the fire grate, whence it is raked down through the clinkering doors in front on to the fire grates themselves. This arrangement enables a great deal of manual labour to be dispensed with, the whole of the transference of the refuse to the particular destructor it is destined to feed being accomplished by means of electric motors, and the storage bins referred to have a capacity equal to sixty tons of refuse, which will enable the furnaces to be fed during the night time, and also during the greater portion of the time that intervenes between Saturday afternoon and Monday morning. The storage bins being placed well above and out of contact with the hot brickwork of the destructor cells, the stored refuse is preserved under the most favourable conditions.

As mentioned previously, the principal object of the whole of this arrangement of boilers and cells is to get a maximum output of steam. I have calculated that the electric light station will require steam at 120lb. pressure at the rate of 12,000lb. per hour for four hours a day, 6,000lb. per hour for three hours a day, and 2,000lb. per hour for the balance of the 24 hours, or in all 100,000lb. weight of steam for twenty-fours.

The contractors who tendered for the carrying out of the works were invited to state what proportion of this weight of steam they would guarantee should be raised by the consumption of ashbin refuse only. Many of them, including Messrs. Manlove, Alliott and Co., undertook that no coal should be required to raise the requisite amount of steam daily. It must be borne in mind that the chief difficulty to be met in the combination of a dust destructor with an electric lighting station, from a steam-raising point of view, is that while the refuse is being burned at an approximately even rate during the whole day, the steam for the electric light station unfortunately is required in very varying quantities, varying from a very small quantity during the greater portion of the day to a maximum at least six or seven times the minimum during the four hours of heavy load; and whilst the furnaces might be quite capable of raising the total quantity of steam required at an even rate, they might be incapable of raising the quantity required during the four hours of heavy load. To meet this difficulty Messrs. Manlove, Alliott and Co. propose to instal in conjunction with the boilers the patented thermal storage system of Mr. Druitt Halpin, and the arrangement of thermal storage reservoirs proposed for Shoreditch is shown on the accompanying sketches. Seven reservoirs, each 35ft. in length and 8ft. in diameter, are provided and connected up to the boilers, thereby accumulating the energy. The temperature in the reservoirs is never allowed to drop below the equivalent of 120lb. steam pressure to the square inch, but, during the accumulation of the energy developed by the boilers, the temperature is raised in both the boilers and these reservoirs until a temperature equal to a pressure of 200lb. per square inch is attained. When in each day the time of heavy load is attained at the central station, both the boilers and these reservoirs feed into the steam mains supplying the engines, and as the energy taken by the engines considerably exceeds that which the boilers are capable of generating, the pressure in boilers and reservoirs gradually falls until a minimum of 120lb. is again reached, and the energy represented by this difference in temperature is that which has been taken up from the boilers during the daytime by the thermal storage reservoirs. Thus is the energy that would otherwise be wasted accumulated and carried on to the time when it can be utilised by the electric light engines. An additional and not unimportant advantage accrues from the use of these thermal storage reservoirs, inasmuch as the feed water is pumped into the reservoirs and not into the boilers, and hot water at the actual boiler pressure is allowed to gravitate from the reservoirs into the boilers to make up for the evaporation in the boilers. At the minimum temperature at which the storage reservoirs are standing, practically all the inorganic salts held in solution in the water are deposited in the reservoirs, and the boilers are fed with water free from these impurities. They therefore remain perfectly clean and unscaled on their water surfaces, and are always working at their highest efficiency, whilst the precipitate in the thermal storage reservoirs is in the shape of soft mud only, since the plates of the reservoirs are not exposed to the action of the fire, and they can be with perfect facility cleaned from this precipitated mud.

The combination of a thermal storage system with a set of dust destructors and boilers will, I believe, appeal to all of you as an ideal arrangement for the utilisation of the steam produced by the latter.

You will notice that very high pressures are to be attained, 200lb. being the maximum.

I have myself heard Papers read before societies in which it has been stated that higher pressures that 70lb. or 80lb. cannot be attained in boilers fired with destructor gases. Statements of this kind do not require much comment from me. It will be obvious to all of you that with destructor gases varying from 1,200° to 2,000°F., such a pressure as this, or, indeed, if it were desired, a much higher pressure of steam, can be obtained. Perhaps those who have made such statements will be reassured when they find a firm of standing guaranteeing, under heavy penalties, the successful issue of a dust-destructor thermal storage scheme in which a pressure of 200lb. to the square inch has to be attained without the use of coal.

A somewhat similar system is about to be erected now under my superintendence for the Corporation of Swansea, the chief differences in this scheme being that only 8 in place of 12 destructor cells are being put up, with four boilers, each, however, in this case with a total heating surface of 2,896 sq. ft. No thermal storage cylinders are for the present being connected to this installation, though provision is being made for their addition at a future date when the load on the station makes it desirable. In this case also the electric lifts are not being used, as the general configuration of the site allows of an easy inclined roadway being constructed for the up load. In all other respects the installations are almost identical.

Having now described these two installations, which are, so far as I am aware, the only complete schemes at present in progress of construction, I should like, if I am not infringing too much upon your patience, to show you what magnificent results may be obtained from such an installation, given a condition of day load which I hope will often occur in the future.

A very interesting Paper was read before this Society last year by Mr. Gibbings, of Hull, in which he pointed out to you the great use that might be made of a destructor for charging accumulators for tramcar service, and of the immense effect it would have on the total costs of production of electricity with interest and sinking fund of capital charges. At that time I informed you that a project was on foot by which the Swansea Corporation hoped to be enabled to supply all the tramways within their own town with electricity generated at their own electric lighting station. This has now become a definite scheme, the Corporation having arranged the preliminaries of an agreement with the Tramway Company. The Tramway Company will ultimately have about 25 cars simultaneously in operation, and these cars will between them run annually an estimated car mileage of 1,000,000. It is a matter of common experience that an electric tramcar takes in an average town a Board of Trade unit for each car mile run, and therefore the output of supply to the Tramway Company will be 1,000,000 units annually. On the basis of the arrangement proposed between the Corporation and the Company, it is estimated that the latter will be supplied with current at about 1½d. per Board of Trade unit conditionally upon the supply being made only during 20 hours of the day instead of 24, the other four hours being those of the heavy lighting load, and to carry the Tramway Company over this period a stationary battery of accumulators will be installed of sufficient capacity. The revenue from this million Board of Trade units represents a sum exceeding £6,000 annually, and it is remarkable that it will be earned with one plant running during the day and late at night time, with an output of about 200 kilowatts. In other words, it will be earned by the same machinery that would in any case be running during the hours of daylight to keep the mains charged, and earning practically no revenue. It

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follows also that the cost of producing this extra million Board of Trade units will be only some additional oil used on the engine owing to its running at full load in place of at an extremely light load; no further charges for attendance, and possibly a small extra amount annually for repairs, though this is doubtful.

Since, therefore, the whole of this large output is produced at an extremely low additional cost, the station and destructor can be run paying all its maintenance charges, as well as interest and sinking fund for the production, not only for the million units day load, but of 350,000 units for public and private lighting, and the cost of attending to the public arc lamps at no extra cost, leaving the revenue derivable from these sources as net profit. It will therefore be feasible for the first time in this country to sell electricity for private lighting purposes at 2d. per Board of Trade unit and to make no charge for the current used for public lighting purposes. I need hardly point out to you that with gas at 3s. 6d. per thousand feet, the price in this town, electric lighting will, under these conditions, be much cheaper than gas.

In considering this apparently Utopian position, you must not fail to bear in mind the fact that the ability of the Corporation to supply this large day load at a price attractive to the Tramway Company is solely due to the use of the dust destructor. For, had the Corporation to pay for the fuel, their costs of production, with the stoker's wages, would be raised by nearly one penny per unit. This would then raise the price of the supply of current to the Tramway Company to a point at which it would be more profitable for the latter to erect their own generating station.

I will not further detain you, and in concluding hope that you will agree with me that the successful combination of dust destructors with electric lighting is in this way likely to produce a complete revolution in the prospects of electric lighting in this country.

DISCUSSION.

Mr. CALVERT said: First of all there was one thing regarding the practical application of the burning of refuse. If Mr. Manville had taken into consideration the damp fuel that they would have to contend with, he thought from his own personal knowledge of burning damp stuff in boilers that the corrosion was so great that it considerably increased the wear and tear of the boiler. Then there was a point on thermal storage. When that subject was first heard of some time ago it certainly appealed to him as being a matter of importance, but on going into it he could not exactly find where the advantage came in. On reading Mr. Manville's Paper through he made a few calculations, and would ask for some information respecting them. As regards the first point, the horse-power required would be 400 H.P. for about four hours. He calculated that the heat stored in Mr. Manville's seven cisterns was 900 H.P. for four hours. How much they would get out of the 900 was the question, on account of the loss of heat by radiation. Possibly Mr. Manville had gone into that subject, and could answer it better than others who had not had experience. Another point which presented itself was that on the one hand with the storage system the storage plant would cost something like £3,000, and further they had to take into consideration that all the boilers would have to be built for 200lb. pressure of 120lb. The 400 H.P. which they required for 4 hours, or about 600 hours per annum, could easily be got out of Lancashire or Babcock boiler, which would cost something like £400. The cost of fuel for, say, four hours per day for about eight months in the year would, reckoning roughly, come to about £200. £200 per annum would scarcely be interest and depreciation on the large items which would be expended providing his calculation was right. He could not see where the advantage of this thermal storage came in, and he had made the remarks in the hope of getting some information, which would be of the greatest interest to everybody there that night, on which he thought was the question of the day, *i.e.*, thermal storage *versus* battery storage. Mr. Manville had given them his views as to the reduction of the cost of production of electrical energy by the burning of refuse. Mr. Manville calculated 2d. per unit. The cost of steam production for electric lighting was something like three-eighths of a penny per unit. Whatever Mr. Manville could do, he could not save more than this, and he did not see where the reduction of 2d. per unit came in. In the thermal-storage question it was evident that only the boilers had the advantage of storage, as of course the engines and dynamos must all be there just as well as in an ordinary plant without storage.

Mr. LONGRIDGE said that, having no practical knowlege of destructors, he had come to the meeting to receive rather than to give instruction, therefore he could not presume to offer any serious criticism of the Paper, but would confine himself to mentioning one or two points which had struck him on reading it. So far as he could gather from the author's figures, there seemed to be from 30 to 35 per cent. of carbon in the refuse. This seemed to him a high percentage, and he thought that if the fact were brought home to householders they would, in many cases, take steps to reduce the waste. But whether they applied their minds to cinder sifting or not, it seemed to him that if, as the author suggested, current could be supplied at 1½ per unit, everyone would use electric light, and the gas companies would have to sell their gas at a low rate for cooking. If such a desirable consummation were reached, the kitchen fire, the mine from which the author probably drew a very large percentage of his fuel, would be put out, and the percentage of coke in ashpit refuse would be considerably less than it seemed to be at present. Another alteration was that the refuse might rise considerably in price. Some years ago coke breeze could be bought in London for 2s. 6d. a ton, but as soon as the means of burning it satisfactorily in steam boilers became known, the price, with the demand, began to rise, and now it had reached 7s. per ton, a price at which it was nearly as dear as its alternative small Welsh coal, having regard to the plant and labour required to burn it. The author had stated that there was difficulty in burning ashpit refuse in the earlier destructors, and that it was only when the temperature was raised by forced draught that destructors became a practical success. He was not surprised at this. To his mind high temperature in the furnace was the essence of the matter. If this were attained he was confident there would be no difficulty in effecting complete combustion. He was surprised how anyone with the blast furnace before their eyes should either hope to work a low-temperature destructor successfully or should doubt the satisfactory working of a high-temperature one. It seemed to him that the success of a destructor was merely a question of sufficient blast. This brought him to the third point which had struck him, namely, the unusually large grate and heating surface provided for the work to be done. As far as he could make out, it was intended to burn from 10lb. to 19lb. of refuse per square foot of grate. He could not see how with such a rate of combustion they could get high temperature desirable specially with a forced draught of 3in. The grates could not be kept covered. The heating surface also was enormous for the power required, which he understood was about 400 H.P. With an apparatus of these proportions he feared the interest in capital would make the scheme, otherwise admirable and interesting, a financial failure.

Mr. TINKER said both the Shoreditch and the Swansea schemes appeared to him to have been most carefully and skilfully worked out in every detail, and he did not doubt but that great success would result from the general arrangement decided upon.

Mr. J. H. RIDER said: With regard to the ash-bin refuse he wished to know whether before it was put into the hoppers it would have to be sorted. Ash-bin refuse was of a very mixed character. It seemed to him that the sorting would entail labour, and labour cost money, and he would like to know how that labour brought up the cost. He was burning at present only coke breeze, and if the price would go up to such an extent as Mr. Longridge said, there was a bad time coming for him, as he was getting it at present for 2s. 6d. a ton. His fuel bill had never been over 0·5d. per unit since using breeze, and last month it was only about 0·35d. If he used refuse, how would the cost of production compare with that? With regard to the thermal storage, he was actually ignorant of thermal storage, and if he should say anything that was absurd, he hoped they would pardon him. In Mr. Manville's scheme they had six or seven very large boilers. Unless these boilers were covered in a very marked degree, the loss of heat would be very great, and so far as he could see they had no external method whatever of keeping up the heat. He did not know how any composition would answer, and would like some information on that point.

Mr. S. V. CLIREHUGH said that he would like to put before the members some tests which were brought under his notice which were carried out in Yorkshire with a refuse destructor. These tests were carried out in order to enable some idea to be formed of the calorific value of refuse in various towns. The refuse was not treated in the most approved style as it was burnt under ordinary Lancashire boilers. Some interesting facts, however, were brought to light with regard to the bye-products which might be obtained. The refuse came in truck loads of about six to eight tons at a time, and it was simply tipped on the floor of the destructor house. It was then taken up by an endless belt through a large sieve which collected the old kettles, tin pans, &c. The remainder was passed into a revolving drum through which gases from the furnace passed before going up the chimney. After leaving this drum the refuse was passed through a fine sieve and the very fine portion of it was allowed to fall down into sacks while the remainder was carried to the front of the boiler and burnt. The results were rather curious, the following being the average result. They found that the amount of water evaporated in the hot cylinder was 25 per cent. on the total weight of the refuse treated, and that only 40 per cent. arrived as fuel in the furnace. They got with 1lb. of treated refuse 5½lb. of water evaporated. Mr. Manville had obtained 3lb. of water evaporated with untreated refuse, that is, containing 25 per cent. per cent. of moisture, so that the results were approximately near one another. The actual results obtained from one ton of refuse were as follows: Fuel, 40 per cent.; dust, 25 per cent.; rags, 6 per cent.; tin pans, &c., 3 per cent.; water, 25 per cent.; sundries, 1 per cent. They found, on analysing the fine dust that it was valuable manure, which sold readily in that district from 9s. to 10s. per ton. Therefore, from one ton of refuse treated they obtained the following:—Dust, 25 per cent. 2s. 6d.; rags (at ½d. per lb.), 5s. 6d.; making a total of 8s. per ton. If Shoreditch Vestry could obtain this price it would amount to the substantial figure of £8,000 per annum. Of course they could not find a market for such large quantities, but in smaller town they could probably dispose of it. With reference to Mr. Calvert's remarks, he said that even were the whole ⅜d., which he assumed coal now cost, saved they could not improve on this. He would point out, however, that they could do very much better than that since the local authorities would be willing to pay something for the destruction of the rubbish. He would like to add, with reference to the question of sorting, that the whole of this, in the system he mentioned, was done mechanically, and the refuse was not at any time touched by hand.

The Last Horse Car at Detroit.—The running of the last horse car in Detroit, U.S.A., prior to working the tramways entirely by electricity, was made the occasion of a great public demonstration. After the trip was concluded the car was torn to pieces by relic hunters, while the team of horses was auctioned off and sold for $100.

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CHRISTMAS WEEK NOTICE.

"THE ELECTRICIAN" will be published as usual on Friday in Christmas week, but as the Offices will be closed on Wednesday and Thursday it will be necessary that Contributions, Correspondence, News Items and Advertisements should reach the Publishing Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London, by, at latest, Tuesday's post.

DUST FUEL.

Among the many and varied suggestions which have been put forward for reducing the works costs of electric supply stations, one of the most notable is the scheme for the utilisation of town dust-bin refuse as fuel for steam raising. This scheme practically involves the union of a dust destructor works with an electric supply station, the combined works being preferably, though not essentially, under the control of the local urban authorities. We feel sure, therefore, that many of our readers will peruse with interest the abstract of a Paper by Mr. E. MANVILLE on "The Use of Dust Destructors as Steam Producers for Electricity Supply Stations," which we publish this week. There is probably no one who could give us more information on this subject than Mr. MANVILLE; and it is gratifying to find that in his Paper he has drawn a little upon his fund of experience, acquired in connection with the Shoreditch and Swansea schemes. Naturally the author of this Paper holds sanguine views in regard to the success of these two schemes in particular, and the generation of electric energy by the aid of dust-bin refuse in general. But he has formed his opinion upon a number of data which it would be difficult to controvert; and, as he points out, the fact of a firm of contractors of high standing having guaranteed, under heavy penalties, the successful issue of the Shoreditch dust-destructor thermal-storage scheme, should be in itself somewhat assuring to those who may have doubts about the matter. Not that there is no longer any room for doubt about the commercial possibilities of dust fuel. Hitherto there has been no extensive experiment in this direction, and the existing schemes must be based upon the evidence of more or less indirect facts. Yet these facts, are in the main, we think, such as may legitimately be made the basis of an experiment on the scale proposed for Shoreditch or Swansea. For instance, although we may not be able to dogmatise about

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the capabilities of a district to obtain light from its own dust refuse, it is quite a simple matter to estimate the volume and the temperature of the gases issuing from any given destructor in a day, or a month, or a year; and therefrom to estimate the weight of steam which may be generated in an efficient battery of boilers. We cannot ignore the existence of many grave and important difficulties attending the working out of a dust-utilisation scheme for electric supply, but it is impossible not to admire the thorough manner in which these difficulties have been faced, and the ingenuity with which it has been sought to overcome them, in the two schemes already referred to.

Some of these difficulties were brought forward during the discussion on the Paper. There was the usual practical, pointed character in the discussion, so commonly a feature of the Northern Institution and so rarely a feature of discussions in the Institution in London. One speaker commented on the trouble which might arise from excessive wetness of the refuse. Another speaker confirmed Mr. Manville's own estimate that this wetness would usually be about 25 per cent. The trouble with wetness is not merely that it has to be evaporated, but also that it corrodes the boilers and shortens their life. A speaker put his finger on the weak point in thermal storage, viz., the increased prime cost which it involves as against battery storage; and the chances of considerable loss of heat from the thermal storage cylinders were also discussed. It should not be forgotten that these cylinders can be completely surrounded by non-conducting composition, and on that account are more favourably situated than ordinary boilers. In regard to the capital cost of the destructors and such matters as the cost of sorting the refuse, it is hardly fair to saddle the electric supply system with these; since they are as necessary without as with an electrical appendage to the destructor works. Mr. LONGRIDGE drew a humorously sad picture of the downfall of electric-refuse-destructor works, from causes arising from their own prosperity. If their could supply electricity so cheaply as had been said, the gas companies would be obliged to bring down the price of gas to such a low figure that every housewife would adopt gas fires and abandon coal fires. And then there would be no cinders in the dust bin, and *ergo* no fuel for the electric-refuse-destructor works. It is a sorry reaction to contemplate!

Two considerations have to be kept in view in arranging for the generation of electric power by means of dust fuel. On the one hand, the fuel must be consumed consistently with sanitary requirements, which will generally mean that the furnaces will have to be fired at a steady rate. On the other hand, it will be necessary to utilise the steam according to the variations of the electrical load. These apparently are conflicting conditions; but they may be reconciled in three ways. The first way—the least to be commended—is to combine the dust-fuel steam generators with ordinary coal-fired boilers, or to mix coal or coke with the dust itself. The second plan is that to be used at Shoreditch, and consists in using some form of storage system, whereby the surplus energy developed in the destructors may be stored against the time when the dynamos will be heavily loaded. At Shoreditch the system of thermal storage invented by Mr. Druitt Halpin will be in operation; but it would be quite possible, perhaps preferable, to have electrical storage. The latter would have the advantage of equalising the work of the engines and dynamos, as well as of the steam generators. The third plan is the most desirable of all, and consists in the provision of such an ample and regular day load that the energy of the destructors will be utilised almost as it is generated. This, we are glad to say, is the plan just adopted at Swansea, where it is intended that the tramcar load and the electric light load shall be taken by the same generators. At the close of his Paper Mr. MANVILLE makes reference to this system, which, we think, will shortly become a more common feature of electric supply in this country. No doubt this extension of useful work on the part of a largely idle lighting station will be facilitated now that the Board of Trade has decided upon raising the standard of low pressure to the pressure usually employed on tramway systems—viz., 500 volts. On the basis of an arrangement only just made between the Swansea Corporation and the local tramway company, Mr. MANVILLE estimated that about one million units will be supplied annually by the former to the latter at 1½d. per unit. We scarcely agree with the author that all this large output is going to cost the Corporation "only some additional oil used on the engine, owing to its running at full load in place of an extremely light load; no further charges for attendance; and possibly a small extra amount annually for repairs, though this is doubtful." Mr. MANVILLE apparently contemplates adopting no unit of less than 200 kilowatts. But it seems to us that were a tram load not in anticipation the plant would be more sub-divided, and a decidedly smaller unit would be running all day, taking attendance and oil and running up the bill for repairs. Indirectly, therefore, the provision for a tram load will include other items of expense than those to be found in Mr. MANVILLE's list. Besides, with so heavy a day load, will coal or coke *never* have to be burned in the daytime?

We confess that our imagination boggles somewhat when we try to follow Mr. MANVILLE's roseate prophecy of the future electrical millenium at Swansea. In the first place, we are told that the tramways will have their supply cheaply because the extra cost of running the plant by day will be so trifling. For this reason the absurdly small levy of 1½d. to 2d. per unit will be made. So far it is all very simple, and, if Mr. MANVILLE's data are correct, we see that a revenue of £6,000 might be derived from the tramway supply. But we are next told that this sum will pay all "maintenance charges, as well as interest and sinking fund for the production, not only of the million units day load, but of 350,000 units for public and private lighting, and the cost of attending to the public arc lamps at no extra cost, leaving the revenue derivable from these sources as net profit." In other words, the supply to the trams is to be so ridiculously cheap because the lighting will bear all the expenses, and the lighting is to cost nothing at all, and to be all profit, because the tramway supply will rake in such a nice lot of money. Between the two jobs, the trams by day and the lights by night, the station is going to supply 1,350,000 units at an average price of 1·65d. per unit!

ANNUAL GENERAL MEETING OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

At the Annual General Meeting of the Institution of Electrical Engineers, held at the Institution of Civil Engineers, Great George-street, on Thursday evening, the President (Mr. R. E. B. Crompton) occupied the chair. The Report of the Council having been read, the PRESIDENT remarked that the Institution might congratulate itself upon having assisted in the very satisfactory Conference with the Board of Trade alluded to in the Report, and then moved "That the Report of Council as read be received and adopted, and be printed in the *Journal* of the Proceedings of the Institution." Prof. PERRY seconded this resolution.

Mr. J. RAWORTH said, before proceeding to the adoption of the Report, he had it on his mind to say a few words. He congratulated the Institution and the Council upon the excellent

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nature of that Report and upon the general prosperous condition of their affairs; but to him it was a matter of regret that the Report had not proceeded to ask the members of the Institution to grant to the Council greater facilities for obtaining the advice and assistance of the members on matters affecting the welfare of the Institution. He approached the subject with a deep sense of responsibility—he did not speak merely upon his own behalf, for he was well assured that he represented the feelings of a large mass of the members of the Institution—and he trusted that his sense of responsibility was commensurate with the greatness of the subject with which he was about to deal. He sometimes wondered whether their various members really rose to a full appreciation of the magnificence of the Institution. It was respectable in its origin, it was remarkable in its progress, and its destiny would be resplendent. They had seen what had been the course of the Institution of Civil Engineers, and it filled their minds with respect, almost with awe, when they considered what a moving force it had been in the civilised world; but that Institution had arrived at, or nearly at, the zenith of its importance and power, whilst the Institution of Electrical Engineers had no zenith until at last they had discovered what was the zenith of electrical science and practice. But it was not the question of prophecy that he was disposed to enter upon that evening. At the head of the Institution they had a great and noble Council of which they were all proud, and which did honour both to the Institution and to the profession with which it was connected. But there was one great defect about their relationship, and that was that the two bodies, the Institution and the Council, were two separate entities, and each was pursuing its own existence without knowing what were the desires and the aspirations of the other. The Institution came into existence some 23 years ago, under the presidency of Mr. C. W. Siemens, afterwards Sir William Siemens. It had a membership of something like 100 members, and had a Council, and that Council had developed into the present Council. That Institution of 100 members had developed into an Institution of something like 1,700 members; but there had been a very slight influx of new blood or of members of Council derived actually from the initiative members of the Institution. The two bodies had grown up together, and they were not intercalated. There was a very great danger in this. They had not arrived at the point of danger, and it was in the interests of the Institution, as long as there was a conceivable source of danger which might at any moment culminate in an actual, tangible danger, to consider whether there was any possible method of removing that possible source of danger, so that the future history of the Institution might be unclouded. He was extremely sorry to hear it, but it was a fact that in the past if anybody who took an interest in the progress of the Institution ventured to express his opinion, and that opinion did not happen to be exactly the opinion of the Council, he was liable to be called a "malcontent." He was prepared to deny that they were malcontents in the broad meaning of that term—that was to say, in the sense that it was impossible to please them. On the contrary, he thought they were very easily to be pleased. He wanted to call their attention to one fact in this connection, because it illustrated his meaning, perhaps, better than any theory. It was within the memory of some of those present that at one time there was a question at issue between the members of the Council and some of the members of the Institution; at all events, the Council were prepared to take certain action in which a large number of the members did not approve. It seemed to those members very natural that they should ask two or three of their number to call upon the Council and give them a few words of advice in an informal way as to what would be the best course to pursue. They would, perhaps, scarcely believe him when he said that they found it extremely difficult to get the ear of the Council at all. Eventually they did get the ear of the Council, and naturally the first question put to them was, "Whom do you represent?" The answer, of course, was that they represented no one but themselves, and whilst they had not an express authority to act, they were perfectly certain of themselves and nearly certain of everybody else. That was an unfortunate position for a deputation to be in. But if there was a feeling on the part of that meeting that there was the possibility of some risk arising in the future owing to the fact that the Council was not always thoroughly in touch with the feeling of the members, then they ought to organise some direct means of bridging over the difficulty, and without discussing further the general question he would suggest that it would be an advantage if the Council had the opportunity of quite privately taking the feeling of the members through the voice of a Special Committee. It would be quite naturally urged that they did not want such a Committee, because their Council was their representative Committee. Of course, if that were the case, the answer would be complete; but he held that that was not the answer to the proposition. The fact of the case was that the Council consisted of 15 movable members, 4 vice-presidents, and 13 past-presidents, so that there were 17 permanent stuck-fast members of the Council who not only had a voice but could vote on the Council, and only 15 active, movable members who had any communication with the members at large and who were drawn from the body of the members within a reasonable time. He did not think the members of the Institution were generally aware of that fact; he did not think they were aware that whilst in the Civil Engineers a certain proportion of the past-presidents did not vote, in this junior Institution the past-presidents did vote, so that they had a more vigorous House of Lords than the Civil Engineers. So far as voting power went, it did not matter whom they put on the Council provided the conservative instinct prevailed, and it could not fairly be said that the Council represented the members. It did not represent them in the sense that a Committee would, if they selected a number of gentlemen from that meeting and asked them to go and talk to the President upon any matter in which the members took particular interest.

Now he had had enough of that very unpleasant business, which it had cost him a considerable pang to allude to. Now he had a much pleasanter matter to turn to. They had had placed in their hands that evening a balloting paper, and he thought that paper must be a source of intense gratification to the members. He found that the Council proposed to elect Mr. Sidney Morse an associate. He thought the Council there had got on to bed rock, for it had chosen an associate who occupied a very exalted position on what he might call the outer ring of the electrical industry. Further, he could not sit down without expressing his satisfaction, and that of every member who had spoken to him on the subject, on the selection by the Council of Dr. Hopkinson as President. He would conclude by proposing this resolution: "That this meeting considers it desirable, in the interests of the Institution, to form a Committee to represent the views of the members in consultation with the Council, and such Committee is hereby constituted of the following members: Mr. A. A. C. Swinton, Mr. E. Manville, Mr. R. P. Sellon, Mr. A. B. Holmes, Mr. W. P. J. Fawcus, (Manchester), Mr. A. W. Heaviside (Newcastle), Mr. H. A. Mavor (Glasgow), and Mr. J. C. Vaudrey (Birmingham), with power to add to their number."

The PRESIDENT asked whether Mr. Raworth intended his resolution as an amendment to the Report or as a substantive motion.

Mr. RAWORTH: It practically constitutes an amendment, but if you like it may be put as a separate motion.

The PRESIDENT: Well, say one thing or another.

Mr. RAWORTH: We will put it as a separate resolution.

The PRESIDENT'S motion, that the Report of the Council be received and adopted and printed in the *Journal* of the Proceedings of the Institution, was then put and carried unanimously.

Mr. G. L. BRISTOW, the honorary solicitor, said he had read the resolution, and he was afraid it was not within the powers of the Annual General Meeting to do what was proposed in it. The business which that meeting had to carry out was stated in Clause 55 of the Articles of Association, and provided that "the Annual General Meeting of the Institution shall be held at the meeting next previous to Christmas Eve, and the business of the meeting shall be to receive and deliberate upon the Report of the Council as to the state of the Institution and to elect the officers for the ensuing year." That seemed to be the only business which it was competent for that meeting to transact. If they desired to pass a resolution of this sort, it should be done at an ordinary general meeting after notice. He took it that the resolution was not designed in any way to alter any of the rules or regulations of the Institution contained in those Articles of Association, but was merely intended as a suggestion, and therefore he thought it might properly be brought forward, after notice, at an ordinary general meeting; but he was afraid it was beyond the power of that meeting to entertain it.

Prof. J. PERRY said the difficulty was that when the resolution was brought forward an idea was given that it might be brought forward either as a resolution or as an amendment. Until the scrutineers had spoken he was still a member of the Council, and he had seconded the resolution for the adoption of the Report; but, in all fairness, he thought it was within Mr. Raworth's right to have this matter considered either as an amendment or as a resolution.

The PRESIDENT said it was a very simple matter. They all wanted the same thing. Mr. Raworth and the gentlemen he represented wished to have this motion brought forward. They (the Council), as in duty bound, asked their honorary solicitor as to what was the best course to pursue, and what was the legal course to pursue. He informed them that the legal course would be that the matter should be brought forward after due notice at an ordinary meeting. What was the use of ignoring the law on the subject and flying in the face of skilled advice? He thought Mr. Raworth's object would be best met by giving notice, and having the matter discussed at a future meeting.

Mr. A. E. MAVOR asked if the honorary solicitor would state whether it would be distinctly illegal to discuss the matter at that meeting. As he understood the object of the meeting, it was to discuss the state of the Institution, and if this did not refer to the state of the Institution he did not know what did.

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Mr. G. L. BRISTOW said the purpose of the meeting was to deal with the Report of the Council. Therefore any resolution come to should have some reference to what was mentioned in the Report. If Mr. Raworth wished his remarks to be taken merely as an expression of opinion, and if other gentlemen wished to express an opinion, he did not think it would be particularly out of order. But he thought it would be out of order to pass a resolution at that meeting. Perhaps the Chairman, in his discretion, if time permitted, would allow the discussion to go on.

Mr. RAWORTH said he felt they had rather got him in a trap. The President asked him whether he was going to submit his motion either as an amendment or as a resolution. He had a strong objection to carrying an amendment on the Report, because that would have the force of a vote of censure on the Council, and would be an extremely unpleasant thing to do; he had been extremely glad to be able to take up the attitude of offering to put it in the form of a separate resolution after the Report had been passed. He did not accuse the Council of having got the information first and then run the solicitor's opinion off on him afterwards, but the effect was the same. He felt that to go on with this matter now would be to place himself in a very false position.

The PRESIDENT said if Mr. Raworth had been trapped it was accidentally. He (the President) was not aware of what would be the effect of what he said; they were advised afterwards, and he did not know what the effect was going to be. He had no wish to take an unfair advantage, but it had seemed inconvenient to discuss the thing partially then and to take it up again afterwards. If the question was one of supreme interest, it might be better to deal with it at once, but he did not think this was a matter of supreme interest. They would get quite as large a meeting to discuss the proposition in the early part of next year, and he was quite ready to put it to the meeting whether they should go on now, or whether they should discuss it later.

Mr. RAWORTH said if they could not take a vote upon it he did not think it would be doing any good to go on with the discussion.

Mr. HANDCOCK said this was decidedly an important matter, and one which could scarcely be decided at one time. It was as well that it should be discussed at once, and that they might consider it in the meantime before it was finally settled. They had to confess that the members, as a whole, were not in touch with the Council, and *vice versâ*. Their intentions were good, but they remained on parallel lines and did not come together. It seemed to him if they started by appointing a Committee to advise the Council, the next step would be to appoint a Committee to advise that Committee. They had better take a few hints from the Civil Engineers. He thought the Institution was working on the right lines in having on the Council the past presidents, whose experience was invaluable; but at the same time, if they were to have voting power in such numbers as to be able to out-vote the purely elective members, there was the danger of their getting behind the times as an Institution. In electrical matters particularly they must go ahead, and he certainly thought it would be much better if it could be arranged that the past presidents could not vote; they would then have a greater number of names to choose from for the purpose of filling up the Council, and they would be bringing fresh blood more or less frequently into the Council. Under these circumstances the Council would more ably represent the ideas of the Institution as a whole. If it were possible to discuss this matter to-night, so that they might have something to think over, it would be better than having the matter sprung upon them and dealt with right off that night.

The PRESIDENT: Shall we discuss this matter to-night or not? I think those in favour of discussing have it.

Mr. R. S. ERSKINE said those gentlemen who thought it was only necessary to make a little alteration in the constitution of the Council had rather mistaken the meaning of Mr. Raworth's resolution and his reasons in bringing forward that resolution. There was a very great difficulty at present for any member to bring any suggestion before the Council. Of course, with individual members, knowledge of the feeling of the Institution was confined to his knowledge of his own personal friends, who necessarily formed but a small proportion of the whole list of members, and when the member had found that among his own friends a certain change was desired he could only, in an informal manner, approach some member of the Council whom he happened to know, and, as Mr. Raworth had very justly said, that member would naturally ask, "Whom do you represent?" Even if he could at that moment remember all those with whom he had discussed the matter, the individual member would only be able to, at the best, represent a very small clique. That that view should be taken by the Council was only natural. It certainly did seem to him that if a Committee were appointed, as Mr. Raworth suggested, that difficulty would entirely be got over. He didnot think it was possible on that evening or in any one evening to bring before the Council all the suggestions which different sections of the members would like to make with regard to the future, and it was highly desirable that there should be a Committee in touch with the members to bring before the Council from time to time the various points which might arise in that direction. There was another point which could not be lost sight of. The deliberations of the Council were necessarily private, and were held with closed doors. It was perfectly right that that should be the case. It might, however, often happen that the Committee would have to bring before the Council certain matters which they would not like to bring forward in that room at the ordinary general meetings, which were practically public meetings. With the Committee such points might be brought before the Council and discussed in the way in which any matter concerning the Institution was at present discussed by that body.

Mr. J. N. SHOOLBRED suggested that the secretary should ascertain what was done by the various learned societies in London in the matter of the voting power of past presidents.

Mr. A. E. MAVOR said they were not entitled to quite so much congratulation as they were inclined to give themselves upon the accession of members to the Institution, for it was astonishing what a number of active and energetic members of the profession did not belong to the Institution. This was certainly due to the fact that the large proportion of the members of the Council were completely or almost entirely out of touch with the members of the profession. He referred, of course, to the past presidents, whose very eminence took them away from those who most in the nature of things have the future of the Institution in their hands. The Council's intercourse with the members was in his experience of the most charming and useful nature; but in asking the Council to open their ears to the desires and requirements of the younger members of the Institution, he did not think they were asking anything which ought not to be considered. The only thing they insisted upon was that the Council should know them better. They knew many of the members of the Council very well indeed, but they desired to be known in return. He spoke for many young members of the profession with whom he was in close sympathy and touch. Mr. Raworth had referred to a deputation which waited on the Council, but he did not state that that deputation took with them the requisite documents, signed by the requisite number of members, to ask for a general meeting to be called to discuss this matter. He was strongly of opinion that they ought to be given more time so that they could really understand the meaning of their Articles of Association. He knew the value of legal advice, but something more valuable than that was to understand sufficient of the law to be able to do without a lawyer. The Articles should be put in plain, simple English, so that they could all understand them.

Mr. G. L. ADDENBROOKE said it seemed to him that the resolution was sprung on the meeting in a very peculiar manner. There was an obscure letter in the papers staing that a meeting had been held, which apparently claimed to actually represent the members of the Institution. As a simple member of the Institution he might say that he never heard anything about that meeting, and it seemed to him that those who attended it had taken a great deal upon themselves. He thought anything of that nature should be approached in the most judicial frame of mind. In another Society of a very democratic kind with which he was connected—the Royal Photographic Society—of which he had been a member for 15 years, he had served on the Council for seven years, and during that period the Society had gone through every phase of the movement they were now starting on in this Institution. The practice of referring to the Society on every question led to a serious addition to the expenses, and in the end the Council became more autocratic than ever. No doubt the Council was anxious to do all it could for the members, and if the members had only been content to proceed in the proper and legal manner by calling a meeting and giving the matter proper attention, they would all have come to the subject with their minds prepared and tempers calm, and probably a fruitful discussion would have resulted. But he would really put it to the meeting whether the discussion, so far, had conduced to the dignity of the Institution, or whether there was any use in continuing it.

Mr. R. S. ERSKINE suggested that a great improvement in the practice with regard to the issuing of the balloting-sheet would be for the names approved by the Council to be sent out six or seven weeks before the election took place. At present it was sent out seven or eight days only before the election, and there was absolutely no time for members to organise or do anything in the way of nominating someone other than those whose names were on the list.

Mr. A. A. C. SWINTON wished to support what had been said by Mr. Erskine. He did think this Institution wished to be guided by the example of a photographic society such as Mr. Addenbrooke had referred to. Let them rather be guided by the Institutions of Civil Engineers and of Mechanical Engineers. In the Mechanical Engineers he believed the practice which Mr. Erskine suggested should be adopted here was followed, in sending out the balloting papers some considerable time before the day of election. Under

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the existing practice in the Institution of Electrical Engineers members had not time to find out anything about the candidates, and they either voted by return of post to get the matter off their minds, or they did not fill in the papers at all. In any case a week was quite insufficient for any action to be taken.

Mr. J. HARDIE M'LEAN said as a country member this was the first he had heard of this matter, and he quite agreed with those who had said they should have had some notice that it was to be brought up. He wanted to hear more about it.

The PRESIDENT said there was other business to come before the meeting, and there was only just time to finish it. He thought they understood that notice was to be given immediately for the ordinary meeting for the special purpose of discussing this matter to the fullest extent. He hoped sufficient time would be given, so that the country members could be made fully aware of the bearings of this really momentous question, which amounted to this: that the Council was to be supplemented by another body to help it and advise it. This would be decidedly a most radical change in the constitution of the Institution, and it required most carefully investigating and thinking out. He wished at once, on behalf of the Council, to say that it was not fair on the part of Mr. Raworth to bring this matter on the meeting that evening and then to suggest that the Council had not acted fairly in declaring his resolution one which could not be put without notice. The Council wished to have the whole thing, the discussion and the voting, kept together, that is to say, to take place on the same night. In that case one long evening might have been given up to it, and people would have come prepared, whereas on this occasion most of those present had come to hear a discussion on the two Papers read at the last meeting.

ANNUAL DINNER OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

The annual dinner of the Institution of Electrical Engineers was held on Friday night at the Freemasons' Tavern, Great Queen-street, under the presidency of Mr. R. E. Crompton, upwards of 250 gentlemen being present. Amongst those present were the Duke of Cambridge, Lord Claud Hamilton, Sir F. Abel, Mr. W. H. Preece, Mr. Latimer Clark, Mr. J. Wolfe Barry (Vice-President of the Institution of Civil Engineers), Gen. Markham (Director-General of Artillery), Sir J. Crichton Browne (Treasurer, Royal Institution), Prof. D. E. Hughes, Sir T. Blomefield, Dr. A. G. Vernon Harcourt (President of the Chemical Society), Dr. John Hopkinson, Prof. W. E. Ayrton, Prof. S. P. Thompson, Capt. W. de W. Abney (President of the Physical Society), Major T. Cardew (Electrical Adviser of the Board of Trade), Sir Henry Mance and Prof. G. Forbes (Vice-Presidents). After the toast of "The Queen" had been honoured,

The PRESIDENT proposed "The Prince and Princess of Wales and the other members of the Royal Family." He did not know why they had never proposed at their dinners the toasts of the Army and Navy, but he could not help feeling that the presence of the Duke was in some way connected with those two professions of which Englishmen felt proud.

Mr. W. H. PREECE, in proposing "The Learned and Engineering Societies," said that the members of the learned societies were the masters of generalising and expressing laws, and engineers were adepts in the art of securing facts. The latter necessarily preceded the former, for they—engineers—succeeded by failing. Failure and success were necessarily sisters. They must in that room, where science and practice were invariably linked together, pay some homage to those great men who had placed science on that basis that they as practical men could handle it with ease and comfort. They could not forget that they lived in a country that had produced a Faraday, a Maxwell, and a Joule. Nor could they forget that they numbered amongst present scientists such names as Kelvin, Rayleigh, and J. J. Thomson. The weapons which scientific and practical men now used were observation and experiment, but the great distinguishing feature that the electricians had introduced into the world had been absolute and accurate measurements. It was by accurate measurement that the last and greatest discovery was produced, principally within the walls of the Royal Institution, where Lord Rayleigh had been able to detect in the atmosphere that which had eluded the observations of thousands of years—the mysterious argon.

Sir J. CRICHTON BROWNE said the toast which had been so felicitously proposed was, in these days of widespread and manifold culture and of highly specialised science, a very comprehensive one, and he was sure he could say that the learned societies of all sorts and sizes and denominations regarded the electrical engineers with intense interest and curiosity, with a lively sense of what they had already done for human advancement, and with keen expectancy as to what they were going to do next. The Royal Society the chief parent of all the learned societies, was of course charged with electricity in every pore, and was, indeed, one huge transformer. But skipping from its universality to the extreme conditions of specialism, and to that branch of medical practice with which he was mainly concerned, he would venture to assure them that these societies devoted to the consideration of mental and nervous diseases were compelled to watch them very closely, for it was unquestionable that they were increasing the bulk of the wear-and-tear diseases with which those societies had to deal. There could be no doubt that by their discoveries and their applications electrical engineers had made life more intense and hurried than it formerly was. He had no hesitation in affirming that the tripod upon which delusional insanity now rests was made up of theology, hypnotism, and electricity, representing respectively the spiritual, biological, and the physical aspects of man's nature; and not a day passed that he had not in his official capacity to listen to strange tales as to the iniquities of the telephone and the illicit employment of the electric light. But if electricity had swollen the tide of nervous diseases and tipped some of its breakers with foam, it had also brought compensations, for it had given them new and valuable means of treating disease, especially diseases of the spinal cord; and it had given increased facilities for securing the advice of eminent London physicians in cases of nervous disease in any part of the country—facilities of which, he regretted to say, the public still only too sparingly availed themselves. As regarded the Royal Institution, all he could tell them was this: that it was gradually sinking lower and lower—not in scientific standing, not in the number of its members, not in commercial success—but in temperature. It had sounded the depths of thermopometry, and it was inundated by copious and cooling streams of liquid air.

Mr. BARRY, after expressing regret that Sir Frederick Bramwell could not be present, said that what had been alluded to by Prof. Crichton Browne was less than the truth, that the future of electric engineering was immeasurable. Civil engineers, whether their business was to deal with the construction of bridges, railways, or docks, were under the deepest obligation to the electrical engineers. They found the use of electricity was more and more necessary and useful in every walk of the profession.

Sir FREDERICK ABEL proposed "The Visitors," coupling with it the name of the Duke of Cambridge.

The DUKE OF CAMBRIDGE said that in the presence of so many scientific gentlemen he felt rather at a loss as to the reason for his being called upon to be the spokesman for the guests. He had, however, perhaps one advantage, which was that through the position he had had the honour of filling for a number of years he had been able to judge for himself of the advantages given by science to that profession over which he had had the honour of presiding. He did not think that any profession had gained more by scientific progress in recent years than had the Army and the Navy. Those Services were now in a condition which no human being, when he himself began his career, would have thought it possible to attain within the period of one man's life, and yet, there he was, not altogether worn out—and he had seen these things, and was able to appreciate the extraordinary advancement of science, and the power it had given to the great professions to which he had alluded. He thought that slow and steady progress was common sense, and on that principle he had always endeavoured to act. Nobody could better appreciate the services that Institution had rendered to the Services by the advance of its particular objects; and he therefore proposed "The Institution of Electrical Engineers."

The PRESIDENT, in reply, said that when he was a young man he held this faith—that in seven days the world was made, and on the eighth was made a rifleman. Now he held the faith that on the eighth was made an electrical engineer. He believed they were the salt of the earth. He had not made that statement for years past without coming to believe it himself. He had not met in society so many friends who said, "Oh! you are an electrical engineer; that is interesting!" without coming to believe that they were doing something that was interesting. They were told that they were on the verge of an electrical age. Some in that room thought they were a little way on in the electrical age. But the public liked to say they were in their infancy. In one sense that was good hearing. There was no doubt that there was some truth in the assertion that as the last 40 years had been the age of steam, so probably the age to come would be the age of electricity. He thought that if invention stood still at the present time, that if they really only attempted to give the public the benefit of the inventions that already existed, that even now the age would be called the age of electricity. For it was now so perfected, and had come so largely into their lives that he was warranted in this assertion. But was there anyone in that room who did not believe that they could do much more? If there was anyone who did not believe that they could do as much in the next 20 years as they had in the past he was not fit to belong to them. They were taking into their ranks the best men of the age. Those who came before them—the great telegraphists; what had they done? It was hardly possible to go anywhere without finding an electric telegraph. The telephone was next in the field. What an enormous amelioration of life that was—or ought to be. He would say the same of the electric light, which had a great future before it. As regarded the future, he believed one thing. The age of steam depopulated the country, and sent the people to the towns. He believed the age of electricity would send them back. The means of communication would be so good that they would be able to work in the country, or, at all events, live in the country. They had only to look at what had been done in America by the vast mileage of electric tramways to realise great possibilities. There was no reason now why a man should not live 20 or 30 miles from his work, and instead of having constant anxiety as to catching trains, would simply jump into a tram passing his door.

The proceedings shortly afterwards terminated.

Argon.—The Académie des Sciences has awarded the Lecomte prize of 50,000fr. to Prof. Ramsay and Lord Rayleigh for their discovery of argon.

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TELEPHONE COMPANIES' ASSESSMENTS.

On Monday a Special Sessions for South London was held at the Court House, Newington, before Col. Ross (Chairman) and other magistrates, to hear the appeal of the National Telephone Company against the rating placed on their property in three parishes in the South of London. Sir George Morrison represented the Telephone Company, and Mr. Horace Avory and Mr. Bassett Hopkins appeared on behalf of the Assessment Committee. The appeal was against the valuation lists of St. Mary, Newington; St. Saviour, Southwark; and St. George-the-Martyr, Southwark. The rateable value of the Company's property in St. Saviour's was placed at £368, in St. Mary's at £150, and in St. George-the-Martyr at £154. The mileage of wire in these parishes was 184, 75 and 71 respectively, and the annual rateable value had been arrived at by multiplying the number of miles in each case by three and two respectively.

Sir GEORGE MORRISON said he should not make any admission on any question of principle, because the case might have to be dealt with hereafter. In the ten years since 1885 the value of the Company's wires for rating purposes had been multiplied by eight. In 1885 the Company was put on a footing in some respects with the telegraphs. It was then rated at 5s. per mile of wire, which was increased in 1890 to 13s. 3d.—the average figure throughout the metropolis—and now it was placed, in the St. Saviour's Union, at no less than 40s. The Court of Appeal had decided that telephone wires were rateable, and he was, therefore, bound to admit that they were, though the case had not yet been taken to the House of Lords. Then arose the question as to the principle on which they were to be rated. He referred to the important case of the Attorney-General *v.* the Edison Telephone Company, which decided that a telephone was a telegraph within the meaning of the Telegraph Acts of 1863, 1868, and 1869, though the telephone was not invented or contemplated in 1869. The system of the National Company, however, was not "constant or fixed," nor had it been "purchased or acquired," as was necessary before he could claim that it should be rated as the telegraphs were. He quoted Mr. Castle's book on rating to show that the difficulty in the case of telephones lay in dividing the rateable value of the whole undertaking amongst the various parishes through which the wires passed. The parochial system of valuation was not altogether applicable to telephones, but some approximation to that might supply what they sought. The Company had 279,000,000 "calls" every year, but they could not tell what parish they came from, nor the earning capacity of a particular parish. He should not object to accept as a basis earning value of a wire per mile, or to take the net annual income of the Company, and divide it amongst the various parishes involved, according to mileage, if that could be done. He contended that batteries, instruments, &c., were chattels, and that their value should therefore be deducted from the property of the Company, before assessment, in the same manner as was allowed as regarded gas meters in the action Regina *v.* Lee. The total mileage of the National Company for the half-year ended June, 1895, was 126,238, and the total revenue for the same period £702,427. From this there had to be deducted £412,081 working expenses; £216,408 cost of reproduction of the 126,238 miles of wire at £12, calculated on a seven years' life all round; and £37,034 on account of "tenants' capital," which would leave £36,904. Deducting, again, rates at 6s. in the £ on £28,388—£8,516—they had £28,388. That produced a net rate per mile of 4s. 6d. The Company did not, however, offer to pay at that rate; but he was instructed to say that they were willing to pay on the basis of 30s., which, all things considered, he thought was fair.

Mr. G. BEAM, rating clerk to the National Company, said it was his duty to examine the assessments of the Company all over the country. He checked the assessments by dividing the rateable value by the number of miles, and if he considered the quotient represented the fair rateable value, he passed it for payment. So far as he knew, no method was employed in assessing. The bounds of an exchange district were fixed for the convenience of the Company and in accordance with the number of subscribers. A "call" consisted of calling up an exchange, and was not complete till the caller was put on with his correspondent. The Company did not enjoy a monopoly in their system, as was shown by the 19th clause of the licence they held from the Post Office. In order to ascertain the rateable value per mile, he divided the rateable value by the number of miles in the particular parish. Since January last he had no doubt the mileage in the St. Saviour's Union had increased. The new exchange in Marshalsea-road was opened for the convenience of the Company, and probably because the business had increased. Since 1892 the business in the metropolis had largely increased. In 1891 the total number of miles of wire of the Company was 39,497; now it was 126,238. He should think that the gross receipts in 1891 (£334,211), as given in a printed statement delivered by the Company in connection with a former appeal, was accurate; now the gross receipts were over £702,000. Roughly there was about one subscriber to every mile of wire, and they increased in about the same proportion as the mileage. He believed the Company was now paying 6 per cent. on some and 5 per cent. on other stock. The working expenses of £412,000 included operating expenses, salaries and general expenses and wayleaves, but not the Post Office royalties, which amounted to 10 per cent. of the gross receipts. The £702,000 was the gross earnings after deducting the Post Office royalties. The "tenants' capital" represented what capital a man would require supposing he took the system on lease. It would be required for switchboards, stores, &c., chiefly instruments. The total of the tenants' capital was £211,000. The earnings in the metropolis were larger than in the rest of the country, but he could not say that they were 60 per cent. greater. It had been stated by the Chairman of the Company that the average earnings per subscriber were £14. 14s. 5d. a year for the metropolis, and £9. 2s. 2d. over the whole United Kingdom. He knew the Company appealed in 1890 against their assessment, and that they withdrew the appeal on terms. The rating in 1892 was 28s., not 30s., as had been stated. £28,388 represented what the Company thought was the total rateable value of their property in the whole kingdom. The capital of the Company was over £4,000,000.

Mr. WALTER BARNET, surveyor, of Winchester House, said that, on behalf of the Telephone Company, he attended a meeting of the St. Saviour's Assessment Committee on October 16th, and asked the Committee on what principle they rated the Company at 40s. per mile of wire, but he did not get a satisfactory answer. The district, from a telephone point of view, was rather poor, and he suggested 30s. as a fair figure, but they declined to accept it. He should value a wire entirely in connection with what it earned. Much of the wire, such as junctions between exchanges, &c., was non-productive. The real way to rate the Company, though it would take a very long time to work out, was on the basis of a given loss or profit on its 279,000,000 messages.

Mr. AVORY, on behalf of the Assessment Committee, asserted that an appeal such as the present, involving an important question of principle—a statement which had been fully admitted by the other side—should not have been brought to this Court of Special Session. The Act of Parliament under which they were proceeding was passed to secure uniformity of rating in the metropolis, and for that purpose the Court of Special Assessment, to which such cases could be taken, was instituted. If this idea were not acted upon it was obvious that there would very likely be different decisions in different parts of London in regard to the same matter. Moreover, if the present appeal failed on figures, the Company would be able to appeal to the Assessment Sessions; but if it should succeed, the rating authority, on the other hand, would not have power to do that. His opponent having admitted liability to be rated, the only safe course for the Court was to compare the figures which formed the subject of appeal with the figures established by the quinquennial valuation of 1890. If an increase in the business had taken place the simple question would be, whether the rateable value had been increased in proportion to the increase of business. On this basis it could not be too much to increase the rating of 30s. in 1890 to 40s. now, because, while the business had admittedly increased over 50 per cent., the increase in the rating was only 33 per cent. He argued that the instruments, switchboards, &c., were rateable hereditaments, inasmuch as the wires would be useless without them, and if that contention were admitted he pointed out that the enormous sum allocated by Mr. Bean under this heading would be liable to be rated. As to this being a matter on which no decision had yet been recorded, he asserted that both the Recorder of Brighton and the Recorder of Manchester had decided it according to the view he presented. The suggestion seriously put before them was that the Company should only pay for the whole undertaking over the whole country on £28,388, although dividends of 6, 5, and 4 per cent. were paid on a capital of over four millions, and £70,000 a year was being put to the reserve fund. The contention was ridiculous. He therefore asked the magistrate to dismiss the appeal.

Mr. WILLIAM MARSHALL stated that he had had 20 years' experience of rating cases. In 1890 he valued the property of the National Telephone Company for the St. Saviour's Union. The rating of the Company then was 30s. per mile of wire. The increase in the mileage of wire in St. Saviour's Union would of itself justify a proportionate increase in the rateable value. In the present valuation he had put it at 40s., but in view of what he had learnt since then as to the earnings of the Company from the Chairman, and from witnesses, it ought to be increased to at least £5; in fact, the rateable value of the metropolitan portion of the Company's undertaking was £64,859, which worked out at £6 per mile as the rateable value. In St. Saviour's parish he made the receipts per mile come to £16 0s. 3d. He had estimated the rateable value of the wire in the Strand at £2 per mile, the same as in St. Saviour's. He did not know that in France telephone subscribers provided the instruments, the Company only providing the wires. The principle on which he should value the whole undertaking of the National Company was to take the total gross earnings in the whole area, subtracting the expenses, Post Office royalties, and wayleaves, which would give the net receipts to be divided between the hypothetical tenant and the landlord. Then, having regard to the little working capital that would be required, he thought 10 per cent. of the gross receipts was sufficient to allow the "tenant." Deducting that, they arrived at the annual value, plus rates, which were about 6s. in the £ in the metropolis. Reducing the sum by the amount of the rates they had the rateable value of the Company's entire undertaking, which would have to be apportioned over the various parishes covered by the undertaking.

Sir GEORGE MORRISON, in reply, addressed himself to one or two questions of law, and briefly reviewed the chief points of the Company's case.

The CHAIRMAN, after consultation with his colleagues, announced that the Bench had given the case their best consideration, and on the whole thought there was insufficient ground to disturb the finding of the Assessment Committee. They therefore dismissed the appeal.

Mr. AVORY asked that costs should follow the judgment, but the magistrates, having been addressed by Sir George Morrison on the point, held that several important points had been raised, and they declined to make the order.

Sir GEORGE MORRISON stated that, as the case applied to the whole of the United Kingdom, he should take time to consider the question of appeal.

BOOKS RECEIVED.

"Elettricità e Magnetismo." By Rinaldo Ferrini. Second Edition. (Milan: Ulrico Hoepli.)

"Elementi di Fisica." By Antonio Roiti. Second Volume (Florence: Successori le Monnier.)

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LONDON COUNTY COUNCIL.

Electric Lighting in Places of Entertainment.

At the weekly meeting of the London County Council on Tuesday it was reported by the Theatres and Music Halls Committee that some time ago they instructed the engineer to inspect the electric lighting installations in all the places of public entertainment in London which were licensed by the Lord Chamberlain and the Council, and the inspection was now being carried out.

Bristol Electric Tramways.

It was reported by the Highways Committee that there had recently been established in Bristol a new system of electric traction upon tramways; and in view of the fact that they had continually before them questions relative to tramway undertakings of various kinds upon which they were called upon to advise the Council, they thought it desirable that they should view that new system in actual operation. They therefore proposed, if the Council approved, to visit Bristol for that purpose on a day to be fixed during the Christmas vacation, and they recommended accordingly.

Col. ROTTON said he would move that the recommendation be referred back. It was proposed that those gentlemen, who were not engineers, should go down and see the electric tramway in operation. What would they do? They would go down to Bristol, he had no doubt. They would be put into a tram and be paraded all through the town of Bristol as the London Committee come down to view that beautiful thing, and it would be an advertisement for that business altogether. But what would they learn? They would only learn that the tram was moved by an electric motor. What on earth had the Highways Committee to do with electric motion? His object in referring it back was that if it were necessary that information should be given to the Highways Committee on the matter of electric motive power, the proper course to adopt was to send down the chief engineer and so obtain the necessary information. The engineer would receive plans and everything it was necessary for the Committee to have.

Mr. BERESFORD HOPE said he would second the amendment. That was the climax of a very peculiar business altogether. It arose first of all by the engineer of the Bristol tramways inviting the members of the Committee personally to come down at his expense and examine the tramway. The Chairman of the Committee and certain members accepted that invitation. A saloon carriage was ordered to be ready at Paddington station to take the members of the Highways Committee down to Bristol at the engineer's expense. The next thing that happened he supposed was that the Chairman of the Committee took higher advice, and the result was that at the last moment a refusal was sent, and the poor engineer had to do the best he could with the Great Western Railway. He was bringing out those facts because he thought they threw a light on the whole thing, and that it was not a *bonâ fide* desire for information on the part of the Committee.

Mr. HUBBARD (Chairman of the Committee) said the whole of the particulars given by Mr. Beresford Hope were not in the report, but they would have no objection to placing them in the report. The members of the Committee were interested in the matter, and had a *bona fide* desire to learn all they could about the different forms of traction, and it was considered by the Committee, if they were going down to gather information which would be useful for the people of London, they had better ask the Council to pay their fares down. However, considering what had been said he thought he would consult the dignity of the Committee if he asked leave to withdraw the paragraph.

THE CHAIRMAN: The paragraph is withdrawn.

Horseless Vehicles—New Act.

It was further reported by the Highways Committee that it had been represented to them that the provisions of the Highways and Locomotives Acts practically prohibited the use in the public streets of light carriages driven by electric or other motors of any kind, those vehicles coming under the description of "locomotives," and that the restriction was likely to be a hardship in the near future upon inventors and makers of such vehicles. The late Government introduced a Bill last year to remove the restrictions on the use of vehicles under two tons in weight propelled by mechanical power, but the Bill was not proceeded with beyond the first reading. The committee were of opinion that in the public interest an effort should be made to obtain an amendment of the existing law in the direction indicated in the Bill referred to, and they recommended: "That the Parliamentary Committee be requested to approach the Government with a view to the re-introduction in the Session of 1896 of a Bill to amend the law with respect to the use of locomotives on Highways."

The recommendation was agreed to.

With regard to the intention of the Charing Cross and Strand Corporation to lay mains from the Charing Cross Bridge of the South Eastern Railway, across and along a part of the Victoria Embankment, &c., to the Corporation's station at Bull Inn Court, it was the opinion of the Highways Committee that the proposed route was not the best that might be chosen, and the engineer to the Council has been instructed to communicate with the Corporation with a view to the proposal being amended. With this object the Council formally disapproved of the proposed works.

VAUGHAN AND BROWN (LIMITED).—The Directors of this Company have declared an interim dividend for the six months ended September 30th last of 7 per cent. per annum on the Preference and 5 per cent. per annum on the Ordinary shares.

CORRESPONDENCE.

PRESSURES DANGEROUS TO LIFE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question of the relative danger to life of the alternating and continuous currents is one which has been often discussed, and various beliefs have been expressed about it. The experimental data are scanty and conflicting, and a study of the reported accidents does not show any very great danger from alternating pressures below 1,000 volts. I cannot call to mind any fatal accident in England on any alternating-current network where the pressure has been 1,000 volts, and every *fiasco* which resulted from the early attempts at electrocutions in the United States points in the same direction. The pressures employed in those were about 1,200 volts.

Most of the fatal accidents in connection with electric lighting have been from arc-lighting circuits.

One case there is, reported by Dr. Biraud in his book "La Mort et les Accidents causés par les Courants Electriques," where death followed from contact with a circuit at 250 volts, alternating; but, so far as I know, the case is quite unique. The victim was very effectually earthed at the time, as he was holding in his hand a copper pipe. Death was instantaneous. No burns were observed. No examination of the body was made, and nothing is said of his age or state of health. On the other hand, there are numerous cases recorded of accidents from contacts with alternate circuits at much higher pressures without fatal consequences. Deaths certainly have occurred from continuous-current circuits at pressures below 1,000 volts. I remember one which happened in England about eighteen months or two years ago, where a man was killed in a mine by touching a conductor belonging to an electric haulage plant. The voltage was stated to have been 600, to the best of my recollection; but I am not able at the moment to find my notes of this case.

So far as I am aware, the case quoted above is the only one which supports the view that alternate currents are more dangerous to life than continuous. The muscular fixation which plays an important part in causing serious accidents is found with continuous currents as well as with alternating, as soon as the magnitude of current rises above a few milliamperes.

H. LEWIS JONES, M.D.

LEGAL INTELLIGENCE.

North Metropolitan Tramways Company v. The London County Council.

In the Appeal Court on Monday last, before the Master of the Rolls, Lord Herschell and Lord Justice Kay, the plaintiffs appealed from a decision of Mr. Justice Romer declaring that the Council could, under Section 43 of the 1870 Tramways Act, compulsorily purchase a portion of the Company's tramways without taking the whole of them. Under this section any local authority may, within six months after the expiry of a period of 21 years after the promoters were empowered to construct any tramway, give notice requiring such promoters to sell the undertaking, or so much of it as may be within the district controlled by the local authority. The North Metropolitan Tramways Company's tramways were authorised by three Acts, passed in 1869, 1870 and 1871 respectively. The County Council gave notice requiring the Company to sell so much of the lines as were authorised by the Act of 1871. The Company claimed that the Council were bound to purchase the whole of the Company's undertaking within the County of London at the same time, and, in support of this contention, pleaded the definition of "undertaking" contained in the 1871 Act, which defined the word to mean "the undertaking of the Company as authorised by the Acts of 1869, 1870, and that Act."

Mr. Cripps, Q.C., M.P., Mr. A. Carrington and F. C. Richardson appeared in support of the Appeal, while the Council were represented by Sir E. Clarke, Q.C., M.P., Mr. J. Fletcher Moulton, Q.C., and Mr. G. M. Freeman.

The MASTER OF THE ROLLS, in dismissing the appeal, said that there were two reasons why the appeal ought to fail. The first was the rule of construction that a private Act could not alter a previously-enacted public Act except by express words. Again, the word "undertaking" in Section 43 of the Tramways Act, as incorporated in the private Act of 1871, was to have the same meaning as in the incorporated Act "unless there was something in the subject or context repugnant to such construction." There was no repugnancy, for the definition of "undertaking" contended for by the Company would make nonsense of Section 43.

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Lord HERSCHELL said that Section 22 of the Tramways Act provided that Section 43 should apply to every tramway subsequently authorised by Parliament, "save so far as it shall be expressly varied or excepted" by the Provisional Order or Act authorising the same. Therefore Section 43, with the meaning attached to the words used in it, applied to the Act of 1871. Mr. Cripps said that, because Section 43 was incorporated by the Act of 1871, the interpretation clause in that Act referred to Section 43 as applied to that Act. He relied on that as an express variation of the Tramways Act. But the interpretation clause alluded to commenced by laying down that the words of the Tramways Act were to have their old meaning, unless there was something in the context repugnant to such construction. Therefore, unless there was something that was repugnant, a new meaning could not be put on the words. There was nothing in this case to prevent the full operation of the word used in the Tramways Act, because "undertaking" was only defined in the private Act for the purposes of that Act. If the word "undertaking" in Section 43 were interpreted by the definition in Section 3 of the private Act it would be nonsense.

Lord Justice KAY delivered judgment to the same effect.

Boyes v. Wellington and Co.

In regard to this case, which was reported in our last issue, Mr. Storey, the expert who had been agreed upon to adjudicate in the matter, said he had tested the chuck in the presence of both parties. He found that the jaws that held the work down did not run true. The defendants' counsel, however, said it was obvious that the expert had not tested the chuck properly. Mr. Commissioner Kerr said he did not believe that. He must find for the plaintiff. The defendant, Mr. Wellington, said the chuck had not been properly mounted, which Mr. Storey denied. Mr. Commissioner Kerr said the defendants must refund the money. Judgment accordingly with costs.

Ritter v. Bolas.

This case was heard in the City of London Court yesterday. The plaintiffs, Messrs. Ritter and Puzey, the proprietors of the Cannon-street Hotel, E.C., sought to recover the sum of £7. 19s. for providing electrical power to the order of the defendants, Messrs. Bolas and Co., Ludgate-hill, E.C. The plaintiffs' case was that in July last their hotel was hired for the purpose of a ball which was given by a gentleman named Marks by way of celebrating his silver wedding. The defendants, hearing of the event, asked the plaintiffs to allow him to photograph the guests at the ball; and to enable the defendants to take the photographs they asked the plaintiffs to furnish them with electric current to supply a lamp with which the photographs were taken in a small room. Magnesium light was formerly used, but the electric light was now preferred and was much more generally adopted. The defendant promised to pay for the electric current used, but he had not done so. The defence was that the defendants went to photograph the guests at the plaintiffs' own request. The defendants never agreed to pay for the current. The plaintiffs agreed to supply it, and to accept a gratis set of photographs in return. The jury found for the plaintiffs.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is in active preparation, and orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. The usual circulars, &c., are now being sent out. Full particulars post free on application.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES *can be obtained of the Booksellers or direct from the Publishing Offices:—*

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

A SHEET TABLE showing Total Capital Outlay and Receipts and Expenditure for the year 1894 of the Statutory Electric Supply Undertakings of the Metropolis is now ready, printed on thick paper. price 6d.

TENDERS INVITED.—Particulars may be obtained at the Brazilian Consulate in London, Liverpool, Manchester or Glasgow of tenders required for lighting the city of Recife, Pernambuco, by electricity, which are invited by the Government of the State of Pernambuco, Brazil. Some particulars are given in our advertisement columns.

——— In reference to the above advertisement the following will be of interest:—Every tenderer must prove that he has deposited into the Brazilian State Exchequer the sum of $15,000 (15 contos of reis) in gold or in certificates of the Brazilian National Debt. This sum is to be returned to unsuccessful tenderers, and the successful tenderer will then have to double the amount of his guarantee deposit, which sum must remain in the State Exchequer until after the expiration of the term for which the concession for electric lighting may have been granted, and, should any portion of this amount be deducted in payment of fines imposed under the contract, the portion so deducted must be made good within eight days of the deduction. In addition to those less specifically set out, fines varying from $200 to $1,000 for breach of any clause of the contract or of any of the regulations drawn up by the superintending engineer are imposed. The Government appoints a fiscal engineer and other officials not exceeding eight in number, whose salaries and wages the contractor has to pay, and the contractor has, in addition, to supply the superintendent's office with a set of instruments and apparatus for testing, &c., at a cost not exceeding $10,000. The maximum term for the whole of the work under the contract is not to exceed two years, and the work has to be commenced within three months of the signing of the contract. Many of the clauses of the contract are very stringent, and those articles dealing with the vested interests of Messrs. Fielden Brothers, who represent the existing gas company in the city, require careful consideration. Under Article 16 provision is made for the possible adoption of a dual system of lighting—electricity and gas. The installation, which is of considerable size, should receive careful attention from British contracting firms.

——— The Guardians of St. Luke, Chelsea, require tenders for the fitting up of an electrical wiring installation, including fittings, in the Chelsea Infirmary extension, Cale-street, Chelsea. Tenders by noon, December 31st.

——— The Corporation of Durban invite tenders for the supply, and for delivery and fixing at Durban, of steam and electrical plant (high-speed steam engines, dynamos, cables, arc and other lamps, accumulators, &c.). Tenders to Messrs. Webster, Steel and Co. (agents to the Corporation), 5, East India-avenue, London, E.C., by the 28th inst.

——— The General Consul of the South African Republic invites tenders for the delivery of 5,000kg. 2mm. hard drawn copper wire for the Telegraph Department of the Republic. Conditions, &c., from Messrs. Belinfante Bros., Paveljoensgracht, The Hague, and tenders must be sent in to the Consul, at the American Hotel, Leidsche Plein, Amsterdam, by December 20th.

——— Messrs. Arnott and Co. (Limited) invite tenders for an electric light and power installation at their new premises in Henry and Princes-streets, Dublin. Tenders by 8th prox.

——— The Saltash Town Council require tenders for lighting the public lamps of the borough by electricity, gas, or otherwise. Tenders by 20th inst.

——— Tenders are invited for the electric lighting of Brumath-i-Els., Germany. Steam power is to be used. Conditions, &c., from the Bürgermeister.

——— Tenders are invited by the municipal authorities of Langué for the concession for the electric lighting of the streets. Tenders to La Mairie, Langué (Haute Loire), France, by the 31st inst.

——— The Municipal Council of Stuttgart are inviting tenders for the electric lighting of the Jakob and Bürger Schools. Tenders to the Städtisches Hochbauamt, Stuttgart.

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TENDERS ACCEPTED.—At their last sitting the Llandrindod Wells Council considered the tenders received for the public lighting of the district. Mr. S. Jevons, of Birmingham, offered to light the streets electrically for £157. 10s. per annum, and proposed the use of 70 32 c.p. incandescents for the purpose. The Council also received a tender from a gas company, but decided by 30 votes to 14 to accept Mr. Jevons' offer.

——— The Harrogate Town Council have accepted the amended tender of the Southgate Engineering Company (Limited) for the supply of a 10-ton overhead traveller for their electricity works.

——— The Newport Free Library Committee have accepted the tender of Messrs. Alger and Sons, of Newport, for wiring the building at the sum of £147.

——— The Executive Committee of the Cardiff Exhibition have accepted the tender of Messrs. Strode and Co. for the electric lighting of the Exhibition from April 1st to November 7, 1896, for the sum of £3,000. Messrs. Strode are to provide 150 arc and 500 incandescents for this sum.

SALES BY AUCTION.—Particulars will be found in our advertisement columns of a preliminary notice concerning the sale, by Messrs. Wheatley Kirk, Price and Goulty, of the entire contents of the Acton Hill Works, London, W., in *re* the failure of Ronald A. Scott (Limited).

APPOINTMENTS VACANT.—It will be seen by our advertisement columns that Messrs. Street and Co., 30, Cornhill, London, E.C., have as clients a leading manufacturing firm, who require an electrical engineer, thoroughly qualified to design installations and prepare estimates, to go abroad.

——— Particulars will also be found of the requirements of a leading firm of electrical engineers and contractors who require a manager for a new branch in Johannesburg.

——— The Gas Department of the County Borough of Salford require an assistant electrician for a central station on the high-pressure alternating current system. Salary £2 per week. Some further particulars are given in our advertisement columns, and applications should be sent to this office, addressed "The Publisher of *The Electrician*," Salisbury-court, Fleet-street, London.

DISSOLUTION OF PARTNERSHIP.—Notice is given that Messrs. F. D. J. George and Henry Waghorne, who are prettily described as "butchers and electric light engineers," of Cheltenham, have dissolved partnership. Debts by Mr. George.

——— The firm of Wake and Sanders, of Crosby-square, London, E.C., mica merchants and general commission agents, has been dissolved.

BUSINESS CHANGES.—We are asked to state that the firm trading as Parr, Gillies and Hornidge, at Haggerston, London, N.E., and Buckingham, will in future be changed to that of Gillies and Hornidge, Mr. Parr having ceased to be a member of the firm. The business will be carried on as hitherto, the sole partners being Thomas Gillies and Edward Hornidge. Debts of and owing to the firm of Parr, Gillies and Hornidge will be received and paid by the new firm.

LIQUIDATION.—At a meeting of the proprietors of the Electric Lighting and General Development Syndicate (Limited), on the 16th November, it was resolved to wind up the Syndicate voluntarily. This resolution was confirmed on the 7th instant, and Mr. A. E. Lott, 8, Bush-lane, Cannon-street, London, E.C., was appointed liquidator.

——— Meetings of the creditors and shareholders of the British Steam Generator and Refuse Utilisation Company, Limited (in liquidation) were held on Saturday last at the Bankruptcy Court, Carey-street, W.C., the Assistant Receiver (Mr. Winearls) presiding. The Company was formed in June, 1893, with a capital of £600,000, to acquire certain patents relating to refuse destruction furnaces and to a system in connection therewith for the generation of steam power and electric current at a cheap rate. It is asserted that the vendor was to receive £30,000 in cash, but it was stated at the meeting that he had only received £286, and that altogether only 210,590 £1 shares had been issued, no public subscription having been invited. The liabilities are estimated at £2,500, and the assets consist of three patents, some works at Halifax, and shares in the London Refuse Steam Generator and Electrical Power Corporation (Limited) to the extent of £100,000, held by creditors for cash advances. The Official Receiver was appointed liquidator, assisted by a committee of inspection.

——— The adjourned public examination of the directors of the New British Electrical Installation Contractors (Limited) was to have been resumed at the Worcester County Court on Tuesday last, but owing to the absence of one of the directors (Mr. Duce), the examination was adjourned to January 22nd.

BROOK HOSPITAL LIGHTING.—The order for the steam engines for the electric lighting of Brook Hospital, for the Metropolitan Asylums Board, has been given to Messrs. G. E. Belliss and Co., of Birmingham. Originally double-acting engines were limited to 200 revolutions, while single-acting were allowed to run as high as 470 revolutions. It speaks well for the Belliss double-acting engine that an exception has been made in its favour, and that it is to run at a speed specified for single-acting engines.

WARNING.—Mr. G. A. Nussbaum, representative in this country of La Société Industrielle des Téléphones, writes as follows :—

"In view of the numerous infringements of the Berthon transmitter, now sold in the market, will you kindly allow me to sound a friendly note of warning in the columns of *The Electrician*. I beg to state that the English patent is still in full force. Consequently, persons dealing in instruments of this kind not made by La Société Industrielle des Téléphones will render themselves liable to legal proceedings."

A POLE-FINDER.—The Berghansen pole-finder is not intended for use by such explorers as Dr. Nansen, but is suitable for finding which end of two cables, or which of two terminals, is positive and which is negative. The instrument, which is supplied by Mr. R. Simon, Zulla-road, Nottingham, in a handy little case, consists of two small parallel glass tubes almost completely filled with a colourless liquid. At the ends of the lower tube are two electrodes, connected to clamping terminals on the frame in which the tubes are mounted. On connecting these two terminals to the points to be tested, a bright rose colouration is developed on the negative electrode. Simply by shaking the instrument after disconnection, the colour will disappear. This pole-finder, which is compactly and strongly made, should prove useful to dynamo and battery tenders and other users of electric current.

CATALOGUE.—Messrs. Clarke, Chapman and Co. (Limited), of Gateshead-on-Tyne, have sent us an advance copy of their 1896 catalogue of electrical plant and apparatus made by the firm. In many respects this useful compilation is a work of art, as it contains several large half-tone illustrations of the Victoria Works and of some of the Company s principal plants. We notice particularly views of the ingenious system of under-hung electric travelling cranes for shipbuilding purposes, which were illustrated in our columns recently. Numerous tables of data in regard to steam engines, dynamos, &c., and a considerable amount of other information, are given, which should prove useful to intending purchasers and to consulting engineers.

ASHTON-UNDER-LYNE.—At the last meeting of the District Council it was decided to form a special Electric Lighting Committee for the purpose of carrying out the provisions of the Electric Lighting Order.

AUTOMATIC MACHINES FOR TELEGRAPH FORMS.—To check the excessive waste of telegraph forms the Post Office have been experimenting with various automatic machines for supplying forms one by one. These appliances have been used at the central telegraph office for some months, and it is now intended to introduce them at the chief provincial offices to test their usefulness. The machine consists simply of a wooden box fixed on to the wall, from which a telegraph form protrudes, and as fast as one is removed another takes its place. The contrivance is not unknown in connection with lavatory papers.

AYR.—At the last meeting of the Town Council, Bailie Ure moved that the question of the advisability of constructing tramways between Ayr and the outlying districts, the motive power to be electricity, be referred to a sub-committee of the Electric Lighting committee for consideration and report, and after a short discussion the motion was agreed to. It is stated that the official inauguration of the electric light works will take place either on January 9th or 10th next.

BALMORAL CASTLE.—£1,400 is to be spent in the electric lighting of a portion of the Queen's residence in Scotland, the waters of the Gelder being utilised for motive power purposes. The ball-room is to be first lighted.

BANGOR (IRELAND).—At a special meeting of the Town Commissioners on Monday Mr. Bowman moved that the Commissioners apply for a Provisional Order. An amendment that the cost of obtaining the Order be first ascertained was, however, eventually adopted.

BATH.—Mr. Robert Hammond has presented his report to the Lighting Committee of the Urban Sanitary Authority on the electric light question and as to the value of the City of Bath Electric Lighting and Engineering Company's undertaking. The subject is dealt with under three heads : (1) the desirability of the electricity works being in the hands of the Corporation ; (2) the system of generation and distribution best suited to the requirements of the city ; and (3) the advisability of the acquisition of the existing electric light works. He favours the view that the works should be in the hands of the Corporation, and in support of this contention states that (*a*) it is the universal experience that even in places where gas is cheap there is a sufficient number of private consumers to make electricity supply works pay ; (*b*) combined public and private electric lighting works are becoming general ; (*c*) where works have been laid down on a sound and economical basis they are proving

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a financial success; (*d*) the tendency is for local authorities to lay down their own works, and in all cases to obtain powers to deal with both public and private lighting; (*e*) there is a great probability of the cost of generating current being reduced as business extends; (*f*) electricity works for private lighting in the hands of a local authority are likely to be more economically carried on than works laid down by a Company, and therefore ratepayers should obtain a cheaper supply; (*g*) statutory powers for the establishment of works for private lighting may prove of great value to the community, and should be vested in the local authority. As to the question of the system to be adopted, Mr. Hammond favours that at present employed by the City of Bath Company (high-tension alternating currents) as being the most suitable for the district. The report recommends the Corporation to purchase the existing undertaking. The space for extension at the present works is limited, but Mr. Hammond thinks that the idea of two separate stations should not be dismissed as impracticable, but they could not be worked as economically as one station. Mr. Hammond deals with the actual value of the Company's works, and he estimates the generating plant and works at £8,285, distributing plant £6,500, or a total of £14,785. This figure, however, excludes the value of the land on which the generating station is built. It would be necessary for the Corporation to make the following additions to the present plant: Generating machinery capable of supplying current to an additional 6,000 lights, £5,500; low tension network, £2,500; extension of mains, £2,500; arc lamps, posts, rectifiers, &c., £3,000; contingencies and engineer's fees, about £1,000. These figures, together with the sum required for the purchase of the works amount to £26,285. If, however, the Corporation could not come to terms with the Company, then they could lay down their own works, either at the Bathwick Mills, where the water power would prove a useful adjunct for working the day load, or at the destructor station. In conclusion, Mr. Hammond thinks that, with 10,000 lights already connected and a revenue of over £5,000 a year, a profit sufficient to cover the interest and sinking fund might be earned from the outset. If the acquisition of the works be accomplished, he also recommends the Committee to carefully consider the bold course already initiated by the Company of utilising the site to the full by laying down additional machinery. At their last meeting the City Council decided to proceed with their application for a Provisional Order.

Berlin Industrial Exhibition.—Special efforts are being made to attract English visitors to this Exhibition, many of the side shows being arranged with this object.

Bexhill.—Mr. R. Kersey and Viscount Cantelupe, on behalf of a local syndicate, recently gave the District Council notice of their intention to apply for a Provisional Electric Lighting Order. This notice was discussed at the last meeting of the Council, and it was decided to offer no objection to the application.

Birmingham.—At the meeting on Monday last of the Public Works Committee of the City Council, Councillor Wilson introduced a deputation from the committee formed to resist the proposed introduction of the overhead system of electric traction on the Nechells tramway route. Mr. A. Dickinson, engineer of the Central Tramways Company, was also present, and produced models of the cars and the trolley system, together with photographs of the system at work in Leeds and Hamburg. He also pointed out that in the method proposed to be adopted in Nechells, instead of the double line of posts with wires stretched across the streets, as in the towns named, there would only be a single line of posts, and in the narrower parts of the route the posts might be dispensed with altogether, and brackets, projecting from the sides of the houses, might be utilised to carry the wires. Referring to the alleged danger of the system, Mr. Dickinson stated that he was prepared to break one of the wires and hand it to any member of the deputation without his sustaining the slightest injury. The Tramway Company were losing about £2,000 a year on the horse cars and 'buses. The Company were willing to place overhead wires on the Nechells route for six months, and if at the end of that time the system was shown to be not satisfactory, they would undertake to remove them. Alderman Cook, the Chairman of the Committee, thought the Company's proposal was a very reasonable one, but they would take further time to consider the matter before presenting their report to the Council.

Bolton.—At the last meeting of the Gas and Electricity Committee of the Town Council the electrical engineer (Mr. J. H. Rider) was instructed to prepare a report and estimate of the cost of certain extensions to the plant at the electricity station. This step was rendered necessary by the continual and steady increase in the number of customers for current.

Bonsall (Derbyshire).—At the last meeting of the District Council the Clerk was instructed to ascertain the cost of erecting gas works, and, alternatively, of electricity works.

Bradford.—Many of the Corporations of our large towns are already in trouble over their electric lighting undertakings, but the trouble is a unique one. The demand for current is so large that it is found impossible to keep up with this demand, and the Gas and Electricity Committee of the Bradford Corporation have some real cause for anxiety in this respect, as the expected demand for Christmas will doubtless overtax the possible capacity of the electricity works. For some time past the Committee have been unable to satisfy the applicants for current, and a special effort will have to be made in made in order to keep the supply for Christmas up to anything like requirements. New customers, we understand, have very little chance of obtaining current.

Bray.—The Town Commissioners have decided to proceed with their application to the Board of Trade for a Provisional Order.

Bristol.—At the last meeting of the Electric Light Committee a very satisfactory report on the present position of the electric light undertaking of the Corporation was presented. The Committee have now 429 customers on their books, and 23,840 lamps have been connected up. As this represents almost the total capacity of the plant at the Temple Back generating station, it will be immediately necessary to put in additional machinery to cope with the increased demand for current. At the same sitting a number of fresh applications were received, but it was decided to proceed with only a portion of them.

Brixton (London).—An effective display of electric lighting has been prepared for the Christmas season at Electric-avenue, Brixton, which for many years has been brilliantly lighted electrically by Mr. Fyfe. On the present occasion about 80 Fyfe-Main 2,000 c.p. arcs are used, and a large number of Ediswan incandescents in foliated shades. The latter are suspended from green festoons which cross at intervals the entire length of the covered promenade. This exceptionally brilliant display is, we understand, remunerative as well as attractive. The shops in the avenue, with their extensive shows of Christmas goods and novelties, reap a large harvest from the vast number of visitors who are attracted by the illumination, which is quite gala-like in its picturesqueness.

Cardiff.—At the meeting of the Lighting and Electrical Committee of the Corporation on Tuesday a letter was read from the Secretary of the Cardiff Exhibition, stating that the Executive Council had considered the offer of the Lighting Committee to supply them with electric current, but they could not avail themselves of it, as the total cost would be greater than that of a separate installation. At the meeting of the Executive Committee of the Exhibition the Machinery Committee presented a report on the cost of illuminating Old Cardiff, the Art Section, and Rosebery Hall with gas, and lighting up the remainder of the Exhibition and grounds by electricity. The report stated that the entire work would entail an expenditure of over £4,000, and as this amount was considered to be too high, it was decided to form a special committee, with power to enter into the necessary arrangements for the effective lighting of the Exhibition buildings and grounds at a cost not exceeding £3,000. This Special Committee have decided that electric light is essential to the success of the Exhibition, and although the cost was necessarily somewhat higher than that of gas, Messrs. Strode and Co.'s tender for supplying 150 arc lights and 500 incandescents from April 1st to November 7th, 1896, for an inclusive charge of £3,000, should be accepted, the Exhibition Committee to supply steam, but the contractor to put down engines and dynamos and instal and maintain the lights. Messrs. Strode and Co. were granted the concession for supplying current to exhibitors on the condition that the authorities receive a proportion of the receipts in consideration of the steam power supplied by them.

Central London Railway.—The City Commissioners of Sewers had before them at their meeting on Tuesday last the report of the Streets Committee on the amended plans for the city station of the Central London Railway Company. The Committee recommended the Commissioners to approve the modified plans, and this was, after some discussion, agreed to. On the motion of Mr. Pannell the following rider, modifying the guarantor clause, was added to the report:—

"That the report be adopted and referred back to the Committee, and that the words 'that the amount so deposited as guarantee be released from time to time as the work proceeds, on certificates given by the engineer to the Company, and endorsed by the engineer to the Commission, so long as a substantial sum remains on deposit to ensure the due completion of the works."

Colwyn Bay.—At a special meeting of the District Council last week it was resolved to proceed with their application for a Provisional Order.

Coolgardie (W. Australia).—The telegraph operators and clerks at the Coolgardie, Kalgoorlie and Kanowna post and telegraph offices are evidently determined to have a share of the "finds" of gold in the district, and are stated to have sent an ultimatum demanding £200 per annum salary, 2s. per hour overtime, and three weeks annual leave, threatening to strike unless these conditions are accepted within 48 hours. The Premier's offer of an allowance of £30 per annum to the operators and clerks on the goldfields, and 2s. overtime in addition, has been accepted,

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the threatened strike being thus averted. In other respects Coolgardie, which but a short time back was a comparatively uninhabited district, is being brought up to date. The Grand Hotel has been lighted electrically by Messrs. R. W. Thomson and Co., of High-street, Adelaide, the plant consisting of a Crossley's [illegible] H.P. oil engine, a Crompton dynamo, and 120 16 c.p. incandescents.

[illegible]NTRY.—The City Council have decided to wire the Public Library for the electric light.

COWES (ISLE OF WIGHT).—At the last meeting of the District Council the Water and Lighting Committee recommended that £10,000 be the maximum expenditure inserted in the Provisional Electric Lighting Order, and that the Order as drawn be approved. This recommendation was agreed to.

DEVONPORT.—The Electric Light Committee presented their report at the last sitting of the Town Council. The Committee recommend that a Provisional Order be applied for, and that a sum of £30,000 be borrowed for the purpose of carrying out its provisions. After some discussion the recommendations were agreed to.

DUBLIN.—The members of the Society of Cab and Car Owners in Dublin are much disturbed at the threatened additional competition likely to arise from the adoption of electricity by the local tramway companies, and the Corporation has received a deputation, who placed the Society's views on the subject before the members. Only poor comfort could be given by the councillors.

DUTIES ON TELEPHONIC MATERIAL.—The Russian Customs authorities have decided that connecting cords for telephones, made of copper wire and covered with fibrous substances, with metallic tags, are to be classed as compound parts of telephonic apparatus under Section 169 of the Russian Customs Tariff, and pay a duty of 8 roubles gold per foot.

EDINBURGH.—At the meeting of the Town Council on Tuesday last the Electric Light Committee recommended that steps be taken to carry out the recommendations of Prof. A. B. W. Kennedy as to the electric light extensions set out on p. 238 ot our last issue. Mr. Mackenzie moved the adoption of the Committees' report, and made a statement as to the present position of and expenditure on the electric light works. This statement was practically a *résumé* of Prof. Kennedy's report, supplemented by figures dealing with the capital account of the undertaking. The report was, after some discussion, unanimously adopted.——At their last meeting the Plans and Works Committee decided to recommend that the Tron Church and Register House clocks be lighted electrically. The Committee had also under consideration the question of adopting the electric light for the City Chambers and the Royal Exchange, and the City Superintendent has been instructed to prepare a report on the question for the next meeting.

ELECTRIC BOAT PROPELLER.—For those who go down to the river in small pleasure boats, there can be no method of electrical propulsion more handy than an apparatus which can be fitted on to the rudder sockets of an ordinary rowing boat. The battery is placed in a convenient spot in the boat, the ordinary rudder is lifted out, and the electric rudder hitched on, a motor, propeller and rudder being combined. It then only remains to couple the battery to the motor by a short piece of cable and a switch, when all is ready for a few hours' boating. There are several forms of electrical boat propeller of this kind, but the latest we have met with is one manufactured by the Portable Electric Boat Propeller Company, of New York. In this the motor is not submerged, but is carried on the rudder handle just over the stern, and it drives the screw by means of a flexible shaft carried in a tube.

ELECTRICITY IN PRINTING OFFICES.—A recent issue of the *Eastern Daily Press*, which is published at Norwich, calls attention to the introduction of electricity for driving the printing machines used in the production of the paper. The work has been carried out by Messrs. Laurence, Scott and Co., electric motors being attached to the Hoe rotary machines used in printing the paper. A remark is made that electric current has proved equally successful as a driving power and as an illuminant.

EXHIBITION.—We learn that an Electrical Exhibition, particularly for the display of electrical novelties, is to be held at the Agricultural Hall, London, in May, 1897.

EXPORTS OF TELEGRAPH WIRE AND APPARATUS.—The exports of telegraph wire and apparatus connected therewith from this country during last month is recorded at £70,459 against £39,769 in October, and £49,438 in November of last year. The returns for the eleven months ending with November show a total of £493,665, compared with £1,376,294 in the corresponding period of last year.

FAREHAM.—Many of the ratepayers of this town are taking their defeat by the local electric lighting company in anything but a kindly spirit. Having elected members to the District Council pledged to undo the action of the outgoing Local Board, with the almost inevitable result that she law would uphold the action of the droperly-constftuted local authorities, the ratepayers are at their wits ends to make the blow dealt in the law courts fall as lightly as possible upon their pockets. It is stated that, in anticipation of increased rates, rents have already been raised. A gentleman who took the chair at a recent meeting of the ratepayers mildly hinted that possibly the members of the District Council in cancelling the contract entered into by their predecessors, had not given due care and attention to the subject, and that, therefore, the consequences might fall upon the shoulders of the members of the Council. This gentleman finally put the whole matter in a nutshell by observing that—

"There were three questions for the ratepayers to take home and consider. First, did the District Council give due care and attention in cancelling a contract entered into by them and the Electric Light Company? Secondly, was it their opinion that it it was advisable that the town should purchase the business of the Company and not pay the damages, £3,800. Th rdly, was it their opinion that the town should not purchase the business but pay the damages, amounting to £3,800."

FOOTBALL BY THE ELECTRIC LIGHT.—An Association football match between the Old St. Stephen's and the Thames Ironworks and Shipbuilding Company's Clubs was played on Monday evening last, at Canning Town, with the aid of the electric light. As might have been expected, under these circumstances, the result was a victory for the Thames Ironworks Club by three goals to one.

GLASGOW.—Sir James Bell has just prepared his third annual review of the municipal trusts and other undertakings of the city. The report states that the additional capital expenditure during the year in the electric light department was £20,524. To meet the increased demand two new Babcock-Wilcox boilers, two 300 H.P. Willans engines, and two dynamos, each equal to 3,000 lamps of 8 c.p., had been brought into operation, while the extension of the mains to the West-end Park district had been completed. The private houses extending from the West-end of Park-terrace to Charing Cross can now be supplied with current, and during the year 28 houses have been connected, with a total of 3,930 lamps of 8 c.p. The aggregate number of consumers has increased from 488 to 725, and the number of 8 c.p. lamps wired from 59,543 to 68,550.

GRANGETOWN.—At the last meeting of the Eston District Council it was unanimously decided to form a committee to inquire into the cost of establishing electric light works at Grangetown. Councillor Dale suggested that the Council should borrow £4,000 at 3½ per cent. for the purpose. He said that £200 was at present being paid by the ratepayers for public lighting by gas which was of an indifferent quality.

HAMPSTEAD (LONDON).—The basis upon which electric meter rents have hitherto been charged having been found unsatisfactory, a new scale has been decided upon, varying from 2s. 6d. per quarter upwards. Further lighting mains have been put down in the district of Lancaster-road and Compayne-gardens.

HARROGATE.—Mr. W. J. B. Clerke held a local Government Board inquiry on Tuesday last into the application of the Town Council to borrow £27,000 for electric lightfng purposes. The consulting engineer, Mr. George Wilkinson, produced plans and gave details of the scheme, to which there was no opposition. The Council have fixed the price of electric current for private consumers at 6d. per unit.

HORNSEY (LONDON).—The District Council recently received proposals as to the electric lighting of the streets and buildings in the district, and the Lighting Committee, to whom the matter was referred, now recommend that these proposals be not entertained.

INDUSTRIAL EXHIBITION AT THE PEOPLE'S PALACE.—It is proposed, with the consent of the Governors, to hold an Exhibition at the People's Palace, to be opened in June, 1896, of the arts, trades, industries and handicrafts existing in the Eastern and other industrial districts of London, together with a general exhibition of the work of students in polytechnics and technical institutes. The former Exhibition of the kind, held in 1887, was visited by some quarter of a million of people. The financial results of the last Exhibition were, on the whole, very encouraging, as, out of a guarantee fund of £4,000 provided, it was only necessary to call up 10 per cent. It is desired in this instance to raise a guarantee of from £8,000 to £10,000, in order to increase the scope of the undertaking, and to distribute as widely as possible all liabilities in connection therewith. More than £6,000 has already been subscribed. It may be pointed out that in this, as in the former instance, those who subscribe to the donation or guarantee fund will do so without any intention or desire to reap any financial benefit, and that if any profits should accrue they will be devoted to social and educational purposes in East London. The proposed scheme may be, roughly speaking, described under five headings :—Section 1.—Open to exhibits of firms. Section 2.—Work of individual craftsmen. Section 3.—Work of students at the People's Palace and other polytechnics, technical institutions and public elementary schools of London generally, and of trade apprentices. Section 4.—An historical loan exhibition. Section 5.—A display of appliances and products bearing upon the social and

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hygienic welfare of the population, supplemented by popular lectures on these and kindred subjects. The Committee appeal to all those interested in the encouragement of local industries, to employers of labour, and all others interested in the social and moral welfare of the industrial classes, to assist them in getting together the necessary guarantee fund. Donations are also invited towards current expenses.

KIDDERMINSTER.—The Town Council have instructed the Borough Surveyor to report upon the plans of the proposed electric tramway between Kidderminster and Stourport.

KING'S LYNN.—The Town Council at their last meeting ordered the corporate seal to be affixed to their petition to the Board of Trade for a Provisional Electric Lighting Order.

LAMBETH.—The gentlemen who attended the recent deputation to the Board of Trade on behalf of the Lambeth Vestry have reported that, in their view, it is unwise for anyone commencing electric lighting operations to do anything further until the whole question has been definitely settled by the Board of Trade and others concerned.

LLANDUDNO.—Some time ago the District Council received an application for permission to construct a system of tramways in this district, the motive power to be electricity, and a special meeting of the Council was held last week to consider the matter. In consequence of the recent adverse decision of the ratepayers, the Council decided not to further deal with the proposal.

LLANELLY.—Messrs. J. C. Howell (Limited) intend to proceed at once with the work of establishing an electricity station in this town. The scheme is estimated to entail an expenditure of £15,000.

LONDON, E.C.—If the extension scheme of the City and South London Railway Company receives the sanction of Parliament, the destruction of the ancient church of St. Mary Woolnoth, at the junction of Lombard and King William-streets, is inevitable, as it is proposed to erect a station on the site. A meeting is, however, to be held at the Mansion House early in the year to protest against the threatened demolition of the church, and it is probable that an influential effort will be made to compel the Company to select a less historic site for the proposed station.

MARYLEBONE (LONDON).—The report of the Special Committee of the Vestry recently appointed to consider the question of the adoption of an electric lighting scheme is practically complete, and will shortly be presented to the Vestry.

NEWINGTON (LONDON).—The Vestry have decided to proceed with their application to the Board of Trade for a Provisional Order, and also to oppose the application of the County of London and Brush Provincial Company for a similar order.

NEWMARKET.—At their last meeting the District Council had before them the request of the Newmarket Electric Light Company, for sanction to their application for a Provisional Order, but the matter was adjourned to the next sitting of the Council.

PLYMOUTH.—At a special meeting of the Town Council on Monday it was decided to proceed with the application for a Provisional Order for the construction of a system of tramways in the town. The Council intend to adopt electricity as the motive power.

POLICE.—The action brought by the Edison and Swan United Electric Light Company against Arthur Attride, Edward Ingold and George Cosgrave, for alleged fraudulent marking of incandescent lampholders, which, as stated in our last issue, was adjourned, was again called at the Clerkenwell Police Court, London, on Wednesday, and further adjourned.

PORT ELIZABETH (S. AFRICA).—At a recent meeting of the Harbour Board the resident engineer submitted a scheme for the electric lighting of the jetties, harbour, grounds and stores, and for the adoption of electricity as motive power for the cranes, at a cost of £4,000.

PORTSMOUTH.—There is a proposal on foot to light the Portsmouth Hospital by electricity. Specifications for carrying out an experimental installation will be discussed at the next meeting of the Hospital Committee. At the last meeting of the Town Council it was stated that the Camber Committee hrd decided to light the town quay and the Camber electrically.

SHOPPING BY TELEPHONE.—A Liverpool firm, Messrs. MacSymon and Co. (Limited), in order to meet the growing disposition for ordering goods by telephone, have arranged two separate telephonic installations each in the care of a separate attendant. The telephonic arrangements admit of the counting house and the managers of the various departments being communicated with by subscribers or other customers.

SHOREDITCH (LONDON).—At their last meeting the Vestry, on the recommendation of the Electric Lighting Committee, approved the specifications and plans of the generating station buildings and offices submitted by the engineers, Messrs. Kincaid, Waller and Manville, and ordered that advertisements be issued inviting tenders for the same.

SHREWSBURY.—The Directors of the Shropshire Electric Light and Power Company have, in consequence of the support already given and promised to the Company's undertaking, reduced the price of current from 8d. to 7d. per unit.

STAPLE HILL (BRISTOL).—The Parish Council have decided to oppose the application of the Great Western Electric Light and Power Company for a Provisional Order for the district.

STIRLING.—At a special meeting of the Police Commission on Monday last it was decided to approach the local gas company with a view to arranging terms for the purchase of the gas works. This course was opposed by Bailie Wingate and Mr. MacDiarmid, who maintained that the Commission should not take any action in the matter until they had disposed of their Provisional Electric Lighting Order.

STOCKTON-ON-TEES.—On the suggestion of Mr. Ford, the gas-works manager, the Corporation have appointed a deputation to visit three towns where the electric light is installed for the purpose of collecting information with a view to the adoption of an electric lighting scheme for Stockton.

THE PRICE OF CURRENT IN THE CITY OF LONDON.—At the last meeting of the Common Council Mr. Brooke Hitching inquired of the Chairman of the Commission of Sewers whether, in view of the high price of current—viz., 8d. per unit, against about 6d. or less in other metropolitan areas—the Commission had reserved to itself the right to purchase the City of London Electric Lighting Company's undertaking on equitable terms, or if not, what notice would be required for the establishment of a municipal electric supply. The Chairman (Mr. Gordon) replied that the purchase of the undertaking could not be accomplished for 21 years, as the Commission had granted an exclusive concession for public and private lighting to the Company for that period. The term would date from the completion of the Company's contract, when the Commissioners' engineer would give his certificate, and nothing could be done until that term had expired. The reason the contract had not been completed before was that the Commission had, up the present, been unable to determine the best mode of lighting the minor streets. He hoped, however, that that question would be settled in the course of the next few weeks. As to whether any other electric lighting company could come into the City in opposition, he was of opinion that no other company could compete. Mr. Alderman Bell, on the contrary, declared that, in his view, there was nothing to prevent another company from coming into the City and working in competition with the present one. Mr. C. T. Harris urged that, while the Commission of Sewers had given no exclusive right, it was bound to oppose any other company which entered into competition.

TUNBRIDGE WELLS.—In consequence of the satisfactory manner in which applications for electric current are being received, it has been decided by the Town Council to proceed at once with the work of enlarging the electricity station, and the Borough Surveyor has been instructed to prepare plans for an addition to the building, and instructions have also been given to obtain another boiler, engine and dynamo.

WAKEFIELD.—In reply to a question, Mr. Alderman Sherwood (Chairman of the Electric Light Committee) stated at the last meeting of the City Council that they could not proceed with their electric lighting scheme until the Sewerage Committee had selected a site for the new sewage works, as the sewerage and electric lighting works were to be a joint undertaking.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

November 16, 1895.

21,817. T. W. ALLAN, A. POWELL, and C. J. TIBBITS. London. Improvements in fittings for incandescent electric lamps.

21,830. SIEMENS BROS. & CO., LIMITED. London. Improvements in electrical apparatus for firing fuzes in mines and other purposes. (Siemens and Halske, Germany.)

November 18, 1895.

21,893. N. DADGE. London. Improvements in electric light fittings.

21,924. G. HUMMEL. London. Improvements in or relating to wattmeters.

November 19, 1895.

21,941. J. DUGDILL, Junr. Manchester. Improvements in casings employed for electrical wires.

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21,993. G. A. Washburn. London. Improvements in combined motive power and electric generating and storing apparatus for the propulsion of movable conveyances and analogous power purposes.*
21,998. G. P. Clark. London. Process for heating rivets electrically.
22,004. J. F. Cummings and W. C. Yawkey. London. Improvements in and relating to electrical conduits.*
22,006. J. M. L. Murphy and A. F. Pierce. London. Improvements in and relating to electric railway signals.*
22,023. P. A. Newton. London. An improved thermo-dynamic process and apparatus. (A. B. Wellington, United States.)*
22,028. G. G. M. Hardingham. London. Improvements in protective coverings for the joints of electric cables. (The firm of Felten and Guilleaume, Germany.)

November 20, 1895.

22,060. W. F. Lounsbury. Manchester. Improvements in automatic telephone exchange system.
22,066. B. M. Drake and J. M. Gorham. London. Improvements in two-way switches.*
22,074. J. Morton. Halifax. An improved means or method of driving or propelling electric tramcars.
22,112. D. Potter. London. Improvements in the gearing and arrangement in an electric crane.
22,120. T. W. Allan, A. Powell, and C. J. Tibbits. London. Improvements in electric accumulators or storage batteries.*
22,133. J. W. H. Hempel, M. Gumpel, and A. Maerker. London. Improvements in telephone message counters.*
22,142. P. Falle. London. An improved electric battery.

November 21, 1895.

22,150. S. Walton. London. Improvements in electric indicators for bells, telephones, alarms, and the like.
22,154. A. W. Butterfield. Oldham. An adjustable clip for securing shades to the brass collar of incandescence electric light bulbs, or lampholder for same.
22,207. C. Kellner. London. Improvements in electrodes suitable for electrolytic apparatus.
22,233. M. Engel and F. Wüste. London. Improvements in accumulators and their electrode plates partly applicable to primary batteries.
22,234. Siemens Bros. and Co. (Limited). London. Improved means for protecting electrical and magnetic apparatus against the disturbing effects of electric railways passing in proximity thereto.
22,246. F. G. Treharne. London. Improvements in and relating to insulators and insulating conduits or tubing for electrical purposes.
22,252. A. B. Blackburn and T. L. Boyden. London. Improvements in direct electric-current transformers or motor generators.

November 22, 1895.

22,337. The Edison and Swan United Electric Light Company and A. W. Hill. London. Improvements in incandescent electrical lamps.*

November 23, 1895.

22,369. H. C. Newton. London. An improved electric arc lamp for magic lanterns.
22,408. W. Durant and T. W. B. Durant. Barnsley. Improvements in dry voltaic batteries.

November 28, 1895.

20,925A. E. Burnet. Liverpool. Improvements in or relating to incandescent electric lamps. (Date claimed under Patents Rule 19, November 5, 1895.)

November 25, 1895.

22,480. H. Chitty. London. Improvements in dynamo-electric machines.
22,482. O. Imray. London. Manufacturer of orange-colouring matters by electro-chemical process. (The Society of Chemical Industry in Basle, Switzerland.)
22,505. F. Dannert, H. Windolff and J. Zacharias. London. Active material for electric accumulators.*
22,506. F. Dannert, H. Windolff and J. Zacharias. London. Electric accumulator.*
22,511. O. M. C. Heyl. London. Improvements in the protection of bulbs for incandescent lamps.
22,519. F. C. Esmond. London. Improvements in or connected with electric railways or electric transport. (Date applied for under Patents, &c., Act, 1883, Sec. 103, April 26, 1895, being date of application in United States.)

November 26, 1895.

22,543. G. Wilson. Aberdare. An improved carbon holder for electric arc lamps and projectors.
22,569. J. W. Creasey and T. W. Breach. London. Improvements in or connected with electric bell pushes.
22,574. C. J. Grist. London. Improvements in the manufacture of insulating compositions for electrical purposes.
22,575. F. H. Judson and C. W. Silcock. London. Improved carbon plates with or without terminals.
22,586. Siemens Bros. and Co. (Limited). London. Improvements in single-phase alternate-current motors. (Siemens and Halske, Germany.)
22,600. I. Kitsée. London. Improvements in and relating to a system of telegraphic communication.*

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1894.

15,192. Sayer. Electric, &c., railways.
21,489. Deming. Electrical apparatus for working railways.
22,157. McGeoch. Electrical switches.
22,866. Morriss. Telegraph instrument.
22,883. Binswanger and Stanley. Electrical measuring instruments.
23,279. King. Electrically propelled carriages.
23,529. Lyon and Bevis. Electric switches.
23,825. Brockie. Arc lamps.
23,854. Wood. Electrical distribution.
24,076. Hoffmann. Telegraphic apparatus.
24,353. Siemens Bros. and Co. (Limited) and Perry. Electrical conductors, &c.
24,906. Blackburn and Buchanan. Electric current transformers.
24,907. Blackburn and Fairall. Arc lamps.
25,544. Johnson and Steele. Electric circuits.

1895.

42. Binswanger. Telephonic apparatus.
226. Herz and Hartfuss. Electric call and alarm apparatus.
281. Oppenheimer. Telephones.
298. Claret and Vuilleumier. Electric vehicles.
351. Gwynne and Kennedy. Arc lamps.
523. Belfield (Westinghouse Electric and Manufacturing Company). Lightning arresters.
1,714. Siemens Bros. and Co. (Limited) (Siemens and Halske.) Electrical glow lamps.

COMPANIES' MEETINGS AND REPORTS.

Froggatt's Electric Lighting Company (Limited).

An extraordinary general meeting of this Company was held on Monday at Winchester House, Old Broad-street, E.C., under the presidency of Mr. C. de Murrieta, to consider two resolutions for winding up the Company, and appointing Mr. W. P. Eldrid liquidator.

The SECRETARY (Mr. Arthur S. Hiley) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, the report of the Committee appointed to examine into the position and prospects of the Company, and the circular addressed to the shareholders, explains so fully the state of affairs that there remains little for me to add, except to express my regret and disappointment that, in consequence of the failure of our efforts to obtain further capital, it has become impossible to carry on the business of the Company, and this at a time when everything points to a promising future provided certain modifications in the working and administration are carried out. The history of the Company must be well known to you, so that I need not detain you with a recital of the difficulties with which we have had to contend—difficulties inherent to every pioneer enterprise. I will only say that we have earnestly laboured without reward in the interests of the Company, and have at least shown that the system adopted by the Company is well conceived, and, under happier circumstances, might still achieve success. But all the available funds being exhausted, and no response having been made to the proposal of issuing Preference shares, it has become necessay for us to call you together to sanction the winding up of the Company, which under the circumstances we feel is the best, and, indeed, the only course to pursue; and for this purpose we recommend that Mr. Eldrid, the auditor of the Company, be appointed, he being already acquainted with the working of the Company, and thus well qualified to judge of the best means of disposing of the assets, or, if it be possible, the manner by which a reconstruction may be effected. I therefore move: "That it has been proved to the satisfaction of the Company that it cannot by reason of its liabilities continue its business, and that it is advisable to wind up the same, and that the same be wound up accordingly."

Mr. FROGGATT seconded the motion.

Mr. PHILIP HALL enquired whether there was no way in which the Company could be amalgamated with one of the larger electric lighting companies of London. It was a very serious matter for the shareholders that, in the space of about 12 months, a Company like theirs should have to be wound up, or it might be said, go into bankruptcy. He hoped that something might be done to see whether they could not either reconstruct or sell their rights to a larger company with a greater capital, which would be more likely to make the enterprise a success.

The CHAIRMAN said it would be a very advisable measure to adopt if the Company could be reconstructed.

The SOLICITOR (Mr. W. L. Cooper) stated that one of the present difficulties was that two or three writs had been issued against them, and it was necessary to pass the resolution proposed in order to protect the assets of the Company. Efforts had been made with the object mentioned by the shareholder, and they were still being made, and it was hoped that the liquidator might be able to carry them to a successful issue. Unless, however, the step now proposed were taken, the assets would be dispersed by execution creditors.

The CHAIRMAN put the motion, and it was carried unanimously. He afterwards proposed—"That Mr. Walter Percy Eldrid, chartered account-

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ant, of 11, Old Jewry-chambers, E.C., be appointed liquidator," and this was approved.

Mr. BAXTER expressed a hope that the liquidator would succeed in reconstructing the Company, and that the contracts entered into would be carried out.

Mr. FROGGATT stated that measures had been taken to prevent all contracts in progress suffering more than could be helped by the present proposals, and he did not think they would suffer in the future.

The proceedings then terminated.

Swan United Electric Light Company (Limited)—(In Liquidation.)

The final meeting of the shareholders of this Company was held on Tuesday, at the offices of the Company, to receive the Liquidator's accounts of the winding-up. Major S. Flood-Page presided.

The CHAIRMAN said they had met not really to bury the pioneer of electric enterprise, for it was not quite dead. Phœnix-like it rises from its ashes in the Edison and Swan United Company. Those present who could go back to the time of the inauguration of the Swan Company could realise what a very great work was done by it. It must be a gratification to them, as it was to all, to know that Mr. Swan, who began his investigations in connection with the electric light in the year 1845, was still among them, giving them invaluable aid and assistance in the work they still had to do. They had gentlemen present who took an active part in the formation of the old Swan Company, at a time when electric lamps cost 17s. 6d. each to make, and were what we should now consider to be of very poor quality. The best quality lamps were now being sold at 1s. 9d. each in the face of great competition.

The LIQUIDATOR (Mr. H. C. Gover) then presented his statement of the distribution of assets, and it was resolved: "That the accounts submitted be received and adopted, and the books and papers connected therewith be handed over to the Edison and Swan Company."

Mr. SWAN seconded the resolution, and said that it was always a melancholy thing to assist at a funeral, but the Chairman had been pleased to speak of its resurrection in the Edison and Swan United Company. The remarks of the Chairman had aroused in his recollection many interesting reminiscences during the vicissitudes of the old Swan Company, and he was glad that he had been able to assist in giving the people a more wholesome and better light than before. The changes of the companies which had taken place had not always been agreeable to him, but he had not opposed them because he had supposed them to be in the interest of the shareholders. In a number of instances he had suppressed his own feelings and his own interests in order that a better chance of success might be given to the Company. He believed that the Edison and Swan Company had a long and prosperous career before it.

The resolution was carried unanimously, and the proceedings terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

BRITISH ELECTROZONE CORPORATION (LIMITED).—This Company was registered on December 10th with a nominal capital of £250,000, in £5 shares, to carry into effect an agreement between John A. Barham and William Digby, and Frederick W. Manley (acting for the Company) to purchase, apply for, acquire, develop and work letters patent, patent rights, concessions, protective trade marks, designs and copyrights for the manufacture and application of Woolf's electrolysing, bleaching, and disinfecting process in the United Kingdom, and in any country except the United States and the Hawaiian Islands, and to carry on the business of manufacturers, merchants, contractors and engineers. The subscribers, with one share each, are: A. C. C. Codd, East India merchant; J. D. Jehu, G. Hazelgrove, A. J. Lusty, merchant; A. Riding, A. E. Griesbach, and E. H. Selby.

ELECTRIC AND GENERAL EXPLORING SYNDICATE (LIMITED).—This Company was registered on December 13th, with a capital of £5,000, in £1 shares, to acquire and deal in land, buildings, hereditaments, business concerns and undertakings, mortgages, charges, annuities, patents, licences, shares, stocks, securities, debentures, policies, book debts, claims, &c., and to carry on all kinds of agency business. There seems to be no particular "electric" business in connection with the Company.

NEW ELECTRIC LIGHT SYNDICATE (LIMITED).—This Company was registered on December 12th, with a capital of £2,000, in £1 shares, to effect an agreement between Bernhard F. de Morgenstern, experimental chemist, and Audley C. Miles (as the trustee for the Company) for the acquisition by the Company of a certain invention for the manufacture of electric current for light and power purposes, and to carry on the business of manufacturers of, and dealers in, electric batteries, lamps, switches, &c. The first subscribers, with one share each, are: C. V. Miles, Lieut.-Col. 1st Life Guards; Cecil Bingham, Captain 1st Life Guards; Audley C. Miles, Bernhard F. de Morgenstern, experimental chemist; J. G. Dalzell, Godfrey Pritchard, H. L. Mather. The first Directors are Audley C. Miles and Hon. Cecil Bingham.

NEWMARKET ELECTRIC LIGHT COMPANY (LIMITED).—The statutory return of this Company to November 2nd has been filed. The nominal capital is £30,000, in shares of £10 each; nine of these have been taken up, the full amount has been called, and £90 has been paid.

NEW-MAYNE ELECTRIC-RUDDER-MOTOR SYNDICATE (LIMITED).—The statutory return of this Company to July 29th was filed on December 2nd. The nominal capital is £20,000, in shares of £10 each; 879 of these have been taken up, and 807 issued as fully paid. The full amount has been called on six shares, and £8 per share on the remainder, resulting in the receipt of £588.

NEW PHONOPORE TELEPHONE COMPANY (LIMITED).—The statutory return of this Company to November 29th has been filed. The nominal capital is £10,000, divided into 9,000 Ordinary and 1,000 Founders' shares of £1 each; 5,031 of these have been subscribed for and allotted, a call of 10s. per share has been made, and £2,515. 10s. has been received.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30⅜d. per oz. (Dec. 19th). Consols (2¾ per cent.) 106⅞—107 for money, 106¾—107 for account; 2½ per cent. 103⅞—104 (Dec. 19th). Stock Exchange Settling Days: Consols, Jan. 3rd; Stocks and Shares Continuation Day, Dec. 27th; Ticket Day, Dec. 28th; Pay Day, Dec. 30th. Mining Share Carry-over Day, Dec. 24th.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—The coupons on this Company's Four per Cent. Mortgage Debentures, due on January 1st next, will be paid on and after that date at Parr's Banking Company and the Alliance Bank, Bartholomew-lane, London, E.C. Warrants in payment of these debentures will be sent out on the 31st inst. The register will be closed from the 27th to the 31st inst. inclusive.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The coupons on the second issue of Five per Cent. Debentures, due 31st inst., will be paid on and after that date at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, E.C. Coupons must be left three clear days for examination.

BRITISH NORTH BORNEO COMPANY (LIMITED).—At the general meeting of the shareholders of this Company, Mr. R. B. Martin, who presided, stated that the telegraph line had been completed to within 23 miles of Penungah, on the east coast section, and on the west coast section the line had been completed to Rayoh.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).— The transfer books of the Four and a-Half per Cent. Second Debenture Stock of this Company will be closed from the 18th inst. to January 4th inclusive, in view of the payment of the interest due on January 1st.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended December 15th were £1,014, against £962 for the corresponding week of 1894, an increase of £52. The total receipts for the half-year amount to £21,541, against £21,480 in the corresponding period of 1894, an increase of £61.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The transfer books of the £300,000 Five per Cent. Redeemable Debenture Stock of this Company will be closed from the 23rd to the 31st inst. inclusive for the purpose of preparing the warrants for the interest due January 1st next.

GUILDFORD ELECTRICITY SUPPLY COMPANY (LIMITED).—At the annual general meeting of this Company, held recently, Mr. A. F. Asher, who presided, explained that the Company, which was originally known as the Holloway Electricity Supply Company (Limited), had applied for a Provisional Order to light Guildford and district electrically. Notwithstanding the opposition of the local authorities, the Company had succeeded in obtaining an Order under very favourable terms. Sufficient capital had been already subscribed to justify the Directors in entering into a contract for the works, machinery, mains, &c., and in securing an excellent site for their station. They, however, required further capital to enable them to provide for an increase in the plant which would probably be shortly required. The Founders' shares, of which there are 500 of £1 each, and upon which no dividend is payable until the Ordinary shareholders have received 6 per cent. per annum, have been allotted to those who provided the necessary funds to meet the expenses of the formation of the Guildford Company.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 15th inst. amounted to £1,081. The amount for the corresponding week last year was £917, an increase of £164.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—This Company announces the payment by warrants, on January 1st next, of interest for the half-year ending December 31st on the Four and a-Half per Cent. First Mortgage Debenture Stock. The transfer books will be closed from the 18th to the 31st inst., inclusive.

PACIFIC AND EUROPEAN TELEGRAPH COMPANY (LIMITED).—The coupons on the Four per Cent. Guaranteed Debentures, due 31st inst., will be paid on and after that date at Parr's Banking Company and the Alliance Bank (Limited), Bartholomew-lane, London, E.C. Coupons to be left three clear days for examination.

STOCK EXCHANGE NOTICES.—Applications have been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to, the City of London Electric Lighting Company (Limited) for the provisional certificates of the further issue of £100,000 Five per Cent. Debenture stock.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended December 13th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,895.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the half-month ended December 15th were £2,464, against £2,055 in the corresponding period of 1894. The August receipts, estimated at £3,226, realised £3,282.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Dec. 11.	Price Wednesday, Dec. 18.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 14. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	10/0	Anglo-American	44 46	43 45	5 0 0	Jan., Apr., July, Oct.	..	..
£2,993,560	Stock	20/0	Do. Preferred	84 85	81½ 82½	5 9 1	" "	84¾	83½
£2,993,560	Stock	5/0	Do. Deferred	6½ 6¾	6 6⅛	.. ..		6¼	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	101 105	101 105	3 17 6	January and July	..	..
120,000	£10	3/0	Brazilian Submarine	13 13½	12⅝ 13⅛	5 13 2	Mar., June, Oct., Dec.	13½	13⅛
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111 115	111 115	4 8 6	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock xd	164 169	160 170	4 2 4	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine xd	13 14	13 14	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 13 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	3½ 4½	3½ 4½	4 8 11	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104⅞ 107⅞	104⅞ 107⅞	4 5 9	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½ 8¾	8 8¼	4 2 4	Jan., Apr., July, Oct.	8½	8¼
400,000	10	2/6	Eastern	16 16½	16 16⅛	3 18 9	" "	16½	16
70,000	10	6%	Do. 6 per Cent. Preference	17½ 18	17½ 18	3 6 8	" "	17⅞	17½
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	125 128	125 128	3 2 8	May and November	127½	126
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107 109	107 110	4 13 3	February & August	..	..
£50,000	10	2/6	Eastern Extension	17 17½	17 17½	4 0 0	Jan., Apr., July, Oct.	17 1/16	17 1/16
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	126 129	127 130	3 2 2	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	102 106	103 106	4 16 5	January and July	104½	..
£80,630	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	102 106	103 106	4 16 5	" "	104½	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108 111	108 111	3 2 2	February & August	110	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112⅞ 115⅞	112⅞ 115⅞	3 9 9	May and November	..	..
180,227	10	1/8	Globe Telegraph and Trust	9½ 10	9½ 10	4 5 0	Jan., Apr., July, Oct.	9⅝	9½
180,042	10	6%	Do 6 per Cent. Preference	16½ 17	16½ 17	3 10 7	" "	16⅝	16½
160,000	10	5/0	Great Northern	21½ 22	21½ 22	3 17 3	Jan., April, and July	22	21 1/16
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1888 issue	104 107	104 107	4 14 7	March & September	..	..
17,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	43⅝	47
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	.. ..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 110	106 110	5 10 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	109 112	109 112	3 19 10	" "	..	..
11,889	8	4/0	Reuter's	4 5	4 5	.. ..		..	..
8,881	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	127 132	127 132	4 10 11	April and October	4¾	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	.. ..	" "	..	..
£233,300	100	5%	* Do. 5 per Cent. Debentures (red.)	103 105	101 105	4 16 5	January and July	..	..
80,000	10	2/0	West Coast of America	1 2	1 2	.. ..	March & September	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	98 103	98 103	8 0 0	January and July	..	..
88,321	10	1/8	West India and Panama	⅜ 1½	⅜ 1½	.. ..	June and December	..	..
24,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	" "	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½ 9½	8½ 9½	6 6 4	May and November	10⅜	10 1/16
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	111 114	111 114	4 9 6	" "	..	..
64,242	15	3/0	Western and Brazilian	9½ 10	9 9½	5 3 2	June and December	..	..
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6½ 6¾	6½ 6¾	.. ..	May and November	..	..
33,129	7½	1/6	Do. 5 per Cent. Deferred	3 3½	2¾ 3½	.. ..	" "	6½	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 14 3	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 14 3	" "	103½	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	113 118	113 118	5 13 2	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100 103	100 103	5 18 3	March & September	115½	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3½ 3¾	3½ 3¾	..		..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16 1/8	1/16 1/8	..	May and November	3½	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	1/16 1/8	1/16 1/8	..	Yearly	..	..
484,597	5	2/6	National	6⅛ 6⅜	5⅛ 6⅛	4 1 8	June and December	..	..
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	6½	6
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15½ 16½	15½ 16½	3 12 9	" "	17 1/16	..
119,284	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅛ 6⅜	6⅛ 6⅜	3 18 5	" "	..	..
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	106 108	106 108	3 6 10	January and July	6⅜	6⅛
58,000	5	3/0	United River Plate	2½ 3	2½ 3	.. ..	" "	106½	106¼
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	92 97	92 97	5 5 6	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12⅝ 13½	12⅝ 13½	1 17 9		12⅝	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15½ 16½	15½ 16	3 15 0		16½	15½
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	132 136	132 136	3 14 9	June and December	135½	133½
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..		..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½ 5¾	5½ 5¾	..		..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..		..	..
8,322	£5	..	House-to-House Electric	.. ..	.. ..	..		..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..		..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July	..	..
£5,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 8½	7⅞ 8½	..		..	..
111,000	5	..	London Electric Supply	.. ..	.. ..	..		..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	10½ 11½	10½ 11½	2 12 2		10⅜	..
£150,000	Stock	4½%	* Do. 4½% Debs.	117 120	117 120	3 16 3	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9	8½ 9	..		8½	..
..	..	..	Rand Electric	1/16 A prem	1/16 A prem	..		..	..
19,980	£5	2/6	St. James and Pall Mall	8 8½	8¼ 8¾	..		..	..
20,000	£5	7%	Do. 7 per Cent. Preference	9 10	9 10	3 10 0		..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8 8½	8½ 8¾	3 2 10		8 1/16	8⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1½ 1⅝	1½ 1⅝	10 0 0		1⅝	1 1/16
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅞ 2⅛	1⅞ 2⅛	5 12 11		2	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 19 0	March & September	114½	112½
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2 2¼	2 2¼	..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1⅞ 2⅛	1⅞ 2⅛	..		..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 5 9		..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..		⅜	..
110,000	2	..	Electric Construction	⅜ ⅝	⅜ ⅝	..		2⅜	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 13 0		..	..
91,195	2	..	Elmore's Patent Copper Depositing	⅛ ¼	⅛ ¼	..		..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¼ ⅜	¼ ⅜	..		..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	18 19	18 19	3 18 11	February & August	18½	17½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101 103	101 103	4 8 0	March & September	..	..
15,993	£10	..	International Okonite Ordinary	.. ..	.. ..	..		..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	½ ¾	½ ¾	..		..	..
37,350	12	12/0	Telegraph Construction and Maintenance	39 41	39 41	5 17 0	March and July	40½	39½
£150,000	100	5%	* Do. 5 per Cent. Bonds	104 107	104 107	4 15 6	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	..		..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..		..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	13½ 14½	13½ 14½	4 2 9		13¾	..
£30,000	10	7/0	Do. 7 per Cent. Preference	15½ 16½	15½ 16½	4 4 10		..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108 111	108 111	4 1 11		..	..
			RAILWAYS AND TRAMWAYS.						
£680,000	Stock	1¾%	City and South London Railway	40 42	40 42	2 19 6	May and November	..	..
7,650	10	5%	Do. 5% Perpetual Preference	14⅜ 15⅜	14⅜ 15¼	3 5 7	" "	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130 132	130 132	3 0 9	May and November	..	..
37,500	£10	2½%	Liverpool Overhead Railway	11⅝ 11⅞	11⅞ 12	1 17 6		..	..
10,000	10	5%	Do. 5% Preference	15⅜ 15⅝	15⅜ 15⅝	3 3 6		..	..
145,000	Stock	4%	Do. 4% Debenture	114 116	114 116	3 9 0	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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NOTES.

We would call the attention of those members of the electrical profession who take an active interest in the affairs of the Institution of Electrical Engineers to the letters on this subject which will be found in our "Correspondence" columns, and also to an article dealing with the methods of electing the Council adopted by the leading engineering societies of this country. A perusal of these documents will make it tolerably evident that the present mode of election at the Institution of Electrical Engineers is the least liberal of all, and the best calculated to lead to friction between the Council and the great body of members. As we have said before, the argument that although theoretically indefensible the system *works* well, cannot be put forward in this case. The question, which has been long simmering, having now been definitely raised, we trust not only that it will be discussed philosophically, but that it will be thoroughly threshed out and settled on a fairly permanent basis, to be heard of no more—during the present century.

Mr. J. W. Wilkins' letter on the earliest beginnings of public telegraphy, besides being highly interesting historically, illustrates another phase of the evolution of invention on which we have commented in our leading columns this week—the phase, namely, of one discovery helping another just in the nick of time to render it practically useful. The discovery of gutta-percha at the moment when the railway wires were standing still at the terminus, for want of an insulating covering, enabled the Telegraph Company to extend its system successfully underground into the heart of the City, and thus prove the practicability of adapting the telegraph to the wants of commercial and public life. Nature is often very generous; and we ought to be especially grateful to it for gutta-percha, seeing that it gave us a respite of nearly 40 years from the pest of overhead wires. Had Mr. Wilkins and company commenced operations in these days they would have carried their wires over the house-tops without waiting for the friendly gum, and we should have been—well, we shudder to think what the overhead system would have reduced us to by this time. By the way, that house in Seymour-street ought to be preserved as an historic relic—the first public telegraph office!

We publish this week an interesting set of Papers by Prof. J. C. Bose dealing with the subject of electromagnetic radiation. It was suggested some years ago in these columns, *apropos* of the "Eider," which, it will be remembered, ran ashore in a dense fog almost at the foot of the St. Catherine's light, that it would be a useful and a remunerative job for some practically-minded man to devise a practicable system of electromagnetic "light"-houses, the receivers on board ship being some electrical equivalent of the human eye. The evolution of a suitable generating apparatus would, we thought, present little difficulty; that of a suitable receiver, on the other hand, seemed likely to give considerable trouble. In this connection we would draw attention to the substantial and workmanlike form of "coherer" devised by Prof. Bose and described by him at the end of his Paper "On a New Electro-Polariscope." The sensibility and range of this type of "coherer" would appear to leave little to be desired, and it is certainly more likely to withstand with equanimity the thousand and one shocks that the flesh is heir to at sea than any of the forms hitherto brought out.

In our issue of October 18th we gave an abstract of a Paper by Klemencic on the development of heat in wires by electric oscillations. The "improvements" foreshadowed by the author have since been carried out by Prof. Cardani, whose Paper on the subject is abstracted in to-day's issue. It will be seen that Cardani has perfected the method and made it capable of accurately measuring the impedance of conductors conveying oscillating discharges. The definition of the "resistance" of a conductor is of considerable interest. "Two conductors offer equivalent resistances to a certain discharge from a condenser if, when placed successively in one of the branches of a divided circuit, the other remaining constant, they lead to the evolution of the same quantity of heat." The anomalous and unforeseen behaviour of very thin wires, especially platinum, iron and copper, deserves special attention.

A distinction of some utility is made by Dr. Borchers' in a recent Paper appearing in the *Zeitschrift für Elektrochemie*, between cases in which electro-metallurgical operations are best performed by means of the arc, and those more satisfactorily effected by the C^2R heat generated in a refractory conductor. When it is desired to prepare perfectly-fused masses of metals and their carbides or silicides, having extremely high melting points, the arc is extremely effective; when, on the other hand, it is sought to heat a considerable mass to a high, but not abnormally high, temperature, the

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resistance method of heating is much to be preferred. The same material may even be susceptible of advantageous preparation by one or other method, according to its intended use. Thus calcium carbide, if made for immediate consumption in the production of acetylene, may be obtained sintered and not actually fused, by the resistance method of heating, and is then sufficiently porous to be rapidly acted upon by water. Should the carbide be destined for sale as such, and consequently required to be of compact character and easy of transport, the attainment of complete fusion by means of the arc suggests itself as suitable. It would be interesting to learn how far this view commends itself to those practically concerned in the manufacture of this new commodity.

It may be taken as generally conceded that the most hopeful field for utilising electrical energy in metallurgical operations is that in which the product is of sufficiently high price to warrant the employment of a comparatively costly method of heating. High-class crucible cast steel is such a product, and it has lately been proposed to prepare it in an electric furnace (of a continuous type) provided with a basic lining similar to that already freely employed for ordinary furnaces used in the manufacture of lower grades of steel and of ingot iron. Of course, in the case of the preparation of a fine cutlery steel the purest procurable raw material would be used, certain samples of spathic iron ore fulfilling this requirement. The roasted ore would be reduced with wood-charcoal in an electric furnace, and its content of carbon, if too low, corrected by the addition of spiegeleisen. According to a recent article in the *Zeitschrift für Elektrochemie*, the computed cost of the finished steel in bar, even when spiegeleisen has been requisite, is about £12. 10s. per ton, a price by no means excessive. The advantage accruing from the fact that the whole operation can be conducted in a neutral or slightly reducing atmosphere, and that it is practicable to maintain the temperature, at all stages of the process, at a point well above the melting point of the product, is not inconsiderable.

Fatality at the Frankfort Electric Lighting Station.—According to the daily papers Herr Sommer, the chief engineer of the municipal central station at Frankfort, has been killed by a 3,000-volt shock.

Cable Interruptions :—

	Date of Interruption.	Date of Repair.
Maranham-Para	December 18.	December 21.
Puerto Plata-Martinique	December 19.	—
Aden-Zanzibar	December 24.	—

King's College, London.—The Lent term of the engineering division, session 1895-96, commences on Thursday, January 16th. The electrical engineering course is under Dr. J. Hopkinson, President of the Institution for 1895. Some further information is given on another page.

Lightning Fatality.—A heavy thunderstorm suddenly broke over Brixham last week, but lasted only two minutes. Two flashes of lightning only were seen, one of which tore up the ground at Furzeham and struck a ropery. Four men were engaged in spinning rope ; one was killed and two injured.

Chicago "Times-Herald" Motor Cycle Race.—It is reported, by the *Electrical Review* of New York, that the $2,000 prize for the best horseless carriage in the *Times-Herald's* contest at Chicago has been awarded to Morris and Salom's "electrobat," on the grounds of absence of sound, vibration, heat and odour. The "electrobat" was equipped with chloride accumulators.

The Supply of Petroleum.—According to the *Gas World* the fall-off in the yield of petroleum in Pennsylvania has led to a good deal of searching for oil in other parts of North America. Los Angelos, California, has assumed prominence as an oil centre, and the Indian Territory has been found to be very rich in oil. It is believed that the basin of the Mackenzie River, 400 miles north of the Canadian Pacific Railway, will prove the richest oil region in the world.

Memorial to Mr. Denny Lane.—A public meeting has been held at Cork, under the auspices of the Mayor and distinguished patronage, to arrange for a memorial to the late Mr. Denny Lane. The meeting was called in accordance with a numerously-signed requisition. The form to be taken by the memorial has not yet been settled ; but the founding of a local scholarship at the School of Art seems the most probable. A subscription list has been opened, and has already been contributed to very extensively.

An Inquiry.—An esteemed correspondent writes us as follows :—"An owner of a cattle ranche in Canada writes that there is no sale for the hides of ranche cattle when slaughtered, on account of the brand burnt into the skin. The prices obtained for the beef have been lately so much reduced, that the value of the hide becomes of importance, and he is anxious to find some way of marking the animal which will not injure the skin. He has heard vaguely of some electrical process of permanently bleaching the hair in patches, and such a process, if it is practicable, might be very useful to him and others Would you be good enough to insert a note in your paper giving this statement, and asking any of your readers who know anything of this process to communicate with me (W. A. P.) through your office."

Patent Expiring.—To-morrow will expire Patent No. 5,702 of 1881, which was granted to Mr. J. W. Swan for "Improvements in Sockets or Holders for Electric Lamps." The claims attached to this patent are : (1) The employment of sockets or holders adapted to incandescent electric lamps without external fittings, and so arranged that efficient electrical contact is made and maintained between the hooks or their equivalents of the socket or holder and the lamp terminals by the outward push of a spring interposed between the lamp and the lamp socket or holder, or by the act of screwing or sliding towards the lamp an external tube substantially as hereinbefore described ; (2) The peculiar constructions, arrangements and combinations of parts constituting sockets or holders for electrical lamps substantially as hereinbefore described and illustrated.

Presentation.—Dr. R. Mullineaux Walmsley, late Professor of Physics and Electrical Engineering at the Heriot-Watt College, Edinburgh, who has been appointed Principal of the Northampton Institute, London, was on Friday, the 20th inst., the recipient of a handsome gift of books from his past and present students of the College. The presentation was made by Mr. C. A. Henderson, one of the day students, the chair being occupied by Principal Ogilvie, who warmly congratulated Prof. Walmsley upon his new appointment, and referred in glowing terms to the good work done by the retiring Professor and the cordial feeling at all times existing not only between the students and their teacher, but between Prof. Walmsley and other teachers in the college. Dr. Walmsley's departure was a great loss to them, but they could quite understand that the call to work in London was the only inducement that would have drawn Prof. Walmsley from Edinburgh, where his teaching work had been so very successful. Prof. Walmsley acknowledged the kindly sentiments expressed by the students and by Professor Ogilvie, and assured them that he would continue to take a great interest in all that concerned their future welfare.

Niagara Power and Buffalo.—On November 26th, says the *Electrical Engineer* of New York, the Buffalo aldermen unanimously reconsidered all action theretofore taken by that Board amending the Niagara Falls power franchise, and adopted the franchise by unanimous vote in practically the form in which it came from the joint committee, with the exception of the clause which fixed the percentage on the gross receipts at 5 per cent. As the franchise has now been adopted, the tax upon the gross receipts is fixed at 2½ per cent., and takes effect six years after the acceptance of the grant. The plans are to

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be presented for approval by the Board of Public Works within 90 days after the acceptance of the grant, and the first 10,000 horse-power is to be ready for delivery to consumers within the city on or before June 1, 1897. The Power Company has indicated that it will accept the grant within the 30 days fixed for the acceptance by the franchise. The grant contains clauses for the ample protection of life and property, and while no maximum price is fixed for the power, as was at first insisted upon by the city authorities, there is a provision that the Company shall not charge any consumer a greater proportionate price or higher rate per horse-power than shall have been previously charged him.

The Plague of Modern Improvements.—Mr. Harry Furniss delivered himself of the following indictment in *The Times* of Friday last:—

"My experience in the last few weeks of the modern inventions which are designed to facilitate business and to benefit the public generally is, I think, worth recording, as I seriously question if these wonderful inventions and the extra expense incurred by adopting them are not a mistake. The working of the telephone has become, of course, a farce, and the sooner the Government take it up the better. Several large business houses have given it up, and London, which ought to be the most favoured, is probably the most unfortunate city in the working of the telephone of any in the world. I have tried half-a-dozen times in one day to ring up different people on the telephone without succeeding in getting through, and have had to send notes by hand. The electric light is another disappointing 'improvement.' Recently it has, in my own experience, gone out four times in one week, and we have had to use candles and lamps. Then there is the District Messengers' wire, which I have in communication with my house. I ring up for a cab; no response. I ring up again; nothing comes. I send out for a cab, and am late to dinner. The next day a representative calls casually to inform us that we cannot use the wire for two or three days, as something has gone wrong. I am now trying the phonograph; but, although at present I have had more correspondence about it than I have had through it I live in hope that I may find it worth the three years' trial the Company asks one to sign for. Altogether, it is a question whether paying rental for all these things, and then having, through their failure, to go to greater expense, is absolutely advantageous, and whether the story of the driver of the old stage coach who, when railways were introduced, remarked to a passenger, 'Well, all I can say is that if a coach comes to grief—well, there you are; but if there is an accident on the railway, where are you?' might not be very well applied to those experiments in the advancement of science intended to facilitate our work and add to our comfort. The electric light kills our sight; the telephone destroys our temper; the district messenger call ruins our dinner; and, conjointly, they waste our time and deplete our purses."

The Electrical Patents of 1894.—If we confine ourselves to the three countries, the United Kingdom, the United States, and Germany, says *Engineering*, we find that, in 1894, 3,315 patents more or less related to electricity were granted. What constitutes an electrical apparatus is not easily defined. The construction of underground conduits, the fixing of electric motors on cars, the casting of accumulator plates, the type-wheel trains of telegraphic instruments, switch plates for trolley wheels, have all a direct bearing upon electrical matters, though they may little concern the electrician. The 3,315 patents which we have classed as electrical are made up by 1,130 British, 1,704 United States, and 481 German patents. The 1,130 represent about $\frac{1}{20}$th of the total of the British patents for one year. The applications for British patents during the years 1893 and 1892 amounted to 25,102 and 24,166. The United States did not grant so many patents in 1894, only 19,874; Germany's contingent is, of course, considerably smaller, 6,279. There were altogether 365 improvements in dynamos and motors, armatures, field cores, and other accessories; and 450 patents concerning the distribution of electricity—apart from transmission of power—the connections of generators and motors, switchboards, leads, cables, their conduits, posts, insulation and insulating materials, safety fuses, rheostats, &c. Electric lighting, so far as not comprised in the two sections already mentioned, makes a special group of 395 patents. The electrical transmission of power introduces 460 more patents, a good many of which might, of course, just as well have been classed in the second section. Electric welding seems to have reached, or rather passed, its climax; the familiar names still predominate; in soldering, heating, &c., things have become more quiet. Electric devices for machinery in general, valves, stop motion contrivances, brakes, and electromagnetic clutches remain steady. The most ingenious, or, at any rate, most complicated automatic apparatus continue to be designed for selling cigars and giving electric shocks. This rather miscellaneous section, from metal working down to automatic apparatus, thermostats, ore separators (very few), and various mechanical applications of the current, contains 288 patents. Primary batteries come to 96, accumulators to 118. Commercial electrolysis, 158 patents, seems almost entirely to rely upon alkalis, bleaching, and chlorates, and what else is connected with the alkali industry. Two firms have new ideas about aluminium processes; electro-metallurgy, on the whole, is very poor, galvanoplastic processes not numerous either. In telephony and telegraphy matters are more lively again. We find 103 telegraph patents proper, 220 telephone patents, and 457 concerning railway and other signalling, police and fire telegraphy, telemeters and cognate instruments, bells, annunciators, &c. One well-known and able gentleman manages to condense his novelties in 127 claims, and has three other patents of the same title to follow. Electric meters of various descriptions, volt and ampere meters, counters, electricity meters furnish matter for 158 patents. Dynamometers are apparently perfect, as nobody bothers about improving them. Everybody has suddenly discovered, however, that one ought to be able to read current meters, &c,, from the side and from below. Two new photometers are offered. A good deal of what may euphemistically be styled electro-therapeutics might be passed over in silence. But there are a few useful suggestions among the 33 electric belts, special batteries, medical electrodes, and induction apparatus.

Contemporary Electrical Science.—The old problem of contact electricity has found another investigator in C. Christiansen, who gives a first instalment of his results in the current number of *Wiedemann's Annalen*. The method used was that of drop electrodes of mercury, the differences of potential being measured between the reservoir and metallic plates dipping into the mercury caught. It appears to have been very difficult to obtain consistent results, but the general tendency of the experiments went to show that the oxygen of the air plays a very considerable part in the electric phenomena. Thus, drop electrodes of zinc amalgam and of pure mercury gave rise to different potentials in air, but the difference vanished when the drops passed through hydrogen.—Ludwig Silberstein evolved a law governing the dielectric constants of mixtures out of his inner consciousness, and then set himself to prove it experimentally. Given two perfect dielectrics which mix perfectly without contraction of volume, and given their specific inductive capacities, what will be the result of mixing them? The law in question is that the new specific inductive capacities will be the sum of the products of the volumes into the specific inductive capacities, divided by the total volume. Silvertein succeeded in finding only two such substances for his test experiment: benzol and phenylethylacetate. The maximum deviation from the formula was 4 per cent., and the average 1·7 per cent. So this process of mathematical law-making may be considered a success. —G. Meyer contributes a laborious investigation into the differences of potential between metals and liquids in connection with the theory of the capillary electrometer, which, by the way, appears to be increasing its sphere of usefulness. Helmholtz's charge-current theory of this instrument is undermined, and the author's conduction-current theory is strengthened by the results obtained.—Another highly interesting portion of Paalzow and Neesen's Paper on "The Passage of Electricity through Gases" appears in the same number. Many curious facts were observed. On surrounding the discharge tube by different media, such as water, alcohol, or turpentine, the discharge is extinguished. This effect is not due to conduction, since the current is, if anything, enfeebled. On placing a point electrified by a Holtz machine near the tube, discharge was facilitated, and on moving the point all round the tube discharge took place even at atmospheric pressures.—K. Mack has continued his researches on the double refraction of electric rays. In the present Paper he repeats the experiments with rays of various wave-lengths, proves that the two rays are propagated with different velocities in wood, and describes the preparation of artificial anisotropic media, in the shape of modified Hertz gratings, or—more simply—piles of news. papers!—A Paper by Elster and Geitel, what may be termed a modified "Lenard" or cathode ray effect will be noticed later in more detail.

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ELECTROMAGNETIC THEORY.—LXXX.*

BY OLIVER HEAVISIDE.

(*Continued from page 181.*)

§ 318. The case of a cable forming a closed circuit in itself without external constraint deserves some notice. Fourier's periodic theorem is involved, of course, but it has a somewhat different application to the one before made. If we have an infinitely long cable containing an infinite series of uniformly spaced point sources of equal size, we produce periodicity by symmetry. Every source produces a double wave, diffusing to the right and left respectively; and the effect produced at any point is the sum of the effects due to the individual sources.

But in the closed cable, in the corresponding case, there is one source only, and only two waves. The apparent multiplicity arises from overlapping. The matter is best understood by introducing self-induction to such a small extent as not to alter sensibly the shape of the waves, whilst making the speed of propagation be finite, say v. Then, if there is initially a charge Q at the point y, it splits into halves, and two diffusive waves result, one to the right and the other to the left, each containing $\frac{1}{2}$Q of electrification. The manner of this diffusion has been described before. The point here is that the two waves have fronts, which are at distance vt from the source, and which therefore rush round and round the cable in opposite directions. There is no reflection anywhere, so that the effect at any point x is the resultant of the overlapping of the right wave on itself, and of the left wave on itself. The potential at any point x makes a very little jump when either of the wave-fronts passes the place. There are two jumps in every interval of time equal to $2l/v$, the time of transit of a wave-front round the circuit. Between the jumps, the potential changes slowly (relatively) by the natural diffusive process. As time goes on, the jumps decrease infinitesimally, and the steady state is approximated to. This is $SV = Q/2l$, the mean value.

If we remove the self-induction, v becomes infinite. The initial waves therefore overlap instantly, and the little jumps disappear. We now have continuous variation of the potential, which is that due to the initial waves in reality, but with the proper allowance made for the overlapping.

The contrast with the behaviour in a distortionless circuit is striking. After the initial splitting, the two half-charges would go on travelling round and round at constant speed without any diffusion, though attenuating by leakage.

But keeping to the diffusion problem, the charge Q represents the result of an impulsive current pQ at y, which divides equally to the right and left. Therefore

$$c_1 = \epsilon^{-q(x-y)}\tfrac{1}{2}p\mathrm{Q}, \qquad v_1 = \epsilon^{-q(x-y)}\frac{\mathrm{R}p\mathrm{Q}}{2q}, \tag{33}$$

represent the current and potential at x, on the right of y, in the initial wave. To allow for overlapping, the factor for a circuital journey is ϵ^{-2ql}. That is, the second term in V_1 is $\epsilon^{-2ql}v_1$, the third is $\epsilon^{-4ql}v_1$, and so on. The total is

$$\mathrm{V}_1 = \frac{\epsilon^{-q(x-y)}}{1-\epsilon^{-2ql}}\frac{\mathrm{R}p\mathrm{Q}}{2q}, \tag{34}$$

representing V at x so far as the wave to the right is concerned.

Now, the same point x is distant $2l-x+y$ from y, when reckoned the other way round. Otherwise it is the same. So

$$\mathrm{V}_2 = \frac{\epsilon^{-q(2l-x+y)}}{1-\epsilon^{-2ql}}\frac{\mathrm{R}p\mathrm{Q}}{2q} \tag{35}$$

epresents V at x so far as the wave to the left is concerned. The complete potential V is V_1+V_2. That is,

$$\mathrm{V} = \frac{\cosh q(l-x+y)}{\sinh ql}\frac{\mathrm{R}p\mathrm{Q}}{2q} = \frac{\cos s(l-x+y)}{\sin sl}\frac{s\mathrm{Q}}{2\mathrm{S}}. \tag{36}$$

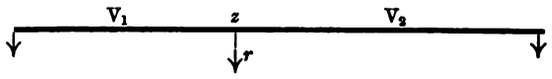
lgebrising this by the expansion theorem, we obtain

$$\mathrm{V} = \frac{\mathrm{Q}}{\mathrm{S}}\left\{\frac{1}{2l}+\frac{1}{l}\Sigma_1^\infty \cos\frac{n\pi}{l}(x\,.\,y)\,.\,\epsilon^{pt}\right\}, \tag{37}$$

where we recognise the unit impulsive function of Fourier's theorem, when we put $t=0$. There is only one such function now, instead of an infinite row; because x and $x\pm 2nl$ mean the *same* point.

§ 319. Passing now to a third minor matter, something should be said about the treatment of cases in which there are two or more connected Fourier series concerned. These cases can be constructed to any extent by means of intermediate conditions, and by combinations of cables. But a whole book would be required for a full treatment, and there are more interesting matters to be considered. So all that will be done here will be to take two or three cases of the kind, to be suggestive of what is necessary in other cases, and to exhibit matters of principle as well as practical working.

Say there is a leak at z. It may be any sort of leak, to be denoted by its resistance operator r. Let the



cable be earthed at $x=0$ and l.

There is one thing that can be done at once—viz., to write down the determinantal equation. For the sum of the currents leaving the point z is zero, and each current is the potential at z multiplied by the conductance operator of the path concerned. Therefore

$$0 = (\mathrm{Y}_1+\mathrm{Y}_2+\mathrm{Y}_3)\mathrm{V}_z \tag{38}$$

is the differential equation of the potential at z, where the three conductance operators are

$$\mathrm{Y}_1 = \frac{s}{\mathrm{R}}\cot sz, \quad \mathrm{Y}_2 = \frac{s}{\mathrm{R}}\cot s(l-z), \quad \mathrm{Y}_3 = \frac{1}{r}. \tag{39}$$

If there are terminal arrangements at $x=0$ and l, Y_1 and Y_2 must be suitably modified. It follows that

$$0 = \mathrm{Y}_1+\mathrm{Y}_2+\mathrm{Y}_3 \tag{40}$$

is the general differential equation of the complete combination satisfied by all subsidence solutions, and the values of p satisfying it, when regarded algebraically, are the values of p in the time function ϵ^{pt} of the normal systems. That is, the solutions are of the form $\Sigma a\epsilon^{pt}$, where the p's are known. But the a's are functions of x, and require further investigation.

The above process of finding the determinantal equation applies when any number of circuits of any kind meet at a point. But it is important to note that any point in the combination may be taken for origin. The difference may be very great in the form of the resulting equation, which may be simple at one place and complicated at another; but all the forms are intrinsically the same in containing a common factor whose vanishing determines the p's in the time functions.

Going further, consider the normal systems of potential. Let

$$\mathrm{V}_1 = \Sigma\mathrm{A}v, \qquad \mathrm{V}_2 = \Sigma\mathrm{A}w, \tag{41}$$

on the left and right of z. Here v and w are the normal functions. Since V vanishes at $x=0$ and l, we require

$$v = \sin sx, \qquad w = \mathrm{B}\sin s(l-x). \tag{42}$$

To find B, make continuity, or $v=w$ at z. Then

$$w = \sin sz\frac{\sin s(l-x)}{\sin s(l-z)}. \tag{43}$$

Two things remain—namely, s and A. To find s, we have the final condition

$$\mathrm{C}_1-\mathrm{C}_2 = \mathrm{V}/r \tag{44}$$

at z. Applying this to a normal system makes

$$\frac{\sin sz}{r} = -\frac{s}{\mathrm{R}}\left(\cos sz+\sin sz\frac{\cos s(l-z)}{\sin s(l-z)}\right), \tag{45}$$

or

$$\frac{\mathrm{R}}{rs}\sin sz+\frac{\sin sl}{\sin s(l-z)} = 0. \tag{46}$$

This is the determinantal equation, and is equivalent to (40) above, subject to (39), in a changed form.

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Lastly, to find the A's to suit any initial state, this requires the construction of A in the case of a point charge. Say there is Q at y, less than z. Then, by the conjugate property,

$$A=\frac{Qv_y}{S\int_0^z v^2dx+S\int_z^l w^2dx+X}. \quad (47)$$

The numerator is the mutual energy of Q and the normal system, that is, Q multiplied by the potential of the normal system at Q. The denominator is twice the excess of the electric over the magnetic energy of the complete normal system itself. The part for the cable is explicitly shown. The part for the leak is denoted by X, to be found as before explained in special examples.

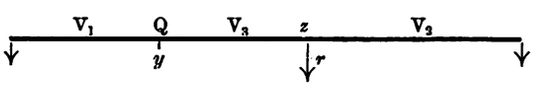
But X vanishes when r is a mere resistance. Then A becomes

$$A=\frac{(2Q/S)\sin sy}{z-\frac{\sin 2sz}{2s}+\left(\frac{\sin^2 sz}{\sin^2 s(l-z)}\right)\left(l-z-\frac{\sin 2s(l-z)}{2s}\right)}. \quad (48)$$

This completes the problem so far as any initial state of V from 0 to z is concerned, by an integration. But when Q is on the other side of z, we must use w_y instead of v_y in the numerator. Else it is the same.

§ 320. It will be seen that there is considerable facility in obtaining the normal systems, and also in evaluating A, provided that there is no allowance to be made for the leak itself, which may be a troublesome matter by the above process. But there is another way, whereby the evaluation of the energy difference is done by a differentiation without detailed examination of r. This will be explained presently. The same remarks about facility and the reservation apply in more complicated cases. But there is, nevertheless, a rather bad failing. We cannot, from the above normal systems, safely deduce the general operational solutions. If, on the other hand, we get the operational solutions first, we can at once deduce the Fourier series, and other sorts of solutions as well.

We may, therefore, now exhibit the more general way. Put a charge Q at y, and see the effect.



Start at $x=0$. First, we have

$$V_1=\sin sx\,.\,A, \quad (49)$$

satisfying the terminal condition. Next, as there is to be continuity in V at y, we require

$$V_3=V_1+\sin s(x-y)\,.\,B. \quad (50)$$

Here B is found by

$$C_3-C_1=pQ \quad (51)$$

at y, and makes

$$V_3=V_1+\sin s(x-y)\,.\,sQ/S. \quad (52)$$

Then there is to be continuity in V at z, so

$$V_2=V_3+\sin s(x-z)\,.\,D, \quad (53)$$

and $V_2=0$ at $x=l$ finds D, and makes

$$V_2=V_3-V_{3l}\frac{\sin s(x-z)}{\sin s(l-z)}, \quad (54)$$

where V_{3l} means V_3 at $x=l$. Finally, we have the discontinuity in the current at z, or

$$\frac{V_{3z}}{r}=-\frac{s}{R}\frac{V_{3l}}{\sin s(l-z)}. \quad (55)$$

This finds A definitely, and makes

$$V_1=-\sin sx\,\frac{\sin s(z-y)+\frac{sr}{R}\frac{\sin s(l-y)}{\sin s(l-z)}}{\sin sz+\frac{sr}{R}\frac{\sin sl}{\sin s(l-z)}}\frac{sQ}{S}. \quad (56)$$

This is the complete operational solution. Q is h/p, where h is an externally introduced source of current, which may in general be any function of the time. It is made impulsive specially to suit the treatment of an initial state.

As regards V_3, it is found by (52). It will usually differ from V_1, though not in the Fourier series solution for an initial state. It will be found that V_3 differs from V_1, comparing (52) with (56), merely in the interchange of x and y. Finally, we may use the modified V_3 in (54), and obtain

$$V_2=-\sin sy\,\frac{\frac{sr}{R}\frac{\sin s(l-x)}{\sin s(l-z)}}{\sin sz+\frac{sr}{R}\frac{\sin sl}{\sin s(l-z)}}\frac{sQ}{S}. \quad (57)$$

There are two distinct expansions, one for V_1 and V_3, the other for V_2. They follow from (56), (57), in the usual way, by the expansion theorem. But, denoting the common denominator $\sin sz+\ldots$ by D, so that $D=0$ is the determinantal equation, we can simplify the numerators by use of this relation. Then the expansion theorem makes

$$V_1 \text{ and } V_3=\Sigma\frac{-\frac{2Qs}{SR}\sin sx\sin sy}{\sin^2 sz\,\frac{d}{ds}\left(\frac{1}{r}+\frac{s}{R}\cot sz+\frac{s}{R}\cot s(l-z)\right)}. \quad (58)$$

Similarly for V_2. The form of the denominator was first changed in order to bring the relation (40) above into view. It may be verified that (58) agrees with (48) when the leak is a mere resistance. But (58) is far more general. The leak may be of any kind, r being a rational function of p, and therefore of s^2. When r is not a rational function of p, the expansion (58) fails. A definite integral is required. But the operational solution (56) remains true.

§ 321. The object of altering the form of the denominator of (57), so as to make the function in the big brackets in (58) be the active determinantal factor, as in (38), (40), was to introduce a point not noticed in the previous. According to (58), the value of the coefficient A is given by

$$A=\frac{Q\sin sy}{\sin^2 sz\times-\frac{RS}{2s}\frac{d}{ds}\left(\frac{1}{r}+\ldots\right)}. \quad (59)$$

This is the same as

$$A=\frac{Qv_y}{v_z^2\frac{dY_z}{dp}}, \quad (60)$$

if Y_z is the conductance operator at the point z, *i.e.*, the sum of the conductance operators of the three paths meeting there.

Now the general formula to find A from the conjugate property goes thus. Let there be selected any two normal systems, belonging to p_1 and p_2, say; let U_{12} be their mutual electric, and T_{12} their mutual magnetic energy. Then

$$U_{12}-T_{12}=0 \quad (61)$$

expresses the conjugate property. From which it follows that

$$A_1=\frac{U_{01}-T_{01}}{U_{11}-T_{11}} \quad (62)$$

is the coefficient for the term involving p_1; if U_{01} is the mutual electric, and T_{01} the mutual magnetic energy of the given initial state and the normal state in question, whilst U_{11} and T_{11} are double the electric and magnetic energy of the normal state itself.

The numerator in (60) agrees with (62), of course, because of the confinement of Q to a point, and because there is no mutual magnetic energy. There would be, if the initial state involved magnetic energy in the leak r. The denominator of (60), therefore, represents the denominator in (62). That is,

$$U_{11}-T_{11}=v_z^2\frac{dY_z}{dp_1} \quad (63)$$

for any normal system, which is here the first one. We need not use the suffixes, which may confuse, but, keeping to one normal system, write

$$U-T=v^2\frac{dY}{dp}, \quad (64)$$

understanding that Y is reckoned at the place of v. Now this property is general; z may be any point in the system v its potential there, and Y the corresponding conductance operator. The variations in v will be exactly compensated by those in Y.

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To illustrate, divide Y into its three members; then

$$U-T=v^2\frac{d}{dp}(Y_1+Y_2+Y_3). \quad (65)$$

Here Y_1 is the ratio (conductance operator) c/v for the first path, Y_2 for the second, Y_3 for the third, all with the same v, but with different c's. And

$$v^2\frac{d}{dp}\frac{c}{v}=v\frac{dc}{dp}-c\frac{dv}{dp}=-c^2\frac{d}{dp}\frac{v}{c}. \quad (66)$$

We may therefore write

$$-(U-T)=c_1^2\frac{dZ_1}{dp}+c_2^2\frac{dZ_2}{dp}+c_3^2\frac{dZ_3}{dp}, \quad (67)$$

if Z_1, &c., are the resistance operators.

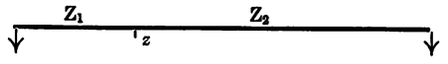
At the point z—that is, at the leak, there are three c's and Z's to be allowed for. But the last two c's may be expressed in terms of the first, bringing us to a result of the forms c_1^2dZ/dp.

If, however, any other point in the cable be taken, there are only two c's, two Y's, or two Z's, and the c's are equal. Then

$$-(U-T)=c^2\frac{dZ}{dp}, \quad (68)$$

where Z is the sum of the resistance operators to right and left of the point in question, which may be any point. dZ/dp is an inductance operator, and dY/dp a permittance operator.

It will be as well to illustrate these remarkable, though somewhat abstruse, properties explicitly. Take then the simple case of terminal earth connection and no intermediate



condition, so that the normal system is simply

$$v=\sin sx, \qquad c=-\frac{s}{R}\cos sx, \quad (69)$$

s having any value making $\sin sl=0$. Here

$$Z_1=\frac{R}{s}\tan sz, \qquad Z_2=\frac{R}{s}\tan s(l-z), \quad (70)$$

are the resistance operators to left and right of the point z, and their sum is

$$Z=\frac{R}{s}\frac{\sin sl}{\cos sz\cos s(l-z)}, \quad (71)$$

so that e/Z would be the current there due to e on the spot. Also $d/dp=-(RS/2s)d/ds$, since $RSp=-s^2$; so

$$\frac{dZ}{dp}=-\frac{R^2Sl}{2s^2}\frac{\cos sl}{\cos sz\cos s(l-z)}=-\frac{RSl}{2s}\frac{1}{\cos^2 sz}, \quad (72)$$

because $\sin sl=0$. Therefore

$$-c^2\frac{dZ}{dp}=\frac{s^2}{R^2}\frac{R^2Sl}{2s^2}=\frac{Sl}{2}. \quad (73)$$

Consequently, if there is initially Q at y, it expands to

$$V=\Sigma\frac{Q\sin sy\sin sx}{\frac{1}{2}Sl}, \quad (74)$$

which we know to be right. Of course the best place for z is at a terminal. Then only one resistance operator is concerned, and it goes simply.

Again, do it in terms of the conductance operators. Here

$$v^2\frac{dY}{dp}=\sin^2 sz\left\{-\frac{RS}{2s}\frac{d}{ds}\left(\frac{s}{R}\cot sz+\frac{s}{R}\cot s(l-z)\right)\right\}, \quad (75)$$

which also works out to the result $\frac{1}{2}Sl$, independent of the position of z. Here Y is the sum of the two conductance operators to left and right of z.

The practically useful point is this. If the evaluation of U – T by integration is troublesome, which is particularly the case when there is externally connected energy to be allowed for, we can avoid it altogether by means of the identity (64), choosing the point of reference so as to make the work as simple as possible. We do not, therefore, need to form the operational solutions and apply the expansion theorem, if the only object is to develop the proper Fourier series.

It may be objected in the above that in taking $v=\sin sx$, and assuming v to be potential, or the transverse voltage, we are violating dimensional properties. The objection is valid, though rather superficial. To be very particular, we may let $A\sin sx$ be the normal system of potential, A being the same as above, and so have a symbol to put the dimensions in (though they are not known, by the way). But this will make no difference in the end, and will complicate the formulæ somewhat. Or we may let $a\sin sx$ be the normal system, and let a be represented by a unit factor. For unity, though constant in a certain sense, may have any size and any dimensions.

A more important objection is that I have given no proof of the general properties used, except what may be contained in the actual verification in the examples used, which is sufficient as far as they are concerned. But the fact is, that the expansion theorem, and the conjugate property, and the equivalence of the integration and the differentiation ways of working it, being general matters, are best proved in a general manner, out of the general equations of dynamics, which, in their application to electromagnetics, will be considered separately.

(To be continued.)

THE GOVERNMENT OF NORWAY AND THE TELEPHONES.

BY ALFRED R. BENNETT.

Before the late Select Committee on the Telephone Service, it was stated that a committee appointed by the Government of Norway had reported in favour of State acquisition of telephones in that country. But the Government of Norway has, in fact, decided to do exactly the reverse; and the considerations which led to this decision are instructive. Telephone exchanges were first established in Norway, without any Government interference whatever, under concessions from the various town councils and local authorities in whose jurisdictions it was proposed to operate. But the Christiania Telephone Company very early in the day proposed to connect its system with that of the Drammen Company, by constructing a trunk line about 40 kilometres in length. The Post and Telegraph Department, fearing that the erection of such a trunk line would interfere with its income from telegrams, promoted a Bill conferring on the Government a monopoly in all inter-town telephonic lines. This became law on May 19, 1881; but the Telegraph Department, having got its way, did not proceed with the erection of any trunk lines, simply because it had no funds available for the purpose. It, therefore, arranged to license the various companies to connect their systems on payment to the State of an amount representing the estimated loss of traffic in telegrams. Matters so remained until 1892, when the companies and the subscribers, discovering that the sums paid to the Government as compensation exceeded the actual loss of income incurred by the Telegraph Department, protested against the continuance of the compensation payments, and petitioned for the abolition of all taxes on inter-town telephonic communication. This movement made itself felt in Parliament, and in December, 1892, the Government appointed a Committee to examine and report upon the whole telephone question. It must be noted that this Committee was not a Parliamentary or even an independent one, as, with the exception of two managers of telephone companies, it consisted of the Director-General of the Telegraph Department and several of his subordinates. The Committee was thus chiefly composed of State officials. In February, 1894, it presented a majority report in favour of the acquisition by the Government of all the telephone lines, local as well as trunk, but the minority reported in favour of the acquisition by the Government of the longer trunk and international lines only, leaving the local exchanges and shorter trunks in the hands of private companies and municipalities.

As soon as the majority report was published, protests were made by the various telephone companies, on the ground that the rapid development which had till then distinguished the Norwegian telephone system would be checked were the management placed in the hands of a central State autho-

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rity in Christiania, inasmuch as such an authority would seek to make everything uniform throughout the country, ignoring local conditions and requirements, attention to which had been a most important factor in the success of the companies and municipalities. It was also feared that the Government would not be able to work so economically as the companies had done, and that it would be necessary to increase the rates of subscription. Colour was lent to this assumption by the proposal of the majority of the Committee to increase the local exchange subscription in Christiania, which for many years past had stood at £4. 8s. 11d., with most satisfactory results as regards dividend, 5½ per cent. having been paid uninterruptedly for many years, to £5. 11s. 1d. A meeting of representatives of the telephone companies and local authorities concerned was convened, and was held in Christiania on April 21, 1894. It was attended by 91 deputies, representing 48 companies and the Trondhjem municipality. Other companies sent protests against the majority report. The meeting, after discussion, adopted the following resolution: "The undersigned deputies from the greater number of the telephone companies in Norway submit that the exceptional development which the telephone has attained in Norway has been due to the manner in which the system has been hitherto managed and administered by local companies and authorities, and this meeting protests against the recommendations of the majority of the Committee appointed by the Government to consider the telephone question being carried into effect, and maintains that the best and cheapest method of working the telephone is that which has hitherto prevailed. With regard to trunk lines, the meeting considers that the question has not been sufficiently discussed, and it declines to pronounce an opinion as to whether the Government ought to undertake the working of the trunk lines; but should the Government resolve to acquire and work the trunk lines, then it is recommended that the present tax imposed on these connections be abolished."

In consequence of the strong public feeling displayed against the proposed State monopoly in telephones, the Government did not take any steps to bring the question before Parliament in 1894, but sent a circular to the municipalities and rural authorities, desiring an expression of their opinion on the subject. The reply to the circular was an almost unanimous expression of approval of the resolution adopted by the meeting of telephone representatives. The Government, thereupon, decided upon its policy, and during the session of Parliament of 1895 proposed, firstly, that the local telephone exchanges should remain as at present in the hands of municipalities, or of companies working under concessions from them; and secondly, that the inter-town trunk lines shall be acquired and worked by the Government. This proposal was adopted by Parliament practically unanimously.

The present position in Norway, therefore, is exactly the opposite to that which was suggested to the late Select Committee on the Telephone Service. Municipalities and local authorities have the right to establish their own telephone exchanges, or to license companies to establish exchanges, and this without any reference to Government, and without paying any royalty to the Post Office. On the other hand, the Government has acquired a monopoly in telephonic inter-town trunk lines.

The decision of the Government may possibly have been influenced by the fact that the telephone companies followed up their meeting in April, 1894, by forming a Telephone Union having for its objects the promotion of the telephonic industry throughout Norway by an interchange of views regarding extensions, tariffs, and technical and working arrangements. This Union held meetings in Christiania on January 28, 29 and 30, 1895, and, amongst other resolutions, determined to publish a fortnightly newspaper dealing with the telephone and electrical questions of general interest. Twenty-three numbers of this publication, the *Telefon-og-Telegraf Tidende*, have already appeared.

There is an institution in connection with the Post Office in Norway which might be copied in this country with advantage. The British system is to have a Postmaster-General who, previous to his appointment, has had no experience of postal, telegraphic or telephonic business, and who, nevertheless, is supposed to be responsible to the country for the conduct of the great Department of which he is the nominal head. Such an official, however experienced he may be in general matters, necessarily falls under the influence of the permanent officials of the Post Office, whom he naturally regards as best qualified by special training and long experience to guide him in matters appertaining to the Department. This course would be a logical one were it not for the fact that the Postmaster-General is appointed for the very purpose of controlling the permanent officials, and not for being controlled by them. The very *raison d'être* of such a functionary is the necessity recognised by Parliament of imposing some restrictions on the permanent officials, and the intention of Parliament is violated by the practical outcome of the present system, which has not infrequently degraded the House of Commons into an arena in which the Postmaster-General of the day has aired his ignorance of matters about which he was technically responsible to the nation.

They manage these things better in Norway. There the posts and telegraphs and such railways as belong to the State are under the immediate control of a standing Parliamentary Committee consisting of nine members, which Committee has power over expenditure and over contracts, and without its consent no modifications of existing regulations may come into force. The Postmaster-General and the Directors of the Telegraph and Railway Departments report to the Minister of Public Works when Parliament is not sitting, but during the Session they report direct to the House. But in any case their reports are referred to the Parliamentary Committee, and are digested by it before coming under the consideration of Parliament as a whole. This arrangement is found to work remarkably well, because the Committee is made up of members of Parliament who come from all parts of Norway and are acquainted with the needs of their several districts. Local requirements are not, therefore, neglected, as with us they are so apt to be, but receive careful consideration. As the members of the standing Committee usually remain on it for several years (as in the event of the dissolution of Parliament a proportion of them always returns to the new House) the Committee becomes well acquainted with postal, telegraphic and railway affairs, and constitutes a direct representation at these important State departments of the commercial interests of the country. Members of the Committee do not receive any salaries in return for their services.

Such a standing Committee of the British House of Commons would be well calculated to put so much life into our Posts and Telegraphs Department as would at least prevent reforms from being shelved indefinitely, or from only being adopted after the permanent officials have, so to speak, died in the last ditch in fighting against them. The responsibility to Parliament, which is now merely nominal, would then become actual and real, and the author is much mistaken if such a Committee would not find a very large field for useful explorations into the operations and methods of administration of the Post Office, which would not then, as now, be the master of the public instead of its servant.

THE DE LAVAL STEAM TURBINE.

At the present time there are in existence but three types of steam turbine of importance. Two of these are the parallel and radial-flow turbines, the invention of the Hon. C. A. Parsons (see *The Electrician*, Vol. XXXI., p. 315, and Vol. XXXV., p. 5), and the remaining one is the de Laval impulse or jet turbine. From a combination of several causes, the popularity of the steam turbine has been on the ascendant and seems likely to continue so. Its high and improving economy, its compactness, small weight, cheapness, and the absence of vibration, combine to make it a suitable motor for driving dynamos. The de Laval type is of more recent invention than those of Parsons; but the results of recent trials would seem to indicate that, though the de Laval engine can hold its own beside many modern steam engines, it is not yet quite equal to the Parsons engines in the matter of

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economy. Before comparing the two makes of steam turbine, it may be useful to give some description of the newer one.

Fig. 1 shows at a glance the working parts of the de Laval turbine; these comprising the vanes, which are mounted on the periphery of a wheel, and the guide jets, in this instance four in number, which direct the steam at a very acute

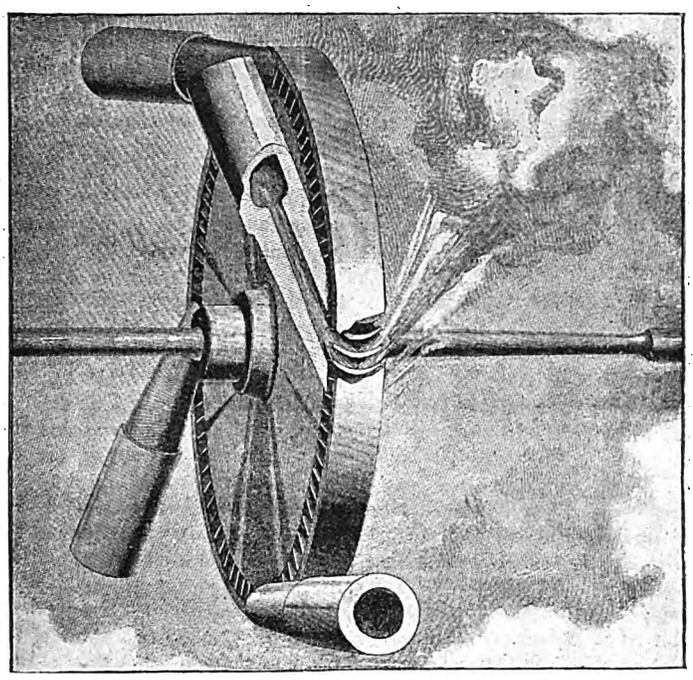

Fig 1.—Showing Action of Steam Jets on Vanes in the de Laval Steam Turbine.

entrance angle against the vane surfaces. The absolute path of the steam over these surfaces is, in any turbine, compounded of the motions of the steam and the vane; and the best conditions obtain only when the absolute velocity of the vane is half that of the entering steam, neglecting the small entrance angle. Accordingly the vanes are said to be run at a peripheral

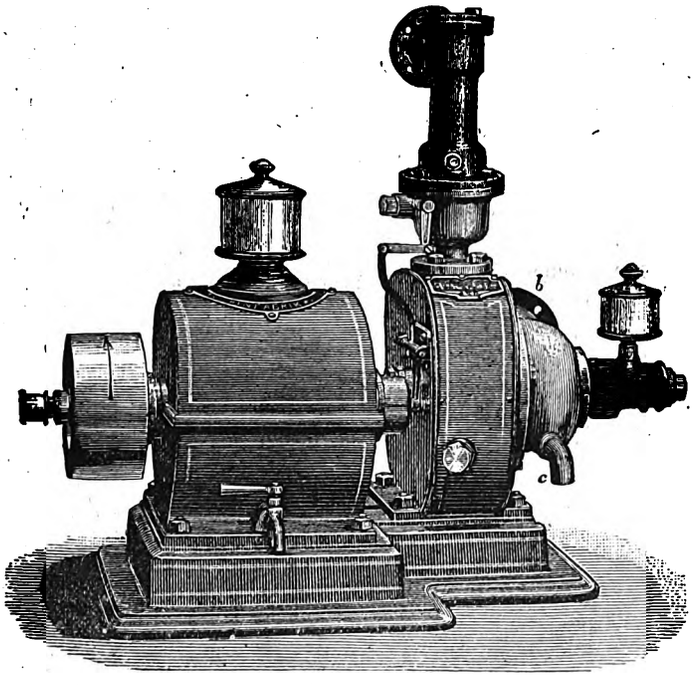

Fig 2.—De Laval Steam Turbine

speed of from 580ft. to 1,320ft. per second, these high speeds necessitating from 15,000 to 30,000 revolutions per minute.

Upon the spindle of the vane wheel are two pinions, with right and left-handed helical teeth respectively cut upon them. The pitch angle is 45deg., and the pinions engage in two large helical wheels, keyed to the pulley shaft of the motor. In this way any desired reduction of speed is obtained. The gear is contained in a separate casing, as shown in Fig. 2, and the use of oppositely-cut gears obviates the need for heavy thrust-blocks. In Fig. 2, which shows an external view of the de Laval turbine, the vanes and guide jets are contained in the narrower case to the right, and the gear in the wider case on the left, which stands somewhat further forward than the other. The following table gives the approximate sizes of the engine for various powers:—

Table I.—*Approximate Dimensions of de Laval Steam Turbines.*

H.P.	Length.	Width.	Height.
	Inches.	Inches.	Inches.
5	32·5	14·4	29·0
10	35·0	19·2	36·0
15	40·0	19·2	36·0
20	42·0	24·0	40·0
30	45·0	24·0	40·0
50	74·0	39·0	55·0
100	96·5	40·0	68·0

In July last, at the Bordeaux Exposition, some trials of this turbine were undertaken by the Philomathic Society. The engine used was rated at 100 H.P. normal load. Table II. shows the results obtained at full and half loads, and compares them with the economy of the Parsons steam turbine, as determined by Prof. A. B. W. Kennedy in 1893.

Table II.—*Steam Consumption of de Laval and Parsons Steam Turbines.*

——	De Laval.		Parsons.	
	Full load.	Half load	Full load.	Half load
Pounds per kilowatt-hour	32·23	40·26	27·9	29·3
Pounds per E.H.P. per hour	23·72	29·66	20·8	22·0
Pounds per B.H.P. per hour	20·15	23·80	—	—

In regard to the dynamo driven by the de Laval turbine, it has been assumed that the efficiency was 0·85 per cent. at ful load and 0·80 per cent. at half load.

A further source of information regarding the performance of the de Laval steam turbine is a Paper read this month by Mr. W. F. M. Goss before the American Society of Mechanical Engineers. The engine tested by Mr. Goss and Mr. G. E. Bruff was rated at 10 H.P. normal load. The belt pulley ran at between 2,000 and 2,500 revolutions per minute; and the reduction ratio of the engine gear was 9·905. Table III. gives a summary of the economy tests, which were made at various loads and with varying numbers of nozzles.

Table III

Nozzles.	Number of test.	Revolutions per minute of belt wheel.	Brake horse-power.	Steam pressure by gauge. In boiler.	Steam pressure by gauge. In engine below governor valve.	Total pounds of steam per hour.	Pounds of steam per brake horse-power per hour.
All four nozzles in action, three having a diameter in throat of 0·138in. and one a diameter in throat of 0·157 inch.	1	2,138	0·00	130	17·1	120·8	—
	2	2,545	1·63	130	42·2	210·3	128·6
	3	2,038	2·36	130	48·5	230·8	99·8
	4	2,118	2·97	130	55·6	254·6	85·7
	5	1,917	3·46	130	61·9	275·5	79·6
	6	2,072	4·38	130	70·8	313·0	71·5
	7	2,128	5·10	130	76·9	328·5	64·4
	8	2,576	7·52	130	99·6	403·0	53·6
	9	2,453	8·24	130	104·4	422·8	51·3
	10	2,411	10·33	130	126·3	491·8	47·8
Three nozzles in action, two having a diameter in throat of 0·138in. and one a diameter in throat of 0·157in.	11	2,584	0·00	130	31·3	121·4	—
	12	2,112	3·95	130	83·6	267·8	67·8
	13	2,125	4·77	130	93·4	286·0	60·0
	14	2,490	6·50	130	111·7	346·3	53·3
Two nozzles in action, each having a diameter in throat of 0·138in.	15	2,546	0·00	130	42·2	99·3	—
	16	2,049	1·95	130	83·5	162·6	83·4
	17	1,909	3·43	130	121·1	222·9	65·0
	18	2,412	3·87	130	127·0	229·6	59·3

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These tests do not show as high an efficiency as those made at Bordeaux, the difference being in part, no doubt, explained by the great difference between the sizes and rated powers of the two turbines. Mr. Goss appends to his Paper some account of tests made with a view to determine the starting effort of a de Laval turbine. To determine the maximum resistance under which the engine might be expected to start, the brake was clamped upon the flywheel so that the latter could not turn within it. Steam was then admitted to the engine, and readings were taken from the scale under the brake arm. The result of this process, of course, depends upon the steam pressure and the number of nozzles in action. With all nozzles, and with a steam pressure of about 125lb., the maximum starting power is equal to a force of 30lb. acting at a radius of one foot. The following tabulated data (Table IV.) gives the starting power for different pressures, and when two, three, or four nozzles are in action:—

Table IV.—*Starting Effort of de Laval Turbine.*

	Four nozzles in action.		Three nozzles in action.		Two nozzles in action.	
Steam pressure by gauge ...	125·2	71·1	125·2	71·1	125·2	71·1
Effective radius of brake arm, feet	1·5	1·5	1·5	1·5	1·5	1·5
Reading of scale under brake arm, lbs.....	20·0	12·1	14·1	9·0	9·5	6·5
Equivalent force in lbs., acting at a radius of one foot	30·0	18·2	21·2	13·5	14·3	9·0

ELECTRODYNAMIC ROTATIONS PRODUCED BY MEANS OF ALTERNATE CURRENTS.*

BY PROF. GALILEO FERRARIS.

Let O (Fig. 1) be a point in a space in which the magnetic fields produced by two electric currents are superposed. Let the directions O X and O Y of the two magnetic fields be different, say, perpendicular

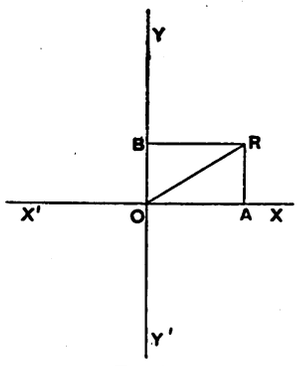

Fig. 1.

to each other. If the lengths O A and O B, cut off along the axes, give the intensities of the two fields, the diagonal O R of the parallelogram O A R B gives the intensity and direction of the resultant magnetic field. If the intensities of the magnetic fields vary with the time, the point R moves and describes a line the shape of which is determined by the law governing the variation of O A and O B; but at each instant the radius vector O R represents the intensity and direction of the resultant magnetic field at the point O. If the two currents are alternating and sinusoidal and of the same period, the intensities O A and O B of the two component fields are also alternating and sinusoidal; if they are represented by x and y respectively, they may be expressed in the terms of time t by the equations

$$x = A \sin \frac{2\pi}{T} t, \qquad y = B \sin \frac{2\pi}{T} (t + b),$$

where A and B indicate the maximum values, T the period, and $\frac{b}{T}$ the difference of phase between the two currents. Eliminating t between these two equations we obtain a relation between x and y which is the equation to the line described by the point R with respect to O X and O Y taken as co-ordinate axes.

When the difference of phase between the two currents is zero, or corresponds to one entire number of half-periods, the path described by R is a straight line passing through O, and on this line the point R traverses distances proportional to those traversed in the same time by A and B on O X and O Y. In this case the resultant magnetic field has a constant direction and an intensity varying according to the sinusoidal law, like the component magnetic fields. In every other case—*i.e.*, when the two currents are not reversed at the same instant—the path described by R is an ellipse, with its centre at O. In this case the vector O R, which represents the intensity and direction of the resultant magnetic field, is constantly different from zero, and rotates in the plane X O Y about the point O; in other words, we have a magnetic field which never becomes zero, and rotates about O. The rotating field goes once round during the time T, the period of each current. The direction of rotation is inverted if the phase of one of the currents is made different by half a period or an integral number of half-periods.

If, in particular, the directions O X and O Y of the component magnetic fields are perpendicular to each other, if the maximum intensities A and B are equal, and if the difference of phase is $\frac{1}{4}$, we have

$$x = A \sin \frac{2\pi}{T} t, \qquad y = A \cos \frac{2\pi}{T} t,$$

hence $$O R = A, \text{ and angle } A O R = \frac{2\pi}{T} t.$$

The path of R is therefore the circumference of a circle of radius A, and the point R traverses it with the constant angular velocity $\frac{2\pi}{T}$; in other words, we have then a magnetic field of constant intensity rotating about O with uniform velocity.

The effects above described may be produced by means of a single alternating current. It is, in fact, always possible in various ways to obtain the two currents necessary to produce the component magnetic forces from a single alternating current, and to vary the difference of phase between them within certain limits. One way of doing this is by letting the current pass through the primary coil of a transformer. Then the original current and the induced current are at our disposal. By letting those currents traverse two electro-magnets with their axes along O X and O Y, they may be used to produce the forces O A and O B. In order that they may present the required difference of phase it suffices to insert a suitable resistance in the secondary circuit; the difference of phase thus obtained tends towards a quarter-period as the resistance approaches infinity. But then the secondary current becomes too feeble, and must be corrected by altering the number of turns in the electro-magnets, so that A = B, and we have a constant field rotating with uniform velocity.

Another method of obtaining the same result consists in producing the two component fields from the two secondary currents produced in two transformers, or in two portions of the same transformer traversed by the primary current. Finally, to produce the forces O A and O B, two derived currents can be used. If in one of the circuits resistances free from self-induction are introduced, and in the other circuit a coil of small resistance and high self-induction, it may be brought about that while the mean intensities of the two currents are equal, or have a predetermined ratio, the phases of the currents themselves differ considerably.

Hence, by a simple alternating current operating in stationary magnets, it is possible to produce a rotating magnetic field, and all the effects obtainable from a rotating electro-magnet.

Among other things, the phenomena of induction produced by making an electro-magnet rotate near a conducting body may be reproduced by means of a simple alternating current, and thus the old experiments on magnetism of rotation may be repeated in a new form. If a conducting body is placed in the space where the two alternating fields are superimposed, the rotation of the resultant field produces in such a body induced currents, which, by Lenz's law, oppose the rotation of the magnetic field, and upon which the magnetic field reacts with forces which tend to whirl the body round in the same direction. If the conductor is movable, it rotates about O, just as if it were placed between the poles of magnets rotating about O.

I shall now describe some of the experiments by which I have verified and utilised this fact.*

Fig. 2 represents diagrammatically the arrangement adopted in a first experiment. The wires 1 A A A 1′ and 2 B B B 2′ represent two flat coils, the former consisting of a few turns of thick wire, and the latter of many turns of a thinner wire. The planes of the two coils are vertical and perpendicular to each other. They intersect along the vertical O O′, which represents the axis of the apparatus. The coil A A A of thick wire is introduced in the primary circuit of a Gaulard and Gibbs transformer. B B B is inserted in the secondary circuit, together with an adjustable resistance free from self-induction, by means of which the ratio between the intensities of primary and secondary current, and hence also the difference of phase between the two currents, may be varied.

* *Atti di Torino.* Vol. XXIII., pp. 360—375. Read March 18, 1888.

* These experiments were made in the autumn of 1885.

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The transformer is arranged for a ratio of transformation equal to unity, but since a great difference of phase must be produced by inserting a high resistance in the secondary circuit, the reduction of the current must be compensated by increasing the number of turns. By suitably arranging the resistance inserted in the secondary circuit the two magnetic fields at the centre may be made sensibly equal while having a considerable difference of phase. This condition can be easily realised by trial. When it is obtained there is in the space between the two coils a magnetic field of approximately constant intensity, which rotates uniformly about the axis O O′, and makes a complete turn for each period of the alternating current. In this space is suspended a small hollow closed cylinder of copper C, by a wire O.

If the current is made to pass through only one of the coils, the cylinder remains stationary, but if the current passes through both coils in the manner indicated, the cylinder at once begins to move about its axis, twisting the fibre through many turns. If by means of a commutator the connections 2 and 2′ of B B B with the terminals of the transformer are reversed, thus producing a difference of phase of half a period in the current B, the rotation of the cylinder is reversed. If the reversal of the commutator takes place while the cylinder is moving in a certain direction, the speed decreases rapidly, the cylinder stops, and then commences to spin round in the opposite direction. The same effects are obtained if the two coils A and B are inserted in two derived circuits, one of which contains a resistance free from self-induction, while the other has only a slight resistance, but contains a coil with an iron core and considerable self-induction.

The experiments were repeated with the same results, substituting for the copper cylinder an equal cylinder of iron. If the cylinder

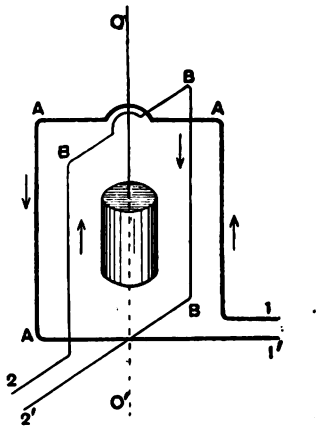

Fig. 2.

employed is small, and occupies only a small part of the space between the coils, the experiment succeeds as well with the iron as with the copper. When, on the other hand, cylinders are employed which fill up a great part of the space between the coils, the experiment succeeds less well with iron than with copper, on account of the high self-induction of the former. When, in fact, the coils A and B have a high self-induction, the necessary difference of phase cannot be obtained except by inserting very considerable external resistances, which waste a great part of the available energy.

In one experiment I employed a cylinder of iron, consisting of a number of discs separated and insulated by as many cardboard discs. In such a cylinder the induced currents by which the above result is explained cannot be produced, and yet the result is the same as before. In this case the rotation is due to the lag of the magnetisation of the iron discs behind the rotation of the magnetic field to which it is due.

The experiments above described, for the performance of which rough and improvised apparatus suffices, may serve not only as modifications of the classical experiments of Arago, Babbage, and Herschel for teaching purposes, but especially for showing the difference of phase between primary and secondary currents in a transformer, or the difference of phase between two derived alternate currents, or that between any two alternate currents of equal period. It is also easy to arrange the experiments in such a manner that they show the variation of the difference of phase as depending upon the variation of the resistances and self-inductions in the circuits.

If now we employ a light cylinder of copper, almost entirely filling up the space between the crossed coils, borne by a long bifilar suspension and provided with a mirror for reading with scale and telescope, we obtain a very sensitive instrument, which shows, even with currents of small intensity, very slight differences of phase.

3. Instead of suspending the movable conducting cylinder by a wire or a bifilar suspension, it may be mounted on a shaft running in bearings, and, by giving it larger dimensions, we obtain an electric motor for alternating currents. It is at once evident, and it also results from considerations which I shall go into later on, that a motor thus constructed would not be of any importance as a means of transforming electrical energy, but by its simplicity and by its properties it is open to some useful applications. I have constructed a provisional model of a motor, and have made some experiments with it.

Fig. 3 is a section of the motor made by a plane perpendicular to the axis of rotation. It may serve to give an idea of the arrangement of the principal parts of the machine. The movable portion of the apparatus consists of a copper cylinder, C, mounted on an iron shaft, O, and in contact with it. The copper cylinder is hollow and closed by plates of copper at the ends. Its outside diameter is 8·9cm., and its length 18cm.; it weighs 4·9 kilogrammes. The shaft O is 1cm. in diameter, and is mounted horizontally on two pivots. The fixed portion of the apparatus consists simply of two pairs of coils, shown in section in the figure at A A, A′ A′, and B B, B′ B′. One of these pairs of coils, A A, A′ A′, is arranged with its turns in vertical planes, and when it is traversed by a current it produces in the space containing the copper cylinder a field directed on the whole horizontally. The other pair, B B, B′ B′, has its turns in horizontal planes, and when traversed by a current it produces in the cylinder space a magnetic field whose mean direction is vertical. The coils are contained in wooden formers of rectangular form. Two of these, those for the coils B B′, only just allow the cylinder freedom to move. The other two, those containing the coils A A′, have the same breadth and a greater length, so that they embrace the two formers B B′ and just fit. When the four are in position they enclose a rectangular space *d e f g*, which is circumscribed about the cylinder C, leaving only space enough for freedom of motion. The gap between A and A′ and between B and B′ is only as wide as the shaft O. The coils A A′ consist of copper wires of 1·92mm. diameter, with 96 turns each. They are

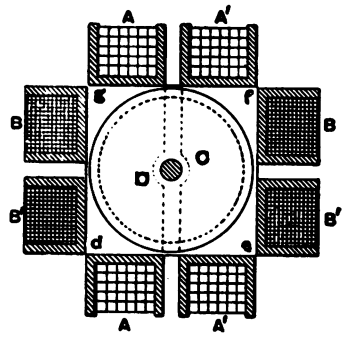

Fig. 3.

joined up in series so as to make a single coil of 192 turns. The total resistance of the two coils is 0·844 ohm. The coils B B′ consist of copper wire 0·97mm. in diameter, each containing 504 turns. The two coils are joined in parallel, so as to be equivalent to a single coil of 504 turns of double the section. The resistances of the single coils are 7·12 and 6·63 ohms: that of the two coils together is 3·43 ohms.

For driving the small motor I used a Gaulard and Gibbs secondary generator. The thick-wire coils were introduced in the primary, and the thin-wire coils into the secondary circuit. In the same circuit was placed a commercial rheostat free from self-induction, by which the intensity and the phase of the secondary current could be regulated. The resistance corresponding to the best running of the little motor was determined by trial. This resistance naturally depended upon the self-induction of the transformer, and upon the periodicity of the current employed. In my experiments the coils of the transformer were equal, and hence the self-induction of the secondary was equal to the mutual induction of both coils. The frequency of alternation was about 80 per second, and it follows from previous experiments upon the transformer that the apparent resistance due to the self-induction of the secondary coil was about 8 ohms. Under these conditions the experiment showed that the best running of the small motor took place when the resistance of the rheostat in the secondary circuit was 15 to 18 ohms. With the above numerical data it may be calculated that the resistance necessary to make the mean intensity of the magnetic field produced by the coils B B′ equal to that produced by the coils A A′ is comprised between those limits. It may also be shown that with the above resistances inserted in the secondary circuit, the difference of phase between the primary and secondary circuits must correspond to little under a fifth of a period.

Under these circumstances the copper cylinder of the motor commenced to put itself into motion when the current in the

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primary circuit reached a value of about 5 amperes. With a greater current the cylinder acquired a velocity sometimes exceeding 900 revolutions per minute. Beyond this limit the imperfect centring of the cylinder on its shaft gave rise to vibration too violent to allow of the continuance of the experiment.

In the secondary circuit was inserted a commutator by which the connections of B B′ with the secondary transformer coil could be reversed. The rotation was then also reversed, or, if it was proceeding in one direction, it was gradually stopped and started in the opposite direction. A small dynamometer brake was attached to the shaft, in order to give some idea of the order of magnitude of the mechanical work and of its changes. The following table gives the number of revolutions per minute, and the corresponding power in watts :—

Revolutions per minute.	Watts.	Revolutions per minute.	Watts.
262	1·32	722	2·55
400	2·12	770	2·40
546	2·65	772	2·04
653	2·77	900	0·0

The mean value of the primary current was about 9 amperes, with 80 alternations per second. It will be seen that there is a maximum at about 650 revolutions per minute. On plotting the above figures as a curve, the first portion, up to 500 revolutions, is approximately a straight line. After that the curve bends down. This is due to imperfect centering. Otherwise the curve would reach a maximum at 1,200, and would then descend regularly until at 2,400—*i.e.*, the speed of rotation of the field itself—the available power would reach zero.

4. The relations between the couple producing the rotations, the useful work, the heat generated, and the velocities of the drum and the field, may better be investigated by assuming ideal conditions, *e.g.*, sinusoidal magnetic fields produced by equal currents with a difference of phase of a quarter-period. Under these circumstances the field is invariable and has a uniform angular velocity. Let this be Ω, and that of the drum ω, then their relative velocity will be $\Omega - \omega$. Putting M for the couple exerted by the rotating field upon the currents induced in the drum, W for the mechanical work given out in the unit of time (including that spent on passive resistances), we have

$$W = M\omega, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Putting P for the energy converted into heat in the unit of time by the production of the induced currents, we have

$$P = M(\Omega - \omega), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

since the energy converted into heat owing to these currents is that spent in producing these same currents, and this is equal to the work necessary to maintain the relative velocity $\Omega - \omega$. Dividing (1) by (2) we have

$$\frac{W}{P} = \frac{\omega}{\Omega - \omega}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

or

$$\frac{W}{W+P} = \frac{\omega}{\Omega}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

i.e., the energy W, obtained as mechanical work or kinetic energy, is to the total energy W + P manifested partly as mechanical and partly as thermal energy, as the velocity of the drum to that of the field.

If, as supposed, the magnetic field is constant and rotates uniformly, there is a system of induced currents in the drum which always retains the same configuration. This system rotates about the axis, but the currents shift their places in the drum. The heat developed by the currents in the cylinder is therefore the same as if the currents were constant and stationary. But in each volume element the current is proportional to $\frac{\Omega - \omega}{\rho}$, where ρ is the specific resistance of the metal. Hence the heat is proportional to $\rho\left(\frac{\Omega - \omega}{\rho}\right)^2$, or to $\frac{(\Omega - \omega)^2}{\rho}$. If k is a constant, we can put

$$P = \frac{k}{\rho}(\Omega - \omega)^2,$$

Substituting this in (1) and (2) we get

$$W = \frac{k}{\rho}(\Omega - \omega)\,\omega \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1')$$

and

$$M = \frac{k}{\rho}(\Omega - \omega). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2')$$

Given the period of the alternate current employed, Ω has a definite and constant value. Hence (1′) shows that the energy W, manifested as mechanical work, is a maximum when

$$\omega = \frac{\Omega}{2},$$

whereas (2′) gives for M a maximum when

$$\omega = 0.$$

When the mechanical energy W is a maximum, or when $\omega = \frac{\Omega}{2}$, (3) gives

$$W = P,$$

so that then the mechanical work is equal to the heat developed.

5. These calculations and experimental results confirm the evident *à priori* conclusion that an apparatus founded upon this principle cannot be of any commercial importance as a motor, and while we may study its dimensions in order to increase notably its power and output, it would be useless here to enter upon any consideration of this problem. Still, the experiments described may be of some interest.

In the first place, the little apparatus may be useful for purposes of instruction. The couple is always in the same direction, and by the sole power of electro-dynamic forces, always feeble, great quantities of kinetic energy may be developed. In the second place, and this is more important, an apparatus like that just described may serve for measuring the electricity supplied by alternating currents. For this it would be sufficient to brake the movement of the drum by a resistance proportional to the square of the velocity. Since the moment of the moving couple is proportional to the square of the mean value of the current, the velocity of rotation would be proportional to the mean value. Thus the electricity supplied might be measured by registering the number of revolutions of the drum. The axis of the instrument should then be placed vertical, to diminish passive resistance and reduce faults of centring.

6. I have sought to repeat the experiments with an iron drum of nearly equal weight, but only a very slight rotation was obtained, owing to the high self-induction thus acquired by the coils B B′. An iron cylinder consisting of insulated discs as before also gave negative results. I also experimented with another kind of motor, where the drum rotated on a vertical axis and occupied the space between the cylindrically bored poles of four electromagnets facing each other in pairs. One pair was excited by the primary, the other by the secondary current. In this case iron gave better results than copper, but the effects were decidedly less than those before described, and for substantially the same reason as given above. Finally, I substituted a liquid conductor, say a mass of mercury, for the solid drum.

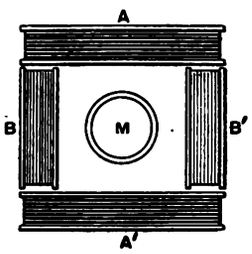

Fig. 4.

For this the following very simple arrangement was sufficient. The coils A A, A′ A′ and B B, B′ B′ were placed in vertical planes, two and two parallel and perpendicular to the other two, so as to form the four fours of a square prism. In Fig. 4 the four coils are seen in plan. They were joined to each other and to the generator as they were in the motor. A A′ were put in the primary, and B B′ in the secondary circuit, together with the rheostat and the commutator. A beaker M, full of mercury, was placed between the coils, and the rotations predicted were observed. Owing to the higher specific resistance of the mercury the speed acquired was much less than that of the copper. The maximum velocity with a current of 10 amperes was about 13 revolutions per minute.

THE COUNCILS OF TECHNICAL SOCIETIES.*

To criticise the council of a technical society is one of those daring acts that may be ranked with "speaking disrespectfully of the Equator." Fortunately, the Councils that deal with matters interesting to our readers afford very little occasion for criticism. They manage their affairs with conspicuous ability, and not only deserve, but also obtain, the confidence and gratitude of their members. Within the limits of their charter, articles of association, rules, bye-laws, or whatever the documents defining their duties may be called, they carry on the business of the society loyally and well, and display the same zeal in its affairs that they do in their own. Time and trouble are freely expended by men whose hours may be valued in guineas, and whose reputation gains nothing from the onerous position that they accept with so much goodwill. The average member has no clear idea what heavy demands are made

* From *Engineering*.

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on his representatives, and how much actual work they do on his behalf. He sees the result, and appreciates it, but the efforts required to attain it are hidden from him. Nevertheless, he is so far aware of the great expenditure of thought and care that the affairs of a wide-reaching society require that he deems it his duty to show his appreciation of the council by not hampering their efforts by hasty criticism.

If the originators of technical societies were always gifted with prophetic powers, enabling them to foresee the lines on which science and society would develop, it is probable that the occasion would never arise when even the most radically-minded member could find matter for comment—other than laudatory—in the action of his council. But, as Sir Benjamin Baker pointed out in his recent Presidential address, engineers and scientific men go as wofully astray as statesmen in their prognostications of the future, and the arrangements they devise for the government of their societies become in time unfitted for the purpose. It is an evidence of Sir Benjamin's courage that he should have chosen such an opportunity to outline the scheme of a large reform in the Council of the Institution of Civil Engineers. A lesser man would have shrunk from the attempt, and rightly so—for reforms are dangerous matters except under the control of a strong will and powerful intellect. They either run into extremes and introduce more dangers than they remove, or else they result in mere tinkering, leaving the chief issue untouched and blocking the way for an unknown time against any true improvement. What it is that Sir Benjamin purposes will be found in his address published in our recent issues, and also in our article on page 607 *ante*? Briefly, he proposes to enlarge the Council and to add greatly to the scope of their possible duties. He would cease to elect it entirely from members living within easy reach of Westminster, and would include representatives engaged in practice in India, Australia, and Canada, as well as in the leading engineering centres of Great Britain and Ireland. The business of the Council would extend beyond the management of the affairs of the institution, and would include the interests of the profession. This enlargement of the Council would necessitate a change in the manner of voting. At present a member desiring to exercise his suffrage must be present at the annual meeting, an arrangement which practically disfranchises 90 per cent. of the members. This limitation of the voting powers of the members must surely have crept into the charter by inadvertence, since in other respects the document is drawn on a fairly broad and liberal basis, evincing full confidence in the wisdom of the members.

The machinery for election of President, Vice-President, and Members of the Council does not lend itself unduly to the retention of office by those that have once secured it. The appointment is for one year only, and can only be renewed by election. At the ordinary meeting next but one before the annual general meeting, which practically means a fortnight before, the Council present a list of persons whom they nominate as suitable for the offices of President, Vice-Presidents (four), and other Members of Council (15). To fill these 20 posts they must nominate not less than 29 corporate members, all the names, other than those of President and Vice-Presidents, being printed in the same character of type, and in alphabetical order. The members have thus 20 names to select out of 29, and it is their own fault if there is not a fair infusion of new blood each year. Further, they may erase any name or names from the list, and substitute one or more others.

Unless a member of Council of the Institution of Civil Engineers is popular, or is respected by the general body of the society attending the annual meeting, he is by no means certain of re-election, despite the fact of his nomination by the Council. But the same can scarcely be said of the President; with him nomination is practically election. According to the bye-laws the senior Vice-President must be nominated, unless he expressly declines the honour. It may be the opinion of a large proportion of the members voting that he is unfitted for the post, but unless they are equally united in the choice of some one else, he will win the election. The time between the appearance of the nomination paper and the taking of the vote is so short that for all practical purposes there is no opportunity for members to provide for concerted action. A great many may relieve their feelings by erasing the name of the President-elect, but unless they also all agree on whom they shall substitute, they waste their efforts. In our recent article on "The Head of the Profession," we spoke of the necessity of having an institution represented and guided by a man fitted to represent its members and its interests worthily and well, and of the dangers that surround a system of election by rotation. A Council is so bound together by friendships and associations that there arise occasions when it is almost impossible for them to choose the best man, unless they know it is not only theoretically but practically possible for the members to override their decision.

It will be interesting to compare with the constitution of the Institution of Civil Engineers the rules and methods of elections that prevail in some newer bodies, such as the Institution of Mechanical Engineers, the Iron and Steel Institute, and the Institution of Electrical Engineers. Taking these in the rotation named, we find that the Mechanical Engineers are ruled by a Council consisting of one President, six Vice-Presidents, 15 ordinary members of Council, and all the Past-Presidents. The President, two Vice-Presidents, and five members of Council (other than Past-Presidents) retire at each annual general meeting, and not the entire body, as with the Civil Engineers. The nomination of candidates to fill the vacancies takes place at the general meeting preceding the annual general meeting, the interval between nomination and election being three or four months, owing to the infrequency of the meetings. Prior to the meeting at which the nomination takes place, the Council issue to the members a nomination list, which includes the names of such retiring members of Council as offer themselves for re-election and also some additional names, the total number of names suggested being, as a rule, three or four in excess of the number of vacancies. Then at the meeting itself any member present may nominate one or more other persons for positions on the Council, and the names of the persons so nominated are added to those nominated by the Council, and are included in the ballot list, which is posted to members. It is thus possible for any member to propose any other, either as member of Council, Vice-President, or President; indeed, there is nothing in the rules to show that he may not propose himself. As a matter of fact, it is common and customary for one or more members to be proposed and seconded at the final meeting each year, and it is only by consulting previous lists that the majority of voters can discriminate between the nominees of the Council and of private members. The voting papers are transmitted by post, and hence all can join in the election, whether present at the meeting or not. Under these arrangements the powers of the members are real, and easily applied. It is worthy of notice, however, that in spite of the popular and democratic constitution of the Institution of Mechanical Engineers, it is in one respect more conservative than the older Institution. Past-Presidents form an integral and irremovable part of the Council, with voting powers the same as the elective members. There are at present 10 Past-Presidents, as against 21 elective members. There is thus, as it were, a House of Lords and a House of Commons sitting in one chamber and voting together.

When a suggestion is made that the constitution of an institution shall be altered in the direction of placing the nomination and election of Council more in the hands of the members, the conservative element generally prophesies that there will cease to be any continuity of policy owing to incessant changes in opinion that pass in waves over a democratic body. The history of the Iron and Steel Institute is a complete answer to this plea. It has a more liberal constitution than either of those we have noticed, yet its career has been singularly free from radical action on the part of the electorate. The retiring members of Council are elected again and again; there has only been one contested election for many years, showing that the members are perfectly satisfied to forego the exercise of their privileges. The Institute is managed by a President, nine Vice Presidents, and 15 Members of Council. Past-Presidents are *ex officio* permanent members of Council; at present there are seven of them. The President is elected for two years; three Vice-Presidents and five members of Council retire annually in rotation, but are eligible for re-election unless disqualified by non-attendance during the previous year. At the ordinary meeting preceding the annual meeting the Council presents a list specifying which of their number are eligible for re-election. Any member is then entitled to add names to the list of candidates, and names may be sent to the secretary for addition to the list up to one month previous to the annual meeting. The voting papers are sent and returned by post, and may, of course, contain more names than there are vacancies. There is a considerable interval between nomination and election, and ample time is available for members to confer together and propose additional names after the publication of the first list. Whether or not there is anything in the manufacture of iron and steel that conduces to a satisfied and pacific frame of mind, we cannot say, but the fact is that there is no society that enjoys a more peaceful career than the Iron and Steel Institute, nor is there one in which the Council is more unfettered in its action. Possibly this arises from the fact that the members never suffer from the irritation of feeling themselves impotent to influence the action of the Council. They have, further, the somewhat unusual power under Section IX. of the rules "to appoint such consulting officers as may be thought desirable from time to time."

The Institution of Electrical Engineers is the youngest of the four societies we are considering. It has passed through several transformations to accommodate itself to the altered conditions of the industry it represents, and hence has had ample opportunities of modifying its constitution if any change were needed. The Council comprises a President, four Vice-Presidents, 12 ordinary members, three associate members, and all the Past-Presidents. Of the latter there are 13, a remarkable illustration of the adage

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"Electricity is life." The four Vice-Presidents retire annually, as well as the whole of the Council. At each retirement three members of Council and the three associate members are ineligible for election during the following year. The Council prepare, previous to the annual general meeting in each year, a list of members whom they propose as suitable for the offices of President and Vice-Presidents. The list also contains the names of a sufficient number of members and associates to fill the Council. A copy of the list is forwarded to the voters not less than seven days before the annual meeting, and each member is at liberty to make a selection from the list, and to substitute the name of any qualified person for each respective office. As a matter of fact the list contains the exact number of names to fill the vacant offices, and there is no provision for other names to be added to it at the instance of private members before it is finally issued. The constitution of the Institution is less liberal in every respect than either of the three we have already considered, with the single exception that the personal delivery of voting papers is not required. The time for deliberation is the shortest of the four—seven days, against 14 in the Civil Engineers. Even these seven days are not really available, for the natural impulse of the country member is to fill up his Paper and return it the day it is received. In any case, seven days are not sufficient for concerted action to be organised, and other names to be substituted by a majority of the members for those submitted to them. The Past-Presidents vote in the Council, as with the Mechanical Engineers and the Iron and Steel Institute; but, unlike the case of those bodies, the Past-Presidents make nearly half of the Council, and are thus almost on a par with the elected body. A large proportion of the Council is thus permanent, and consequently must grow out of touch with the members. The reason of this state of affairs is to be found in the practice of electing a new President each year. In the Iron and Steel Institute the election is for two years by the rules, and among the Mechanical Engineers the same practice obtains by custom. The Institution of Electrical Engineers commenced with a number of eminent and distinguished men on its roll, and hitherto it has had reason to be proud of the occupants of its chair. It also contains an unusually large number of young men who have yet their reputations to make, and who for many years will not be suitable to fill the highest office. In a short time the dilemma will have to be faced of either electing some of these, or of habitually re-electing those that have already pressed the chair. The Mechanical Engineers, with their much larger roll, containing a greater proportion of men of mature age, find that the claims of all that can justly aspire to the presidential office can be met on the basis of a two years' term, and it is well worth the consideration of the Electrical Engineers whether the same course would not be worth their following. From the accidents of the origin and development of the society there must necessarily be a great gap, not only in age, but also in ideas and in aspirations between the Council and the members, and it is conceivable that this might develop into a positive want of sympathy should the feeling arise that the Institution was being "run" from the Council table. As we have already remarked, the possession of a democratic constitution renders a society the more ready to give practical proof of its confidence in its Council by leaving its affairs in their hands.

We have been induced to give this recapitulation of the constitution of these societies by the fact that reform is in the air. Sir Benjamin Baker has started the subject, and under his initiative other technical bodies need not be ashamed to inquire if there is any imperfection in their arrangements. When science and practice are constantly developing, there is the danger of engineering societies getting out of harmony with their environment, unless from time to time they take stock of themselves and their surroundings.

THE THERMOPHONE.*

In the Newport, R.I., gas and ice factory use is made of an instrument called the "thermophone," for determining the temperature at different points in the gas-holder tanks. The apparatus was designed by Messrs. H. E. Warren and G. C. Whipple. It resembles the Siemens pyrometer, and takes advantage of the fact that different metals have different electrical temperature coefficients. The accompanying diagram illustrates the general arrangement.

A and B are coils of different metals placed in proximity and joined together as shown in the figure. These coils are connected with a slide wire, C D, by means of the leading wires L and L¹. The two ends of C D are connected in circuit with a battery, M. A galvanometer, G, is put into a leading wire connecting the junction of A and B with a movable contact, Y, on the slide wire. The galvanometer will indicate zero current when $\frac{A}{B} = \frac{CY}{DY}$. But A and B, having different temperature coefficients, will vary in resistance at different rates with changes in temperature; consequently there will be a different value of $\frac{A}{B}$ for every temperature. The value of $\frac{A}{B} = \frac{CY}{DY}$ may be directly read from a scale placed under the sliding contact Y, or the temperature corresponding to the given ratios of $\frac{A}{B}$ may be marked upon the scale.

In practice the slide wire is wound around the edge of a disc above which there is a dial graduated in degrees of temperature. The hand on the dial is directly over the movable contact on the slide wire, and both are moved by turning a knob in the centre of the dial.

It is easily seen that the temperature of the slide wire C D has absolutely no effect upon the reading of the instrument, for being made of one piece of metal, which has the same temperature throughout its length, each portion of it will rise or fall in resistance at the same rate with changes in temperature; consequently the ratio of its parts will not vary. The effect of temperature changes on the leading wires L and L¹ will not sensibly affect the readings for the same reason.

In place of the galvanometer it has often been found advisable to use a telephone, in connection with a circuit-breaker, to show the presence of a current. It is in this form that the instrument is illustrated here. The coil having been placed in the position where the temperature is desired, the transmitter is taken from its hook on the left-hand side of the box and held to the ear while the right hand of the operator turns the knob over the dial until a point is reached where no sound is heard. The dial hand then indicates the true temperature. If desired, a number of coils can be located permanently at a number of distant points, and thrown into connection with a central dial box, at will, by means of a little switchboard.

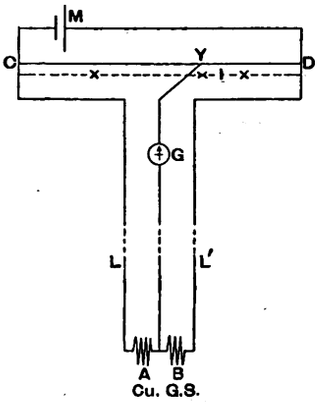

Diagram of Connections of the Thermophone.

MUNICIPAL TELEPHONY.

The following is an abstract of the discussion on Mr. A. R. Bennett's Paper on "Municipal Telephony," which was read before the Northern Society of Electrical Engineers on November 11th, and appeared in *The Electrician* of November 15th:—

In a written communication Mr. Henry Edmunds said that he would point out that competition in such a matter as telephony must inevitably result in absorption, or in public inconvenience. When, in one district, there were rival telephone systems, the subscriber had to pay for both. A case in point occurred in Manchester itself, where 500 of the subscribers to the Mutual Company had to become subscribers to the National also. Consequently, instead of paying merely £4 or £6 for their telephone service, as Mr. Bennett made out, these 500 were compelled to contribute some £15 or £16 per annum. It was hardly fair to compare an isolated little Norwegian town of 30,000 inhabitants, with the English industrial centres. If each small town had its own system, with varying rates, varying conditions, and varying management, the confusion could be better imagined than described. The same thing applied to every great town in the kingdom. Liverpool, for example, had within its telephone area three county boroughs, and 12 local boards. London had within its telephone area the whole County of London (which alone possessed a population of 4,230,000 as against the 30,000 of Trondhjem) and also the towns of Dartford, Reigate, Redhill, Croydon, Epsom, Richmond, Kingston, Tilbury, Woodford, Romford, Epping, West Ham, Harrow, Ealing, and Hampton Court, all included in one rate. Even according to Mr. Bennett, at Trondhjem there was no royalty to pay, no way-leaves, no night service, no telegram service. With nearly 800 subscribers there were no multiple switchboards. Furthermore, the Norwegian system was not being worked under the conditions of a limited tenure. It was shown before the late Select Com-

* Abstract from the *Electrical Engineer* of New York

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mittee that if the National Telephone Company were relieved from these direct and extraneous charges (which did not press, or very lightly pressed, upon the telephone systems abroad) that the average annual subscription in this country would be reduced to £6. 5s. 11d., including London, where the rates were higher than in the provinces. It was also shown that the present working expenses of the National Telephone Company (including the items above referred to) amounted to £6. 4s. 7d. per line, without taking into account interest upon capital or depreciation of capital. It must, therefore, be assumed that the Mutual Telephone Company, with its subscription of £5 or £6, would have quickly reached the bankruptcy court, when the condition of affairs had become normal, and its working expenses had reached those of the National Company.

Mr. BENNETT stated that the subscription of the Dundee Company was £5. 10s. per annum, and that it paid an average dividend of 9 per cent. during the 4¼ years of its existence. It may be pointed out, however, that in the earlier part of the Company's existence its subscription was £10, and the Chairman of the Dundee Company said before the late Select Committee, "I think we allowed too little for depreciation, and I think if we had gone on we would not have been able at the £5. 10s. rate to have paid anything at all. After the rate was reduced to £5. 10s. the dividend was reduced to 5 per cent."

Mr. THOMSON said he had taken much interest in the telephones of Manchester, he having been one of those who tried to oppose, by the establishment of the Mutual Company, the great hold which the National Telephone Company had upon the country. It seemed to him clear from the amount of "water" and other useless capital which the National Company had, that whatever that Company could do, the people of Manchester could erect wires and appliances over the town very much cheaper themselves. He thought that the amount of £6. 4s. 7d. for working expenses per line which was given by the National Telephone Company was out of the question as compared with the small figures which Mr. Bennett had shown with companies who possessed no useless capital. Of course, as the telephones increased in number the demand for telephones would be greater and the number of times per day which each wire would be used and the consequent cost per wire would be greater on a large than on a small exchange; but the record given by Mr. Bennett of what could be done at Stockholm for £4. 8s. on a 14,000-wire exchange showed that the charges for the wretchedly small exchange in Manchester and Salford were absurdly too high. For himself, he used the telephone perhaps three or four times per week, and he was quite satisfied to pay £5 or £6 per year for that favour. At the same time he did not use the telephone sufficiently to make it worth £10 per year to him, as that would cost an average of about 1s. per message. He thought that it was strange that the municipality of Manchester had not taken more interest in this matter, the reason no doubt being that it was very difficult to make gentlemen who had many other matters on their minds to clearly understand the telephone question. He himself four years ago had tried to show the telephone users in Manchester that if they paid £20 for one telephone they could have two for £15 by joining the opposition, but many seemed to think that they would get the benefit of the opposition without joining it themselves, and so the work required by those actively engaged in the opposition was increased many fold by the general public inertia, and thus practically it had come that Manchester people were for the moment bound hand and foot and laid at the mercy of the very worst form of monopoly. He trusted that the Manchester Corporation and the other corporations throughout the country should have telephonic exchanges of their own, which would certainly produce ample interest on the capital expended, and profit if the people were allowed to pay a reasonable amount for telephonic communication. He thought that a telephone should be constructed in Manchester at rentals sufficiently low to allow of the formation of a very large exchange in place of the wretchedly small one which existed under the present monopoly, and as the trunk lines would next year be in the hands of the Post Office it could be very easily arranged that they should send messages from one town to another through the Post Office wires. He hoped that that Society would use its influence to lay some stress upon the Manchester Corporation with a view of getting it to establish a municipal telephonic service.

Mr. MARR said it was all very well to talk of watered capital—and they all knew pretty well what it meant. On the other hand, on starting a new industry, such as the telephone business was, it became impossible to do away with watered capital, owing, in a large sense, to the element of doubt as to whether it would be successful or not; and if his information was correct, Prof. Bell himself received something like three-quarters of a million in cash and shares, directly and indirectly. Those shares required a dividend, and must go down as watered capital. It seemed to him that the position of to-day with regard to telephone rentals in Manchester, and increased rentals all over the country, was caused by the Government not taking it up in the first instance, and, having regard to the fact that the law courts gave the decision that a telephone was a telegraph, and came under the Telegraphs Act, it seemed to him that the only solution of the question lay in the Post Office taking it over and working it.

Mr. CALVERT said he was intimately acquainted with the Scandinavian system, and he would just like to make a few remarks on the matter. He thought it was rather a pity that Mr. Edmunds was not there to reply, but, at the same time, of course, he would not criticise in any way unjustly. He understood that Mr. Edmunds said if every corporation had its own telephonic system, with State trunk lines between the different corporations, that that would lead to a great deal of confusion. Now that was just what Sweden had. He thought it was rather a pity that Mr. Bennett had taken such a small town as Trondhjem. For example, particulars as to Stockholm would have been better. Stockholm was a town of 260,000 inhabitants, and had probably more telephones than any city in the world on its population basis. There were 14,000 telephones, one for every 18 men, women, and children in the place. When the State took over the Stockholm Bell Company the Stockholm General Company would not sell, and the State could not compel them. The General Telephone Company would not sell to the State, but it had just been arranged in a friendly way, and there was now inter-communication between the concerns, so that anyone on the General Telephone Company could telephone on to the State lines. Coming back to the point of inter-urban communication, the State in Sweden owned, of course, all the trunk lines up and down the country. They then made arrangements with the urban companies to allow inter-communication on payment of a certain fee, simply for the trunk line, and there was no confusion whatsoever. The state of telephony in Sweden was probably most complete as regards the rapidity of communication. In a town like Stockholm, with one central station, 8,000 wires went up to one tower, and he could stand in his office and get 10 communications in 10 minutes, so rapid was it. He said that as soon as he rang the answer came instantly, and the communication was made. This was not the case in England. As regarded the cost—well, it was of course exactly as Mr. Bennett had put it. The general price in Sweden was about 80kr.—that is to say, £4·80, but the small towns and villages had it for about 27s. 6d. per annum, and then inter-communication, for which they paid each time. Most business men had the metallic circuit, the extra wire being laid for a small extra cost once and for all. This was one point which Mr. Bennett had not dealt with. They had to take into consideration that, in the first place, there were no wayleaves required to be able to put up telephones. In the second place, there were relatively bad postal arrangements, which make it absolutely necessary for men to have telephones. The result was that there was scarcely a farmer in all the country with a few acres of ground who had not a telephone. Then, of course, the wages were fairly low in some respects, although the girls got practically as much as in England. There was also one little point about the price of the poles. He thought the price given by Mr. Bennett could not be correct.

Mr. BENNETT, in reply, said that he was sorry Mr. Edmunds was not there, because it was necessary to take very strong exception to some of his remarks. Mr. Edmunds seemed to have favoured the Society with an extract of the evidence given before the late Select Committee by the National Telephone Company on its own behalf, but omitting the cross-examination, which showed that many of the statements made were not susceptible of substantiation. Taking the statement that 500 of the subscribers to the Mutual Company had to become subscribers to the National Company also. Actually the exact converse was the case. These 500 subscribers were already members of the National Company's Exchange, and in order to obtain a prompt and efficient local service they joined the Mutual Company also. Mr. Edmunds said that it was not fair to compare a Norwegian town of 30,000 inhabitants with the English industrial centres. He (Mr. Bennett) had done nothing of the kind. What he asserted was that the example of Trondhjem was applicable, with very slight modification, to British towns of the same size; for a comparison with our larger cities he went to Stockholm and Christiania. Mr. Edmunds had enumerated the various divisions of Manchester and Salford, and assumed that it would be necessary, under municipal management, to have a separate licence, a separate exchange, and a separate set of tariffs and regulations for each district. That sort of thing was made much of before the late Select Committee, but the witnesses from Edinburgh and Glasgow repudiated the notion, pointing out that Edinburgh, for instance, serves Leith, Portobello and other outlying boroughs with water, with gas, and also in some cases with tramways, and the same state of things obtained in other Scottish as well as English boroughs. It would be the same with a municipal telephone exchange. Mr. Edmunds also enumerated the names of various districts and towns around London and said that all of them were included in one rate. Was Mr. Edmunds aware of the fact that in most of the places he named there were no telephone exchanges at all, and that in some of them there was not even a solitary telephone wire, although, in the majority of cases, the respective populations far exceed that of Trondhjem? Mr. Edmunds said further that the Norwegian system was not being worked under the condition of a limited tenure. In this he was not quite correct; but if he were, what had limited tenure to do with the people who wanted cheap and good telephones? Mr. Edmunds was evidently a thorough advocate of the National Telephone Company. He (Mr. Bennett) was not an advocate against it. His advocacy simply extended to the right of the public to have an economical and efficient telephone service and the right of the telephone industry to be free in this country—matters which had nothing to do with considerations of limited tenure or with the interests of existing telephone companies. Mr. Edmunds further said that it was shown before the late Select Committee—"alleged" would have been a better word—that if the National Company were relieved from extraneous charges that the average annual subscription would be reduced to £6. 5s. 11d. It was also shown, he said, that the present working expenses of the National Company amounted to £6. 4s. 7d. per line. He (Mr. Bennett) would like the Society to compare this statement with that made on the same point by the National Telephone Company to the Manchester Town Council when negotiating the agreement which had been mentioned during the discussion. According to Alderman Milling, as reported in the *Manchester Guardian*, the National Telephone Company stated that out of £10 received from subscriptions £8 went in expenses, £1 to Government, and there remained only £1 for dividend and renewals. This makes the working expenses per line more than £9, while the Select Committee was told that the amount was £6. 4s. 7d. per line. Which of these two statements was correct? Both cannot be, yet the authority was the same. The fear expressed by Mr. Edmunds that the Mutual Company would have quickly reached the Bankruptcy Court was superfluous, as they never could, by any possibility, have done so. Mr. Edmunds stated that the whole of the outside plant of the late Dundee Company of the late Mutual Telephone Company had had to be taken down and renewed. Mr. Edmunds was wrong here. As regards the Mutual Company's plant it was still up and still working, as there were over 1,000 subscribers still connected to the exchange. As regards the

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Dundee and District Company's plant, it was true that much of it was taken down, but not because it was badly constructed and of no use. The reason was quite a different one. He was personally acquainted with the facts of that case, and he could say that Mr. Edmunds was quite mistaken. Mr. Edmunds said that the rate of the Dundee Company was originally £10, and that after it was reduced to £5. 10s., the dividend fell from 9 per cent. to 5 per cent. ; but the £10 rate of the Dundee Company endured but a very short time, and the development which took place under it was exceedingly small. Practically the whole of the Company's good work was done on a £5. 10s. rate. That Company had to contend against exceptional obstacles, as the patents were in full force during its existence, and its greatest difficulty was in obtaining instruments that it could use without fear of infringement. But nevertheless that Company paid a dividend of 9 per cent. per annum for the 4¼ years of its existence, and ultimately got its capital back with 40 per cent. added. It also compelled the National Company to undertake never to raise the rate in Dundee beyond a figure which was exactly half of that on which the National subscription stood when the competition commenced. So much for the results of competition. Mr. Marr mentioned the Post Office telephone service, and inquired why only 1,300 subscribers to it could be found in all the United Kingdom. There was very small inducement in the matter of rates for the oppressed to fly to such a sanctuary as was afforded by Her Majesty's Post Office. Secondly, the spirit of Post Office management was inimical to the development of such a business as the telephonic. The Post Office officials sat in their offices and waited for business to walk in to them. Mr. Marr remarked that companies could seldom do without "water," and that large sums were paid to the inventors of the telephone. If Mr. Marr would look into the matter closely, he would find that the money paid for the patents was not included in the "water" part of the capital. Before the late Select Committee, the National Telephone Company admitted the existence of £1,292,000 of "water," but this was entirely made up by amalgamations with, and acquisitions of, other companies. Mr. Marr also asked for information as to the present state of the agreement between the National Telephone Company and the Manchester Corporation. In his (Mr. Bennett's) opinion the present state of affairs was that the Manchester Corporation had put itself absolutely and entirely under the heel of the Company. Alderman Leech warned them of what they were doing at the time, but ineffectually, and the consequence was that unless the citizens of Manchester made a prompt remonstrance they would soon find the Company had acquired what would shortly become an unchallengeable monopoly. Before the late Select Committee the Institution of Electrical Engineers, through the medium of their President (Mr. Crompton) and of Prof. Silvanus Thompson, gave evidence as to the evil wrought to the electrical industry by the present monopoly, and expressed opinions strongly in favour of competition. His suggestion was that the Northern Society of Electrical Engineers should render help in the same direction. If the Northern Society would appoint a committee to watch the progress of the telephone question, and take such action thereon as might appear desirable in the interests of the electrical industry generally, he was sure that the Society would be performing a good work both for itself and the public. In conclusion, he would like to explain that he had instanced Trondhjem, because that town was at present the best example of a telephone exchange managed by a municipality. Before the late Select Committee it was said in effect that municipal authorities were not capable of managing a business such as a telephonic exchange, and they had heard that opinion re-echoed to-night in Mr. Edmund's remarks. He thought that such an allegation ought to be proved or disproved, and the Paper he had given them this evening was, he thought, a very complete refutation of it. After Trondhjem there remained the greater example of Christiania, and soon the exceedingly important towns of Rotterdam and Amsterdam would be added to the list.

LONDON CHAMBER OF ARBITRATION.

Up to the present the electrical industries have been comparatively free from trade disputes, and we sincerely trust that such a satisfactory state of affairs may long continue. If Boards of Arbitration, or Councils of Perfection, or under whatever other name such bodies may prefer to be designated, have any *raison d'etre*, it may reasonably be presumed that the most opportune moment for its conciliatory functions to be exercised is on the first serious conflict between employer and employed in a new industry, and it is, therefore, to be hoped that, should such a deplorable event occur in connection with the Electrical Trades, the London Chamber of Abitration will make special efforts to ensure its voice being heard for peace. A report, dated November 15, 1895, has just been printed and circulated amongst members of the Court of Common Council of the City of London, which is signed by Messrs. H. Clarke, A. Rollit, A. Pursell, J. Chambers, W. J. Thompson, jun., and F. G. Burmester, as to the working of the Chamber since its establishment on November 23, 1892. The report states that :—

The Chamber was established with the object of providing for the speedy and inexpensive settlement of commercial disputes, and although the number of cases which have been brought to the Chamber has been less than was anticipated by its founders, the Corporation and the London Chamber of Commerce, it has achieved in a large measure the object for which it was instituted. The average time occupied in the disposal of the cases which have been heard in the Chamber, from the lodging of the submission to the award, has been ten days, whilst one case was recently completed in so short a period as six days. The amount of the fees in each case has not exceeded, in the average, five guineas, and this notwithstanding that several important disputes, involving in some instances large sums, have been dealt with. Those who have had recourse to the Chamber have been exceedingly satisfied with its working, and have expressed their surprise at the rapidity with which cases have been carried through and the smallness of the expenses incurred.

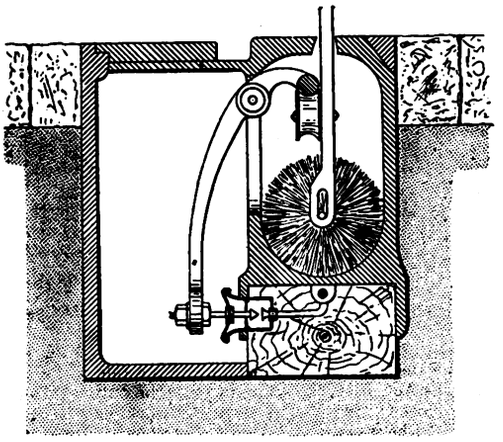
The establishment of the Chamber awakened considerable interest on the part of the public and the Press, and suggestions were freely made that the Law Courts might with advantage bring their method of procedure more into harmony with the wants of commercial men, especially in reference to rapidity and the avoidance of long vacations. These suggestions have already borne fruit, and the establishment of a Commercial Court is now an accomplished fact.

The members express themselves confident that with time Chambers of Arbitration in this country will attract as much business as some of the largest tribunals of commerce on the continent. In proof of which it is stated that Chambers of Arbitration have been recently formed in the provinces, and even in the Colonies, with rules similar in provision to those of the London Chamber of Arbitration, and in some cases identical. As evidence of the success of the arbitration idea amongst commercial men it is mentioned that some of the arbitrators engaged by the Chamber have been engaged in outside arbitrations.

Several modifications in the existing rules are recommended. In reference to the complaint that the existence of the Chamber is comparatively unknown, it is pointed out that the proceedings of the Chamber are necessarily conducted in private, as commercial firms object to the decisions come to in the cases submitted to arbitration being made public. It is, however, intended to issue a printed letter, giving full information as to the advantages of the Chamber, and particularly drawing attention to the fact that the Chamber is under the management of the London Corporation and the London Chamber of Commerce, to every Chamber of Commerce both in the United Kingdom and abroad, with a request that they will advise their members to insert in their London contracts the arbitration clause referring any dispute that may arise to the London Chamber of Arbitration ; and, further, it is intended that the Chamber shall from time to time be suitably advertised.

BURT CONDUIT SYSTEM OF ELECTRIC TRACTION.

Our American contemporaries have recently contained accounts of a somewhat hopeful-looking system of electric traction on the underground conduit system. This system, which is due to Mr. John Burt, is on the sectional conductor plan, and does not in any way rely upon electromagnetism for effecting the necessary contacts. The sectional conductors are supported, as shown in the illustration, on the upper ends of bell-crank levers, the lower ends of which make contact through stuffing boxes with the insulated feeder which runs along at the bottom of the conduit. The car makes contact with the sectional conductor by means of a pair of under-running trolley wheels secured to a stout iron frame. When the trolley wheel comes into contact with the extremity of one of the lengths of conductor, it lifts that end, and causes the lower



end of the lever to make contact with the insulated feeder. When it has got beyond the centre of the section, the upward pull of the under-running wheels causes the back end of the sectional conductor to fall, and to break contact with the insulated feeder, the forward end of the conductor being now lifted, causing the lower end of the lever at that extremity to make contact with the insulated feeder. The successive lengths of conductor are joined by flexible insulated joints. The distance between the two wheels of the contact maker is sufficient to bridge over these breaks. As will be seen in the illustration, the lower end of the frame which carries the trolley wheels also carries a brush. The spindle of this brush is at an angle with the axis of the conduit, and the result is that as the car runs along, the brush sweeps out the conduit.

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THE BIRTH OF THE POLYPHASE SYSTEM.

Among the observed phenomena of mental activity, there are perhaps none more striking, none more likely to reward a patient investigation, than the steps in the evolution of an invention. The history of engineering and electrical science at every stage bears witness to the fact that on mind, as on matter, "like causes produce like effects." It has been argued by one who bears an honoured name in the domain of electrical science, that the action of the mind is so regulated as to be capable of predetermination, so that, for example, it is possible to reconstruct the form of Shakespeare's plays, given the history of his life. Be this as it may, it is certain that historically hardly any invention or discovery can be said to have been originated solely by one mind, but frequently, within a few days of one another, by thinkers or investigators in many different parts of the world. It is this fact, realised by those to whom invention is a business or profession, which explains that somewhat undignified race to the patent office, and that hurried publication of half-matured researches so often commented upon.

These thoughts are suggested by a translation, which we publish in our columns to-day, of a Paper read by Prof. GALILEO FERRARIS before the Turin Academy in 1888. No full translation has, so far as we know, hitherto been published in English, but the importance to many of our readers of the subject of this Paper on "Electro-dynamic Rotations produced by means of Alternating Currents" has led to its appearance at what may seem a somewhat late period. We have already in these columns referred to claims which are being put forward in the law courts of the United States, France and Germany to the priority of NIKOLA TESLA as the inventor of the polyphase induction motor, and its use in the transmission of power, and as the Paper we publish to-day is relied upon in England and the Continent as a prior publication of the principles of such motors, it is likely to assume a position of importance. This Paper was published by being read to the Turin Academy on March 18, 1888, and the first publication

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in England of TESLA'S invention dates with the date of his complete specification, May 8, 1888, nearly two months later. In America, however, this order is reversed, as TESLA'S various patents date in 1887 and early in 1888. To return, however, to the Paper itself, the first few paragraphs give in an admirably condensed form the geometrical conception of a rotating magnetic field produced by two sinusoid alternating currents differing in phase, but of the same period; then follows a description of how two currents differing in phase *may* be derived from a single alternating E.M.F., whilst Part I. closes by describing the mechanical effects producible by such a rotating field. Part II. describes actual experiments with several forms of apparatus made three years earlier, in 1885, to demonstrate the theoretical conclusions arrived at, and we have a motor described having a short-circuited armature nearly 9cm. in diameter and 18cm. long, which developed a maximum available power of 2·7 watts, whilst for comparison we may note that a machine of modern construction of the same size would probably develop 500 watts. It was, no doubt, because of this very small output that, after having shown the laws which govern the output and efficiency of such a motor, Prof. FERRARIS seeks to find the conditions of *maximum output*, and finds that this is reached (neglecting as he does leakage) when the speed of rotation of the armature is half that of the revolving field. But under these conditions he shows that the efficiency cannot exceed 50 per cent., and passes to the following conclusion:—"These calculations and experimental results confirm the evident *à priori* conclusion, that an apparatus founded on this principle cannot be of any commercial importance as a motor, and while we may study its dimensions in order to increase notably its power and output, it would be useless here to enter upon any consideration of this problem."

To anyone reading the Paper to-day with present knowledge the wonder must be that, with so clear an insight as Prof. FERRARIS evidently had of the principles of his invention, the forms which he designed were such as to give these small results. But in 1885 the magnetic circuit was hardly understood, and the motor was probably quite as far advanced as the transformer from which it was worked. It is not very clear in the Paper whether the actual phase difference (given as ¼th of a period) between the currents in the two coils was measured or calculated; if the latter it is at least reasonable to suppose that the phase difference may not have been as great as estimated, which might in part account for the small output. Just as the "evident *à priori*" statement, known as the law of Jacobi would have strangled the continuous-current electric motor in its infancy, if left to mathematics alone, so was this new departure left to die unrecognised by its parent. "Up to the summer of 1879 there seemed to be a curious misconception arising in the minds of even distinguished electricians, regarding the theoretical consideration of the efficiency of electric transmission of power. There are two distinct questions to consider. Do you want a motor to give out work rapidly? or Do you want the arrangement to transmit power most economically? The two questions are quite easy to solve and lead to quite distinct answers." We quote Prof. AYRTON, speaking in 1881 (*Proceedings* of the Society of Telegraph-Engineers and of Electricians, 1881, p. 118). Prof. FERRARIS wanted the motor to give out work rapidly, and seems to have omitted to notice the other and quite distinct answer. But because he did this the fact is not altered that in this Paper the essential principles at least of a two-phase induction motor, and the general theory of its action, are most explicitly given—so explicitly, indeed, that it would seem impossible for any serious claim to be made that this Paper was not a complete publication in this country of the polyphase induction motor. Particular constructions, particular methods of working—these may form the subject of subsequent invention, a very different matter to a broad claim such as has been suggested.

In thus reviewing this subject nothing is further from our minds than to belittle the work done by TESLA in the solution of this problem of polyphase motors, but there is no disguising the fact that those who controlled his inventions, partly from commercial, partly, perhaps, from personal motives, did not do much to develop them, and that they now seek to reap a harvest which is the result of toil and skill not their own.

ON POLARISATION OF ELECTRIC RAYS BY DOUBLE REFRACTING CRYSTALS.*

BY PROF. J. C. BOSE, B.A., B.SC.

A ray of ordinary light incident on a crystal of Iceland spar is generally bifurcated after transmission, and the two emergent rays are found polarised in planes at right angles to each other. The object of the present inquiry is to find natural substances which would polarise the transmitted electrical ray. It was thought that the analogy between electric radiation and light would be rendered more complete if the classes of substance which polarise light were also found to polarise the electric ray. The identity of the two phenomena may be regarded as established if the same specimen is found to polarise both the luminous and electric rays. As the wave length of an electrical ray is very large compared with that of visible light, one would think very large crystals, much larger than what occur in nature, would be required to show polarisation of electric rays. By working with electric radiations having very short wave lengths, I have succeeded in obtaining very satisfactory results with crystals of moderate size. These experiments show that certain crystals are double refracting as regards electric rays, and that they polarise the transmitted beam. With the help of a rudely constructed apparatus, I was able last year to detect traces of these effects. The apparatus has since been improved in detail; it is now possible to detect the polarisation effects with certainty. The usual optical method of detecting the bi-refringent action of crystals, is to interpose the double refracting structure between two crossed Nicols. The interposition of the crystal generally brightens the dark field. This is known as the depolarising effect, and is regarded as a delicate test for double refracting substances. There is, however, no depolarising effect when the principal plane of the crystal coincides with the polarisation planes of either the polariser or analyser. The field also remains dark when the optical axis of the crystal is parallel to the incident ray. A similar method was adopted for experimenting with polarised electric radiation. The electric ray is first polarised by a wire grating. A similar grating acts as an analyser. The two gratings are crossed, and the crystal to be examined is interposed. The receiver is a modified form of "coherer" with its associated voltaic cell and galvanometer. Brightening of the field is indicated by a throw of the galvanometer needle.

APPARATUS USED.

Radiator.—A small Ruhmkorff's coil is used for the production of oscillatory discharges between the two small metallic spheres, the diameterof each sphere being 1·5 c.m. The choice of a coil to produce electric oscillation has been a matter of necessity. I obtained oscillatory effects with ease and certainty by using a small influence machine of the replenisher type. But in the damp atmosphere of Calcutta, the satisfactory working of such a machine is a matter of great difficulty, at least for the greater portion of the year. I had therefore to abandon the influence machine with regret, and to use a Ruhmkorff's coil instead. This coil caused me the greatest trouble. The discharge would of a sudden cease to be oscillatory; after a great deal of coaxing it would work satisfactorily just for a short time. The only coil I could get was a badly constructed one, with defective insulation. I made it serviceable by changing the condenser and improving the vibrator. By looking to many points of detail, I succeeded in making the apparatus work with fair uniformity for several hours. It must be borne in mind that the receiving apparatus also requires careful adjustment.

Among the possible causes of unsteadiness may be mentioned the following:—(1st) The current actuating the coil may vary after a time. To overcome the difficulty a fairly constant battery was made to charge a small storage cell, and a derived circuit from this

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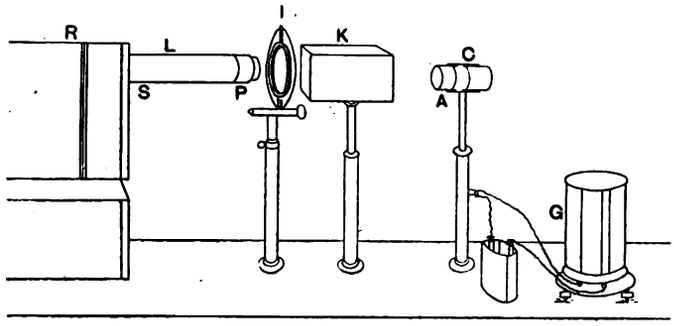
cell was led to the primary coil. (2nd) The interrupter may have its rate of vibration changed by heating, wearing out of contact points, and other causes. Any change in the periodicity of the vibrator is at once made evident by the corresponding change in the pitch of the note given out by the vibrator. (3rd) The sparking balls may have their surfaces roughened by the disintegrating action of the spark. To avoid this difficulty the balls were thickly coated with a deposit of gold, and were turned round at intervals to expose fresh surfaces.

The coil with a storage cell is enclosed, with the exception of a horizontal tubular opening, inside a metallic box (*see* figure), not dissimilar in appearance to an optical lantern. The interrupter is actuated by turning a key from outside. The sparking balls are at one end of a brass tube 25 c.m. long and 5 c.m. in diameter. At the further end of the tube is the polariser. Inside the tube is placed a convex lens with the spark gap at its principal focus. With the help of the lens and suitable diaphragms, the electrical beam is made approximately parallel. By means of an iris diaphraghm the amount of radiation may be varied.

Polariser.—The success of the experiment depends greatly on the care with which the polariser and analyser are constructed. Fine copper wire 2mm. in diameter is carefully wound in parallel lines, round two thin sheets of mica. There are about 25 lines for every centimetre. The mica pieces are then immersed in melted paraffin, and the wires thus fixed *in situ*. By cutting round, two circular pieces, containing the gratings are obtained. The mica pieces are too thin to produce any disturbing effect. The gratings are fixed with wires parallel, at the ends of a tube 5cm. long. This polariser tube rotates inside the outer end of the tube which sends out the parallel electric beam.

Analyser.—The analyser is similar in construction to the polariser. It rotates inside the receiving tube, which contains the sensitive surface for detecting radiation.



Polarisation of the Electric Ray.

R=Metallic box containing Rhumkorff coil. S=Position of sparking balls. L=Position of convex lens. P=Polariser. I=Iris diaphragm. K=The crystal. A=Analyser. C=Coherer. G=Galvanometer (placed at a distance).

Receiver.—The receiving apparatus consists of a "coherer" with a voltaic cell and galvanometer in series. The coherer is modified from its usual tubular form. The filings, a single layer thick, are spread over a large surface. This arrangement secures great sensitiveness. A pair of insulated wires from the ends of the coherer, are led out to a distant dead-beat galvanometer of D'Arsonval type in series with a constant cell. The leading wires are shielded from radiation by enclosing them inside two coatings of tinfoil along the whole length. As an additional precaution the galvanometer is also enclosed in a metallic case, with a slit in front of the galvanometer mirror. A spot of light reflected from the mirror is received on a scale. By adjusting the electromotive force of the circuit the sensitiveness may be increased to any extent desirable.

When the analyser and polariser are properly constructed, and the two exactly crossed, no radiation will reach the sensitive surface, and the galvanometer will remain unaffected. The field is then said to be dark. But any slight rotation of either polariser or analyser will partially restore the field, and the spot of light will sweep across the scale.

Method of Experiment.

The spark gap 2 m.m. in length is adjusted in a line inclined at 45 deg. to the horizon. The wires of the polariser are placed at right angles to this line. The transmitted beam is then plane polarised, its plane of vibration being inclined at 45 deg. to the horizon. The analyser is now adjusted in a crossed position. On starting the electric vibration, by closing the Ruhmkorff coil circuit, the galvanometer remains unaffected. The crystal to be examined is now interposed with its principal plane vertical.

The Geological Department of India kindly lent me a large number of crystals for examination, for which I have to express my thanks. Out of a large number of experiments, I give below an account of some typical cases.

Rhombohedral System.—1deg. Beryl.—The first piece experimented on was a large crystal of beryl. It is a hexagonal prism with basal planes. The specimen examined has each face 11 × 5cm. The three axes lying in the same plane are inclined at 60deg. to each other, the fourth axis which is also the optical axis, is at right angles to the plane containing the other three. This crystal was optically opaque. On interposing this block with its principal plane vertical, the galvonometer spot flew off the scale. The crystal had thus produced the well-known depolarising action. The crystal was now gradually inclined till its principal plane coincided with the polarising plane of the polariser. There was now no action on the galvanometer. On continuing the rotation the galvanometer at once responded. The spot became quiescent a second time, when the principal plane coincided with the polarisation plane of the analyser. The crystal was now placed with its optic axis parallel to the direction of the incident ray. There was no action on the galvanometer. Rotation of the crystal round this axis did not produce any effect on the galvanometer. The field continued to be dark.

(*2deg. Apatite.*)—This specimen exhibited decided double refraction. (*3deg. Nemalite.*)—This is a fibrous variety of brucite. This specimen exhibited a very strong depolarisation effect. It also exhibited certain interesting peculiarities which will form the subject of a future communication. (*Rhombic system.*)—A large piece of barytes was found strongly double refracting. (*Triclinic system.*)—Microcline, a greenish blue crystal of the double oblique type, exhibited polarisation effect to a remarkable degree. (*Regular system.*)—A large crystal of rock salt was taken. This, as was expected, did not produce any effect.

Having satisfied myself of the fact that systems of crystals other than regular, produce double refraction and consequent polarisation of electrical ray, I tried the action of electric radiation on crystals ordinarily used in optical experiments. I got a fairly large piece of black tourmaline. On interposing this with its plane vertical, there was prompt movement of the spot of light. There was no action on the galvanometer, when the principal plane coincided with the plaue of polarisation of either the polariser or analyser. With ordinary light a piece of tourmaline of sufficient thickness absorbs the ordinary, but transmits the extraordinary ray. With the piece of tourmaline used in the last experiment I found both the rays transmitted, but, it seemed to me, with unequal intensities. In other words, one ray suffers greater absorbtion than the other. It seems probable that with greater thickness of crystal one ray would be completely absorbed. I found other crystals behaving more or less in the same way. I reserve for another communication particulars of experiments bearing on this subject.

Lastly I tried an experiment with a crystal of Iceland spar, taken out of a polarising apparatus. With this I got distinct depolarising action.

The above results, with the exception of the last, were obtained with uncut specimens. Their faces were often rough and irregular. Better results, were they needed, could no doubt be obtained by judicious cutting and polishing the faces.

Summary.

It will thus be seen that crystals which do not belong to the regular system polarise the electric ray, just in the same way as they do a ray of ordinary light. Theoretically all crystals, with the exception of those belonging to the regular system, ought to polarise light. But this could not be verified in the case of crystals opaque to light. There is no such difficulty with electric rays, for all crystals are transparent to them. As a matter of fact, all the above experiments, with one exception, were performed with specimens opaque to light.

ON DOUBLE REFRACTION OF THE ELECTRIC RAY BY A STRAINED DIELECTRIC.*

BY PROF. J. C. BOSE, B.A., B.SC.

The following investigations were undertaken to find whether a dielectric becomes double-refracting to the electric ray when the substance is subjected to a molecular stress by unequal expansion due to heat, or is mechanically compressed. The electric polarisation apparatus, previously described (see page 289, *ante*), was used for this experiment. The analyser and the polariser were crossed, each being inclined at 45deg. to the horizon. The strained substance was then introduced between the crossed analyser and polariser :—

Effect due to Unequal Expansion.—I cast a rectangular piece of paraffin, and placed it, while still hot, in a freezing mixture. The surface was thus chilled. On interposing this between the polariser and the analyser, the galvanometer spot was at once deflected, proving the double-refracting nature of the strained paraffin. The piece was cast six months ago. It has retained its unannealed property even now.

* From the *Journal* of the Asiatic Society of Bengal.

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Effect due to Compression.—It appeared to me that stratified rocks, which, from the nature of their formations, were subjected to great pressures, would serve well for the purpose of my experiment. My anticipations were verified, as the following experiments will show: I took a cube of sandstone, about 5cm. on each side, and held it between the polariser and the analyser, *with the plane of stratification vertical* and parallel to the direction of the ray. The galvanometer at once responded. I then rotated the piece of rock, and adjusted it with its *plane of stratification parallel to the vibration plane of the polariser. There was now no depolarisation effect*, the galvanometer remained unaffected. On further rotation in the same direction, the depolarisation effect reappeared, to disappear again, when the plane of stratification was made parallel to the vibration plane of the analyser.

I repeated this experiment with many other rocks with the same result.

ON A NEW ELECTRO-POLARISCOPE.*

BY PROF. J. C. BOSE, B.A., B.SC.

In a Paper read before the Asiatic Society of Bengal on "Polarisation of Electric Rays" in May last (see page 289 *ante*) I gave an account of some experiments which showed that crystals which do not belong to the regular system, produce double refraction of the electric ray; and that the refracted beams are plane polarised. Among the numerous crystals examined, I found nemalite, a fibrous variety of brucite, polarising the transmitted beam. The crystal also possesses the remarkable property of extinguishing, more or less, one ray and transmitting the other. A piece of tourmaline also produces the same effect, though to a less extent.

I interposed a piece of nemalite between the crossed electric polariser and analyser. In certain positions of the crystal, the radiation was restored. I then superposed a piece of tourmaline on the nemalite, the two pieces being parallel. The electric ray was now found quenched. If the vibration plane of the transmitted ray in tourmaline is parallel to the length, the vibration plane of nemalite would appear from this experiment to be perpendicular to the length. This was verified by crossing the interposed crystals. The vibration planes are then parallel and the electric ray was found transmitted through both.

I found many crystals of a fibrous nature, exhibiting this property of transmitting the ordinary and the extraordinary rays with unequal intensities. It is thus possible to quench one of the two rays by taking a crystal of sufficient thickness. Serpentine exhibits this property to a marked degree. Different varieties of satin spar are also very effective.

I next tried to construct a polariscope for the electric ray. My first attempt in this direction was to get rid of one of the two rays by total reflection. Calc spar could be used for this purpose; a piece of beryl when properly cut would act still more efficiently. But crystals like nemalite offered greater facilities of construction as one of the two rays is absorbed by the crystal itself. The polariser and the analyser may thus be made of nemalite, tourmaline or serpentine. To ensure a complete polarisation in one plane, a compound polariser could be made by crossing the tourmaline and the nemalite.

The above-mentioned crystals, none of which were very perfect, were kindly lent to me by the authorities of the geological department. I mounted them on temporary supports, and obtained with them satisfactory results. As none of the above crystals can be bought in India, I have to wait for a supply from dealers in Europe. These crystals, when properly cut and mounted, will, I expect, prove to be very efficient polarisers.

In the meantime I have been experimenting with other substances more easily accessible. I discovered that human hair polarises the electric ray. Wool and silk are also good polarisers. One of the most efficient substances for the purpose of polarisation is common jute. I cut fibres of this material 5cm. in length, and built with it a cube with all the fibres parallel. The cube was afterwards mounted in a tube. Two such cells may be used, one as the polariser, and the other as the analyser. The complete polarisation apparatus consists of a radiator emitting electric rays of short wave-length, an analyser and polariser, and a receiver for detecting the radiation. I give below an account of the improved apparatus.

The Radiator.

The electric sparks are produced between two small brass beads and an interposed gilt metallic sphere (*see* Fig. 1). This arrangement, as was shown by Prof. Lodge, produces oscillatory discharge, and the discharge is not much affected by the nature of the surface. In the centre of an ebonite piece is fixed a gilt brass ball 1cm. in diameter. Two jointed electrodes carry two beads at their ends; the distance between the beads and the interposed ball can thus be adjusted. This is a matter of importance, as the receiver does not properly respond when the spark length is too large. The metallic ball may be turned round to expose a fresh surface. The two electrodes press against two springs in connection with an electric machine. The electric generator may be an influence machine, enclosed in a metallic box. I found considerable difficulty in working such a machine in the excessively damp climate of Calcutta. I got over the difficulty by making a Voss machine with ebonite. The machine is enclosed in a metallic box, with an inlet pipe at the top and an exit pipe at the bottom. Air is blown through a calcium chloride tube by means of bellows; the air may be slightly warmed. By working the bellows for a minute or two all moisture is expelled. The tubes may now be closed; the machine will now work satisfactorily for hours even on a most rainy day.

A small Ruhmkorff coil offers some special advantages. It occupies a smaller space, and is easily worked when the modifications mentioned below are introduced. I have discarded the use of the usual vibrating interrupter. The interrupter often fails to produce oscillatory discharge; the sparking balls are worn out by long-continued action, and the battery power becomes unsteady. A single flash of radiation is all that is required. This can be easily obtained by a single sudden break at the primary current; very little battery power is used, and the sparking balls are little affected. In the modified coil there are two condensers and two keys. When the current through the primary is kept flowing always in the same direction the discharge after a time becomes irregular. By alternately pulling the two strings in connection with the two keys the current may be sent in one direction or the other. The keys are provided with springs for the break to be sudden. Instead of two condensers, a single condenser and a reversing key may be used. But for various reasons the arrangement mentioned above is the best.

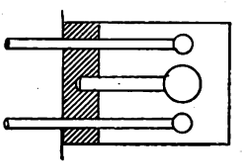

Fig. 1.

The Analyser and the Polariser.

Three different kinds of polarisers may be used:—

(1). *The Jute Polariser.*—I find some difficulty in keeping the fibres accurately parallel, and the transmitted radiation is not, therefore, completely polarised. The absorption of one of the two rays is not complete unless a polarising cell with a great thickness is employed. I am constructing a second pair of cells which will, I expect, be more efficient.

(2). *The Nemalite Polariser.*—A thickness of about 5cm. would produce a fairly complete polarisation.

(3). *Wire-grating Polariser.*—Copper wire about 2mm. in diameter is carefully wound round a thin piece of mica, and the mica immersed in melted paraffin. The wires are thus permanently fixed. There are about 25 wires in 1cm. Four circular pieces are cut out of the grating. Two of these are fixed parallel at the two ends of a tube 5cm. long and 5cm. in diameter. The polariser and the analyser thus made are very efficient.

The Receiver.

I find the following modified form of the "coherer" possessing very great sensitiveness. It has the additional advantage of not losing its sensitiveness:—In a circular piece of ebonite depressions are cut out for the reception of coiled steel springs of a small diameter (*see* Fig. 2). A brass piece slides in or out by the action of a screw. The springs may in this way be gradually compressed, with a corresponding diminution of the resistance. By a slight rotation of the screw the galvanometer spot can easily be brought to the false zero point of the scale. The contact points in this arrangement are numerous and the effective surface very large. The resistance of the receiver varies within wide limits. The receiver I use gives the best result when the resistance is reduced to about 4,000 ohms, the corresponding current circulating round

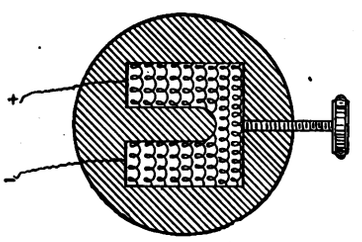

Fig. 2.

* From the *Journal* of the Asiatic Society of Bengal.

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the circuit is then about $\frac{1}{10000}$ ampere. The incident electric radiation reduces the resistance to about 10 ohms or less. The sudden fluctuation of the current, due to the diminution of the resistance, produces a deflection of the spot of light. I use a couple of these receivers, mounted at the two ends of a tube. One of the receivers, say, one to the left, is put in action by screwing the corresponding screw and unscrewing the other. If by any accident (which hardly ever happens) one receiver becomes less sensitive, the other is brought to the front by turning the receiving tube round the vertical axis.

The galvanometer used is a dead-beat d'Arsonval one. It has a resistance of 300 ohms. I find a small E.M.F. best suited for ordinary experiments. The galvanometer spot may then be adjusted with the greatest ease. By increasing the E.M.F., the sensitiveness is increased till the spot becomes unsteady. By shunting a single Daniell cell with a resistance box, the E.M.F. may be gradually varied. At the beginning an E.M.F. of 1 volt is sufficient. After a time the sensitiveness of the receiver begins to diminish. To increase the sensitiveness, the E.M.F. may be gradually raised to 1 volt. An E.M.F. of about 0·5 volt is best for all-round work. To obtain this I made a copper-iron cell, the iron rod being immersed in a solution of ferric chloride and the zinc in sulphuric acid. This gives a fairly constant E.M.F. Its value is about 0·45 volt.

THERMAL PHENOMENA OF DISCHARGES IN DERIVED CIRCUITS.*

BY PROF. P. CARDANI.

In a note which I published last year,† I had occasion to point out that the problem of the resistance offered to discharges by conductors is not completely solved by Lodge's experiments. In these experiments the chief element was the spark passing between the knobs of a spark gap introduced in one of the derived circuits, and the presence of this spark would necessarily render the phenomenon itself more complicated.

The production of the lateral discharge, as this spark is called, depends essentially upon the manner in which the potential is distributed in the chief circuit at the commencement of the discharge. In the case of continuous constant currents the distribution of the potential simply depends upon the resistance of the circuit; in the case of variable currents we must also take into account the phenomena of self-induction, which influences this distribution in two ways: firstly by the E.M.F.'s. generated, and secondly by changes in the resistance of the conductors.

It is, in fact, well known that continuous constant currents are distributed uniformly throughout the section of the conductors, while in variable currents, such as alternate currents, the phenomena of self-induction condense the current towards the surface into a thinner and thinner stratum as the rate of alternation increases. When these alternations are extremely rapid, as in the discharge of a condenser, the current is crowded into an extremely thin surface layer, which serves to guide it.

If, then, we intend to measure the resistance of a conductor to a discharge from the maximum difference of potential manifested at its ends during the discharge itself; if, in other words, we measure the resistance of a conductor by the total obstruction or impedance which it offers to the discharge, as was done by Lodge, we may measure this resistance by the maximum length of the spark passing in the derived circuit, since this lateral spark depends upon the maximum difference of potential at the points of derivation. But as soon as sparking sets in in the derived circuit the conditions of the phenomenon are changed. As I have shown in the Note above referred to, the spark plays the part of a metallic conductor closing the circuit through the spark gap; the discharge circuit, formerly consisting of a single conductor, is modified by the closing of the derived circuit. In this second period of the discharge the total resistance of the circuit must be different from the initial resistance, and the distribution of the potential must be correspondingly different.

What the true resistance of the conductors in the derived circuits during this second period is, how this resistance is affected by the form and nature of the conductors and of the surrounding dielectric, what the influence of the quantity of electricity concerned or the initial potential is—all these are problems, and not the only ones, that are left unsolved by Lodge's interesting experiments.

The question of derived discharges, therefore, presents itself under two completely different aspects: in one, we suppose but one of the derived circuits is interrupted, and we inquire into the conditions of its being closed by a lateral discharge, and into the behaviour of the conductors which make up the uninterrupted branch; in the other, we suppose that the two derived circuits are continuous, which includes the preceding case from the moment that the lateral discharge closes the spark gap of the derived circuit, and we find, under these entirely different conditions, the resistance opposed to the discharge by each branch circuit.

Under the first aspect the resistance may be measured by the maximum length of the spark in the derived circuit; under the second the resistance of the conductor can only be found *by measuring the thermal effects produced in the derived circuits.*

The Apparatus.

In all the experiments a Voss machine was used with a rotating disc of 92cm. The condenser consisted of 40 jars 40cm. high and 13cm. in diameter, coated with tinfoil. Those 40 condensers were coupled up in four batteries; two of these were insulated and arranged in cascade under the two others whose external coatings were connected with each other and with earth. The inner coatings of the two insulated batteries communicated with the poles of the machine, between the terminals of which sparks 20cm. long could be obtained by using the whole battery.

From the same inner coatings of the insulated batteries was derived the circuit guiding the discharge, and to this circuit, consisting of brass tubes about 1cm. thick, were attached an adjustable spark gap, and the derived circuit in which the thermal effects were to be measured.

The thermometers employed were similar to those used last year.

A platinum wire 0·03cm. in diameter occupied the axis of a glass tube (Fig. 1), and traversed two brass rings, A, B, fixed at the ends of the tube with sealing wax. The platinum wire was well stretched and then soldered to the rings. The ring A bore the bent tube C, to which a forked glass tube, D, was fixed by means of sealing wax. One of the arms, DE, ended in a capillary tube serving for the measurements, and chosen of the best calibre; the other arm, DF, served to fill the whole thermometer with petroleum. For this

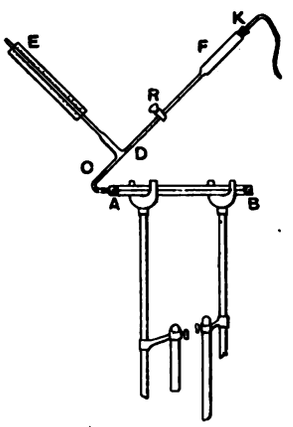

FIG. 1.

purpose there was a tap, R, in the arm, and it ended at the top in a kind of receptacle closed by a cork, K. The latter was traversed by a glass tube attached to an india-rubber tube. Petroleum was introduced into the receptacle, and with judicious compression and aspiration the whole thermometer was filled with petroleum, taking care to drive out all the air. After closing the tap any variation of temperature of the petroleum was indicated by a displacement in the capillary tube. This thermometer also acted as a calorimeter, and measured the amount of heat gained or lost during any interval of time.

To measure the amount of heat developed in the thermometer by a given discharge, the number of degrees was read by which the meniscus of the petroleum was displaced during the minute preceding and following that in which the discharge took place. The mean of these gave the displacement of the meniscus at the time of the experiment by the exchange of heat between the thermometer and its surroundings; adding or subtracting the number thus obtained, accordingly as the thermometer received or lost heat with respect to its surroundings, to or from the number of divisions through which the meniscus travelled in the intermediate time under both influences, the difference or the sum gave the number of divisions corresponding to the heat developed by the discharge. This number, being proportional to the heat developed, could be taken as a measure of the thermal effect due to the discharge.

The Experiments.

Preliminary experiments showed that if one of the branches of the derivation consists of an homogeneous wire, of which one part (that forming the thermometer) is immersed in petroleum and another is open to the air, the quantity of heat is the same as if the whole were immersed in petroleum, and the total quantity of heat developed in the whole of the derived circuit is to that

Nuovo Cimento, 4, 2, p. 69, 1895 (abstract). †*Ibid.*, 3, 36, p. 142, 1894.

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developed in the thermometer as the total length to the length in the thermometer.

As regards the definition of equal resistances, we may say that two conductors offer equivalent resistances to a certain discharge from a condenser if, when placed successively in one of the branches of a derived circuit, the other remaining constant, they lead to the evolution of the same quantity of heat.

For comparing the resistances of the various conductors I used the method described in the note previously referred to, which I shall now develop in greater detail.

Let a divided circuit be formed by two homogeneous wires, one of constant length L_1 and the other of variable length L_2. This length L_2 can evidently be varied from 0 to ∞, by immediately joining A and B, or by breaking the circuit L_2.

If we determine the quantity of heat developed in L_1 by successively varying the length of L_2, and substitute for L_2 the conductor whose resistance is to be determined, we may from the quantity of heat developed in L_1 determine what length of the conductor first making up L_2 would offer an equivalent resistance.

This principle, which would be evident with ordinary currents, I have thought of sufficient importance to be experimentally proved for the case of discharges.

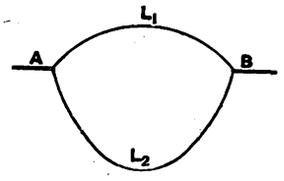

FIG. 2

It is based, in fact, upon the assumption that to every value of heat developed in L_1 there is a corresponding determinate and *unique* value for the heat developed in L_2. This might not apply to currents for which self-induction assumes a preponderating character to such an extent as to render the laws of propagation of these currents in conductors entirely different from those governing the propagation of ordinary currents. But experiments (described in detail) prove that the above principle holds good for every kind of discharge. It was also found that variations in the area embraced by the divided circuits do not sensibly influence the thermal phenomena. The phenomena of self-induction always had the effect of apparently shortening the length of L_2.

The final arrangement adopted consisted of an invariable branch containing the thermometer A, 200cm. long, and of a variable branch, which was successively given the lengths 30, 40, 50, 75, 100, 125, 150, 175, and 200cm. With these a very large number of measurements were made, so as to ensure constancy of conditions. The thermometer A was observed every minute. The sparking distance was kept constantly at 2cm. The wires experimented upon were of copper, brass, iron and platinum.

As regards diameters, it appears that the behaviour of the different metals is sensibly the same, and the resistance decreases

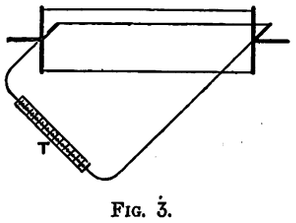

FIG. 3.

gradually as the diameter of the wire increases, but the law of variation is totally different from that for ordinary currents. The results of these thermal experiments distinctly bring out this influence of the diameter, whereas Lodge's and Murani's investigations by the spark length of the lateral discharge show independence of the diameter.

The behaviour of very fine wires is specially interesting. In copper and brass it appears that the resistance of the wires assumes a maximum value for a certain diameter, so that for still smaller values the resistance begins to *decrease*. For iron wires, on the other hand, the variation is regular, at least down to diameters of 0·017cm., the smallest I have tried. The behaviour of platinum is very curious. The resistance at 0·03cm. diameter is practically equal to that at 0·06cm., but the resistance of the wire 0·01cm. thick is exceedingly high compared with all the other wires. Four wires twisted together, with an equivalent diameter of 0·02cm., gave about the same resistance as a wire of 0·03cm. The resistance of very thin platinum wires undoubtedly increases very rapidly as the diameter decreases. I shall probably deal again with the thermal phenomena of very fine wires.

Excluding this case, in which all the metals appear to behave in a special manner, it may be said that the chemical nature of the metals has little effect upon their resistance. Here Lodge's results and mine agree.

The comparison of the results obtained with iron and copper respectively is of special interest. From Lodge's experiments the resistance of iron appeared to be smaller than that of copper. Murani obtained the opposite result, but the differences were small and doubtful, and probably depended upon the special conditions of discharge. The experiments made by Lord Kelvin seemed to prove the decided superiority of copper over iron for conducting the discharges. My results prove that for larger diameters copper and iron wires behave in an identical manner, but that for small diameters iron is more highly conducting than copper. Thus, for the common diameter of 0·136cm., the length of platinum wire giving a resistance equal to that of 100cm. of copper wire is 97·5, while for iron wire it is only 93. These results agree with those obtained by Villari.

Brass shows the same behaviour as copper and iron at larger diameters. At small diameters it has less resistance than copper. Platinum, in the case of the two larger diameters (0·06cm. and 0·03cm.) employed, was a better conductor than any other metal.

A case deserving of special consideration is that of multiple derivation. The experiments were made in the following manner: To the two terminals were fixed two stout conductors at right angles to them (Fig. 3). Each had a length of 10cm., and to these the wires were soldered. Each wire was 100cm. long. Another circuit contained the thermometer A, as before. It was found that these multiple circuits, when the wires are sufficiently far apart, give resistances incomparably smaller than those with single derivations of equivalent section. The resistance varies, in fact, inversely as the number of derivations. Wires twisted together offer a resistance equal to that of a single wire of section equal to that of the sum of the sections.

The results given up to the present refer to the resistance of conductors when all the experimental conditions are left unaltered, such as the form of the conductors, the capacity of the condensers and the sparking distance, and hence also the quantity of electricity; finally, the resistance of the discharge circuit. But in order to draw some conclusions of general import it is necessary to examine in what manner the results are modified by changing those conditions of the experiments. With this I shall deal very shortly in a second part of the present Paper.

PHYSICAL SOCIETY.

At a special general meeting, held on December 13, 1895, Prof. Reinold (Vice-President) in the chair, the resolution with reference to the change in the amount of the life composition fee, passed at the special general meeting held on November 22nd last, was confirmed. The ordinary meeting was then held.

Dr. JOHN SHIELD read a Paper

"On a Mechanical Device for Performing the Temperature Corrections of Barometers."

The form of barometer to which the author has adapted his device is that devised by Dr. Colley; it is intended for general laboratory use, and is capable of being read to within 0·1mm. The barometer tube can be moved in a vertical direction so that the lower meniscus can be adjusted to the zero of the scale. Attached to the barometer tube is a thermometer with a horizontal stem, passing in front of a scale which is fixed to the vertical scale of the barometer. The graduations of this thermometer scale, with the exception of the one passing through the 0°C. mark on the thermometer, are inclined to the vertical, and are so spaced that the reading opposite the end of the mercury column of the thermometer gives directly the correction to be applied to the observed height of the barometer (B_t) in order to obtain the reduced height (B_0). That is, the reading on the thermometer scale gives the value of $B_t(\beta - \gamma)t$, where β and γ are the coefficients of expansion of mercury and of the material of which the barometer scale is composed respectively, and t is the temperature.

Mr. BOYS admired the simple method the author had adopted for plotting the corrections, and said he always felt that the trouble involved in applying small corrections ought, if possible, to be avoided, or the corrections would often be omitted.

Mr. APPLEYARD advised the placing of the bulb of the thermometer within the barometer tube.

Dr. SHIELD, in his reply, said as the barometer was only intended to read to 0·1mm., the placing of the thermometer within the tube did not appear necessary.

A Paper by Prof. RÜCKER, on

"The Existence of Vertical Earth-Air Electric Currents in the United Kingdom,"

was, in the absence of the author, read by Mr. KAY.

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In a Paper read before the British Association at Oxford, Dr. Schmidt stated that he had expanded the components of the earth's magnetic force in series, and had deduced expressions, two of which give the magnetic potential on the surface of the earth, in so far as it depends on (1) internal and (2) external forces. "The third series represents that part of the magnetic forces which cannot be expressed in terms of a potential, but must be due to electric currents traversing the earth's surface." Dr. Schmidt concluded that such currents amount on the average to about 0·1 ampere per square kilometre. The author has tested this conclusion, drawn from the state of the earth as a whole, by means of an examination of the line integral of the magnetic force taken round a re-entrant circuit taken in the United Kingdom. The necessary data have been obtained from the results of the magnetic surveys for the epochs 1886 and 1891, carried out by the author and Dr. Thorpe. Two circuits, called the α and β circuits, were selected, having their greatest extension N. and S. and E. and W. respectively. The work done by a unit magnetic pole on traversing these circuits was calculated for the epoch 1886 by means of the terrestrial lines found for that date, and also for the epoch 1891 by means (1) of the same lines when due allowance was made for secular change, and (2) of the independent set of lines found by aid of the 1891 survey. The same calculation was made for a third circuit (γ) using instead of the calculated terrestial lines the true values of the forces and declinations as deduced from the nearest stations. The following table gives the results in amperes per square kilometre :—

——	α	β	γ
1886	−0·026	−0·004	...
1891 (1)	+0·001	−0·005	...
1891 (2)	...	...	−0·008

From these figures the author concludes that there is not, in the United Kingdom at any rate, a vertical current amounting on the average to 0·1 ampere per square kilometre.

Mr. WATSON said a few words on the difficulty experienced in determining the line integral in South Wales due to the presence of closed curves.

The Society then adjourned till January 24th, 1896.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December 13, 1895.*

Fundamental Trolley Patent Sustained.—A Federal Court has sustained the fundamental Van Depoele patent on the under-running electric railway patent, the application for which was filed in 1887 and the patent granted as recently as 1893. This decision, if sustained by the higher Court to which it will be appealed, will introduce serious complications in the electric railway industry, as it recognises the fundamental claims of the patent in suit, which appear to cover every possible form of under-running trolley. The opinion of the Court admits that numerous forms of trolleys had early been devised for railway train signalling and lighting purposes, eleven of which were for under-running trolleys; also, that the "third-track trolleys" of Edison and Daft, which antedate the Van Depoele patent in suit, are devices of substantially the same construction as the latter. The argument of the defence that it was only necessary to turn the Daft and Edison devices over in order to obtain the Van Depoele invention is met by the Court with the answer that these devices would not have possessed the vital feature of providing capacity for universal movement, and it is upon this consideration that the patent is sustained. The Court, in fact, held that when Van Depoele reversed the trolley of Daft and Edison and added capacity for lateral and vertical motion, and thus "disclosed to the public a practically operative means, such as the whole world had heretofore sought in vain, he made an invention within all the rules applicable to this question." The several elements of this addition were the long "upwardly spring-pressed" pole, its pivotal support and lateral hinge, which, in the eyes of the Court, caused the electric railway to pass at a bound from an experimental and impracticable state to that of a completed art.

An Electric Elevated Railway in a Snowstorm.—During a recent severe snowstorm in Chicago traffic on all of the street surface roads in the city—trolley, horse and cable—was suspended, while the electric elevated road continued in full operation, carrying not only its usual quota of passengers, but most of those left unserved by the surface lines.

Trolley Trouble in Philadelphia.—The Quaker city is stirred up by the recent action of the street railway monopoly of that place in abolishing transfers on certain portions of its system. The traction interests some months ago procured the passage of an Act—by equivocal means, it is charged—enabling the consolidation of the various important roads of Philadelphia into a single company, and recently parts of the transfer system, in force before the consolidation, were abolished. A mass meeting, at which there was an attendance of 5,000, held to protest against this action, was addressed by an ex-Governor and other leading citizens, and sweeping denunciations were made of the street railway monopoly and of the legislative action which placed the people in its power. It was proposed, if the Traction Company did not come to terms, to procure the construction of elevated railways and agitate for the purchase and operation by the Municipality of the city surface roads. It is not at all probable, however, that this latter will be done in any event, as the knowledge of the political corruption experienced in connection with the municipal gas plant will deter such action.

CORRESPONDENCE.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At the annual general meeting of the Institution of Electrical Engineers, held at Great George-street on Thursday last, I addressed the members and proposed a resolution which appeared to meet with nearly unanimous approval.

From the remarks of one or two speakers it became evident that the resolution was not clearly understood, and as some time will elapse before the issue of the *Journal*, I think it desirable, in order to prevent misconception, to give you for publication an exact copy of the words used.

In opening the discussion I said (reading from a written memorandum):—

"I observe with regret that the Council, in their Annual Report, have not asked the Institution to grant them increased facilities for obtaining the opinions and advice of members on matters affecting the welfare of the Institution."

And in concluding I proposed the following resolution:—

"That this meeting considers it desirable to form a Committee to represent the views of the members in consultation with the Council, and such Committee is hereby constituted with the following members:—(London) A. A. C. Swinton, E. Manville, R. P. Sellon; (Liverpool) A. B. Holmes; (Manchester) W. P. J. Fawcus; (Newcastle) A. W. Heaviside; (Glasgow) H. A. Mavor; (Birmingham) J. C. Vaudrey, with power to add to their number."

The wording of the above resolution was defective in that it did not describe the proposed Committee as temporary. I may also state that there was no intention to invest the Committee with legal powers. The honorary solicitor ruled that the resolution was out of order, and the President recommended that an extraordinary meeting of the members should be specially called to discuss it.

Personally I am sorry that this course has been recommended, as it will tend to give the discussion a more belligerent tone than I had any intention of imparting to it. There is no question at issue between the members and the Council, and so far as my knowledge extends the members are not only satisfied with, but also proud of their Council. There is, however, a strong feeling that the Council is hampered in interpreting the wishes of the Institution by the existing rules, which do not provide any simple and constitutional means of communication between the Council and the body of members. This defect in the constitution is not a mere creation of the imagination, but a fact attested by actual experience. At the same time I imagine it is a defect which the Council will be

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as eager as the members to see remedied. An extraordinary general meeting is at best a clumsy contrivance and ought to be resorted to in extreme cases only, or for the purpose of altering the rules.—Yours, &c., JOHN S. RAWORTH.

December 16, 1895.

[We regret that, owing to non-receipt of corrected proof, this letter was not inserted last week when editorial reference was made to it.—Ed. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Some years ago I found myself in identically the same position as Mr. Raworth was at the last annual meeting, and although the proposals I wished to make were, I think, calculated to enhance the usefulness of the Institution, I refrained from getting 10 members to ask for an extraordinary meeting. Put it as we will, an extraordinary meeting convened at the request of members has an appearance of hostility to the Council, which none of us want. I venture, however, to express the hope that the Council will themselves appoint a Committee for the purpose of considering whether a revision of the rules has not, by reason of the vast increase of members, become advisable. If the Committee arrive at the conclusion that the rules may be improved upon, the proposed revision could be circulated amongst the members, and the Council themselves might call an extraordinary meeting.

Having said so much, perhaps one ought to suggest one or two alterations that seem worth consideration. Do we not use up our presidents too quickly? Why should they not keep office for two years? As to qualification, the second rule is, to say the least, vague. Is it not an anomaly that the senior vice-president should be entitled in the absence of the president to preside at a Council meeting, and yet may by some not be considered eligible for the office of president? And last, though not least, surely in a large institution such as ours has become there ought to be some legitimate and recognised method by which members may at the annual meeting bring forward proposals for the benefit of the Institution without being placed in the invidious position of being obliged to move an amendment on the report of the Council. —Yours, &c., S. FLOOD-PAGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It does not appear to be disputed by anyone that, owing partly to the rapid growth of electrical industries in several directions, and partly to progress in people's ideas as to the functions and scope of representative professional institutions, the methods, organisation and procedure of the Institution of Electrical Engineers have fallen somewhat behind the times, and are no longer adequate to represent properly either the aims or the requirements of the profession.

That under these circumstances there should be discontent and agitation is only natural. That, in the onset, this agitation should be obscure in its origin and indefinite in its objects almost absolutely follows, when the diversity of the interests depending on electricity is considered. For discontent and dissatisfaction to grow would be very undesirable, while there is every reason for trying to satisfy those aspirations of members which are legitimate, and for endeavouring to make the Institution as representative, useful and up-to-date an organisation as possible. There is therefore no reason for either haste or secrecy, nor for anticipation that the existing Council of the Institution would meet any well-considered and influentially-backed suggestions in other than a friendly spirit. It is therefore most desirable that any schemes of reform or alteration should be brought forward openly, be debated carefully, and should be finally put forward only if there is a considerable body of opinion in favour of them.

Granted that a representative meeting of members were called, and that they, after discussion, appointed a committee to consider the matter, it may be asked what form the suggestions of that committee should take.

Before going into this it appears important to take into consideration what is the position of the Institution and its members at present. It is obvious that the members are firstly divided into broad groups comprising telegraphy, telephony, electric light and power, and electro-chemistry. Each of these groups again comprises consulting engineers, manufacturers, contractors, executive engineers, besides educationalists and some smaller sub-divisions. No argument is needed to show that there is much diversity of aim and interest in the main groups alone, not to speak of their sub-divisions. It is also pretty clear that these groups will tend to differentiate still further in time. It is also manifest that all these groups of industries are increasing in importance and advancing at a rapid rate.

This heterogeneous mass of members is represented at present by a Council consisting of 13 *ex-officio* past-presidents (with full voting powers), 1 president, 4 vice-presidents, 12 full members of Council, 3 associate members of Council: a total of 33 voting members of Council.

Of these 33 voting members 14 are perpetual, and 4 nearly perpetual, so that the balance of voting power always lies with the perpetual members; besides this, the latter have all the moral advantage which continuity gives. The 3 associate members, of course, do not count for much, their position being a semi-honorary one.

The real representation of the body of members, numbering 1,700, is therefore confined to the ordinary members of Council, who only amount to 14, and of whom only three are, except in case of vacancies, elected annually. The new blood which can thus be introduced is only 10 per cent. of the Council annually, even if no members are asked to serve a second period, which is often the case. When it is further recollected that out of the four places, which is about the number vacant annually, and open to the introduction of new blood, places must be found for representatives of the army, navy, occasionally of the law, and sometimes of electrical finance, it needs no argument to show how ridiculously small must be the representation of that vast body of men who, not to include telephony and telegraphy, have been pouring into the electrical industry proper during the last 10 or 12 years at the rate of many hundreds a year. With the present constitution and at the present rate of progress, which bids fair to be maintained at any rate for some years, the representation of this great and increasingly influential body of men must become more and more inadequate unless something is soon done to put matters on a more up-to-date footing.

The question then becomes what line these reforms should take. This is evidently very debatable, but it seems to me that something on the lines of the following suggestions would meet the difficulty fairly.

In addition to the present Council, which might remain as it is, three permanent committees might be appointed—one to represent Telegraphy and Telephony, one for Electric Light and Power, and one for Electro-chemistry. Each of these committees should consist of about six members, under the presidency of a senior member of Council or Vice-President. Three members of each committee might retire annually, and three new ones be elected annually by the Society. These three committees could make any recommendations they pleased to the Council through their President, and such recommendations might be in writing and could be published in the *Journal*, together with the Council's replies, favourable or otherwise, in which way members would have some idea of what was going on. These committees need have no executive power except through the Council; but they would be in much closer relations with the particular group they represented than the Council are now, and would know the requirements of their constituents much better, and as at least nine new men would be needed each year in addition to those now required, it would offer an opening for the infusion of sufficient new blood, while each branch of the electrical industry would feel that there was a body to look specially after their interests. The committees would also form an avenue to the Council.

The above is, of course, a mere outline, but it would appear as if, in some such way as sketched above, adequate representation of all the groups of members could be secured for some time to come, while the usefulness and progressiveness of the Institution would be much increased, without upsetting existing arrangements.

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There are, it seems to me, a number of important and pressing questions which the strengthened Council could then deal with, and which would add immensely to the utility of the Institution if properly taken up, besides which its prestige and capacity for promoting the interests and convenience of members would be much increased.—Yours, &c.,

G. L. ADDENBROOKE.

December 21, 1895.

P.S.—At the Royal Photographic Society, the allusion to which so amusingly excited Mr. Campbell Swinton's ire at the general meeting, great benefits have arisen from a scheme of affiliation by which local and provincial societies are kept directly in touch with the senior Institution.

TELEGRAPHY IN LONDON: 1847-1895.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has just been drawn to a paragraph which appears in a contemporary, stating that the new Post Office telegraph station at St. Martin's-le-Grand is the largest establishment of the kind in the world, some 3,000 operators being engaged within its walls.

There can be but few of your readers who will be able to realise, personally, the difference between the result of what the above statement conveys and the status of the electric telegraph in England not quite 50 years ago, when London had *no* telegraph, as we understand it now, just as only about 10 years before that it had *no* railway either. These are two facts within my own ken; for about 60 years ago I played cricket with schoolfellows at Willesden on ground that was soon after appropriated by the London and Birmingham Railway Company for the construction of the first line into the metropolis. I fix this date also by having been present at a meeting between Mr. Ericson (of American "Monitor" fame), then on the staff of surveyors for George Stephenson, and my father, who at that time was building houses in the neighbourhood of the proposed railway route nearer London, on which work had not been commenced.

It was not until 1847 that London had its first telegraph office for the reception of private messages for transmission to other places. I am able to fix this date, too, for, beside having the charge of lines leading to it, I had the responsibility of this first office in addition. I will admit it was not much of a charge after all; but it is just the little it was that I wish to draw your attention to—the object of this letter, in fact.

The first important move in the matter of telegraphs, in this country, took place in the year 1845; and by the beginning of the next year the Trent Valley from Rugby, the "Midlands," the "North Midlands" with Birmingham on the one side and Hull on the other, with Newcastle, and well on to Scotland, were all supplied with the telegraph for railway purposes. Other railways, with the numerous cities and towns on their lines, were soon included in the net; but London was *not* among them until the year 1847. This extension was effected at the cost of the Electric Telegraph Company, on the line of the London and North-Western Railway, in order to afford the metropolis the facility of telegraphing private messages all over the country.

Gutta-percha had not yet made its advent. Imperfect insulation was then the *bête noir* of the telegrapher, so underground wires of any length were not to be thought of. In consequence of this the London telegraph office had of necessity to be situate as near as possible to the Euston Station. For this purpose, then, a house in Seymour-street was secured—the third from the south-eastern corner of the crossing of that thoroughfare with Drummond-street. Here, with only three operators, the business of telegraphing all over Great Britain for a few months was accomplished; and my own part of the duty was easily got through, with the attendance of an hour or two, on two or three days of the week. For succeeding weeks the receipts for messages to all parts did not exceed £30; and even after two or three months' working, little progress was made towards increasing that amount; until at last I was able to congratulate the officers of the Company, at 345, Strand, on my having brought *£35* with me, in my cash box, as the result of *one week's* takings.

But, as if by magic—all at once, the impossible became possible of realisation—*gutta-percha* came to our rescue, and the Seymour-street office was without loss of time abandoned for Founders-court, near the Bank of England. From that moment, as might be expected, the greatest change came over the scene. We see the result of it to-day—a *thousand* operators employed where *one* sufficed then; and a hundred, doubtless, must now be engaged in the work of superintendence—that I was able then to get through in a few hours per week.

If you, Mr. Editor, think this little illustration of what must have been accomplished in telegraphy within the last 50 years, or less, would be interesting to some of your readers, I have great pleasure in placing it, or any part of it, at your service.—Yours, &c.,

J. W. WILKINS.

PRESSURES DANGEROUS TO LIFE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I be permitted to remind Dr. H. Lewis Jones of two deaths from alternating currents which he seems to have overlooked, viz., that of a sailor on board the Czar's yacht "Livadia," and that of a member of the orchestra at Aston Lower Grounds, Birmingham.

If my recollection of these fatalities does not mislead me, they were both caused by alternating-current Gramme machines, used with Jablochkoff candles. Each machine had four circuits, with five lamps on each, so that the pressure on each of the circuits, which were quite independent of one another, was about 250 volts.

Probably Mr. Applegarth could give precise information on these almost forgotten accidents, which occurred some 15 years ago.—Yours, &c.,

T. E. GATEHOUSE.

THE COST OF LIGHTING BY GAS AND BY ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The two letters referring to the above in your last week's issue will probably have struck many of your readers as being somewhat contradictory. The engineer of the Hastings Gas Company, very justly points out that nothing is gained by rival companies making erroneous statements to damage one another, and the vice-chairman of the same Company follows this up by repeating his original statement, viz., that gas at 8s. per 1,000 cubic ft. is one-third as cheap as electricity at 9d. per unit.

I think that Mr. Botley should have explained (since he now takes objection to some of the arrangements made by Mr. Trotter) that he was invited to be present at these tests to see fair play, but that he declined, his chief reason for doing so apparently being that he failed to understand why such tests were necessary.

Mr. Botley points out that the measurement of illumination is a very different thing to the photometrical examinations of the real value of different descriptions of light, and I am quite willing to admit that it is so, but the question that chiefly interests a customer is, not what is the photometric value of the two lights, but what will be the comparative cost of producing a certain illumination in his premises, whether gas or electricity be used.

Objection is raised to the gas burners tested; we endeavoured to be as fair as possible over these, and so got two local plumbers and gas fitters to lend us a selection of the burners they found from experience to be most generally used in Hastings. As the Sugg burner was a new one, if it was out of order, it shows they are very liable to get so, consequently it would hardly be fair for a practical comparison only to take the results to be obtained from a perfect one.

If the Gas Company, when endeavouring to persuade the Hastings public that electricity was three times as costly as gas, had explained that this statement did not apply to those who used 2½ to 3 watt lamps, or globes with their gas lamps, or flaring batswing burners, or Bray burners, or even Christi-

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ania burners—unless great care was taken to keep them always in perfect order—those to whom it did refer would have been so few that the Electric Light Company would never have needed to call in Mr. Trotter to their assistance.—Yours, &c., L. Andrews, Engineer and Manager to the

Hastings and St. Leonards Electric Light Company

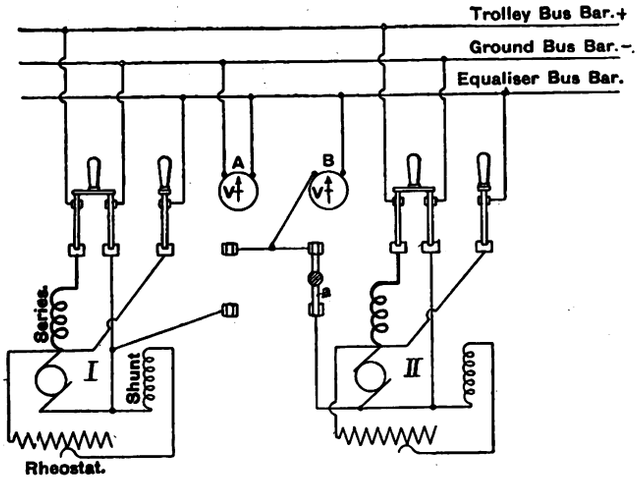
December 18, 1895.

HOW TO THROW ON A RAILWAY GENERATOR.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Referring to the Note, published in your issue of the 13th inst., on "How to Throw on a Railway Generator," I may mention a special switch combination for the purpose of preventing, as far as possible, a railway generator being thrown in circuit by careless operators before the equaliser switch has been closed.

The main double-pole switches and the equaliser switches are connected in the usual way. The voltmeter A is permanently connected with the negative bus bar and the equaliser 'bus bar, while the voltmeter B, on which are taken the readings of the dynamos to be put in circuit, is connected with one pole to the equaliser 'bar, with the other pole to the upper terminals of as many voltmeter switches as there are dynamos in the station. All these voltmeter switches have only one common removable connection bar, *a*, fitted with an insulated handle.



This bar, or knife, is put into the voltmeter contacts of the dynamo to be put in circuit, but, as the voltmeter circuit B is then not yet closed, the operator, in order to take any readings on the instrument, has to close the equaliser switch II. By this simple device there is little chance of the operator forgetting to close the equaliser switch before putting the generator in circuit by means of the main switch.

As there is only one connection knife for all the voltmeter switches, the said device prevents, too, the short-circuiting of generators through these switches, which are generally very dangerous when of the double-pole type.—Yours, &c.,

H. Dubs,

Chief Engineer of the Marseilles Tramways.

THE MICHIGAN MINING SCHOOL DEGREES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Owing to illness I have for some months been absent from Houghton. During that time I was unable to look over the various technical journals, and in consequence I have but just read your issue of August 16th, and its editorial "Graduation in Business." This article entirely misrepresents the Michigan Mining School, but it is so inaccurate it its statement of facts that I have neither the time nor the inclination to answer it in detail. The following extracts will enable those interested to gauge the value of this criticism. "There are numerous subjects, many not connected with mining (*sic*), taught at the Michigan Mining School, and each is worth so many units or fractions of a unit; and the *game—for it is not unlike a species of game*—is to 'pass' in enough units to win a degree. To qualify as a mining engineer at the Michigan Mining School you must pass in 22 full courses, including subjects 20 and 21, *which means that you must get 22 units anyhow you please*, except that *decimal two* of a unit will have to be obtained by studying 'elementary geology,' and *decimal three* of a unit by passing in 'elementary principles of mining.' And then you are a full-blown E.M., and may bore holes in the ground, and put up ricketty machinery, which will presently fall down and kill somebody." The italics are mine.

Consulting the introduction, page 5, of the "Prospectus" from which you quote, you will find that for details concerning methods of instruction, the equipment of the Institution, &c., the reader is referred to the regular school catalogue. Unless you read this catalogue (and your remarks show that you did not), you have no means of judging what degree of proficiency is here required of a student that his work may be accepted. Had you given more study to this aspect of the question, you would not have written, toward the close of your article, "The degree will sink rapidly into discredit and become an object of scorn, if its only basis be a vellum certificate bolstered up by a pile of college note-books, and a three-years course of lectures." A little investigation would have shown you that the basis here referred to exists only in your imagination. As to the value of our degree, allow me to say that up to date there is not a single graduate of this School out of employment, so far as we know. It might further interest you to learn that some of your own leading engineers have investigated the Michigan Mining School more thoroughly than you have yourself. One of our recent graduates was sent here from an English mining town and mining school to get a "degree." He is now employed by one of the largest and most important mining companies in the United States, and when we last heard of him his employers considered him an able and competent engineer.

As to getting "22 units *any way you please*," kindly refer to Prospectus, page 13 (last paragraph), and to page 25 ("Required Studies," *et seq.*), and you will find information to convince you that this statement is wholly inaccurate. The student chooses his *major subject*, and the sequence of studies explained in the paragraphs to which I have just referred you settles at once what ground that student must cover to prepare himself thoroughly for the main subject so chosen; nor has he any power whatever to omit any single preparatory subject essential to the proper prosecution of the advanced work.

Kindly pardon me for calling your attention to the fact that $\frac{2}{5}$ is not equivalent to decimal two, nor is $\frac{3}{5}$ the equivalent of decimal three. I merely mention this to show how little care was taken when gathering the facts upon which your editorial is based.—Yours, &c., Edgar Kidwell.

Houghton, Mich., December 9, 1895.

[It is unnecessary to say that we had no intention of doing the Michigan Mining School an injustice in our interpretation of its system of Elective Studies. The system itself is so elaborate and so unusually complicated that, although we spent a considerable amount of time in the perusal of the pamphlet explaining it, there is perhaps little wonder if we failed to completely grasp all its intricacies. It is gratifying to hear of the genuine and useful work which has been done by this Institution; past work, however, is not necessarily a guarantee that the new "elective" system of granting degrees possesses peculiar merit. In regard to the relation between *decimal two* and $\frac{2}{5}$, &c., we have no recollection of having implied their equality. To the best of our recollection of the matter, "elementary geology" is awarded one-fifth of a unit, which is "decimal two."—Ed. *E.*]

University College, Nottingham.—The Committee of this College invite applications for the post of Demonstrator in Electrical Engineering from candidates who have good technical knowledge, which must include electrical testing and the management of dynamos, alternators, motors, transformers, arc lamps and secondary cells, and the design and construction of electrical instruments and machines. Some further particulars are given in the advertisement columns of the present issue.

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TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is in active preparation, and orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. The usual circulars, &c., are now being sent out. Full particulars post free on application.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES can be obtained of the Booksellers or direct from the Publishing Offices:—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

'THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

A SHEET TABLE showing Total Capital Outlay and Receipts and Expenditure for the year 1894 of the Statutory Electric Supply Undertakings of the Metropolis is now ready, printed on thick paper, price 6d.

TENDERS INVITED.—The Gas Committee of the County Borough of Salford invite tenders for the supply of 1¼ miles of concentric cable. Some particulars will be found in our advertisement columns, and tenders must be in by 5 p.m. on January 2nd.

——— The Guardians of St. Luke, Chelsea, require tenders for the fitting up of an electrical wiring installation, including fittings, in the Chelsea Infirmary extension, Cale-street, Chelsea. Tenders by noon 31st instant.

——— Messrs. Arnott and Co. (Limited) invite tenders for an electric light and power installation at their new premises in Henry and Princes-streets, Dublin. Tenders by 8th prox.

TENDERS ACCEPTED.—The Leyton District Council have received the following tenders for the supply of plant and apparatus, the erection of buildings, &c., in connection with their electric lighting scheme:—

Buildings, Machinery, Foundations, &c.

Rous, H. R., Grays, Essex (*accepted*)	£2,394	14	7

Gas Producing Plant.

Dowson Economic Gas and Power Co., London (*accepted*)	854	15	0

Dynamos, Switchboards, Transformers, Wiring Buildings, &c.

Electric Construction Company (*accepted*)	1,330	7	2
Holmes (J. H.) and Co. (Newcastle-on-Tyne)	1,726	10	0
Johnson and Phillips	1,602	6	0
Thames Ironworks and Shipbuilding Company	1,502	7	6
Brush Company	1,492	0	6
India Rubber Company	1,479	8	2
Siemens Bros. and Co.	1,478	7	0
Laurence, Scott and Co. (Norwich)	1,411	5	0
Wigston Electrical Engineering Company	1,371	6	0
Crompton and Co. (Limited)	1,339	12	0
Nalder and Harrison Construction Syndicate	1,163	0	6

(Remainder of London.)

Storage Batteries and Cable Connections.

A. B. Pescatore, Manchester (*accepted*)	£743	4	6
Headland's Patent Storage Battery Company	1,113	0	0
Johnson and Phillips	1,082	10	0
Epstein Electric Accumulator Company	844	16	1
Conze and Simon	818	16	0
Electrical Power Storage Company	754	5	10
Pritchetts and Gold	632	16	6

Mains.

Siemens Bros. and Co. (*accepted*)	£8,996	1	6
India Rubber Company	11,354	15	10
Henley's (W. T.) Telegraph Works Company	10,286	11	10
Wigston Electrical Engineering Company	9,920	13	4
Glover (W. T.) and Co. (Salford)	9,646	5	1
British Insulated Wire Company (Prescot)	9,380	15	5
Fowler-Waring Cables Company	9,295	16	2
Callender Company	9,240	14	1

(Remainder of London.)

BUSINESS CHANGES.—The London address of Messrs. Dorman and Smith will be changed after January 1st from 11, Grocers' Hall-court, E.C., to 94, Charing Cross-road, W.C., the firm's telegraphic address, "Prefix London," remaining as before.

EXTENSION OF WORKS.—The Electric Construction Company propose to make some important additions to their existing works at Bushbury. The work of clearing the site of the new building has already commenced.

DIVIDEND.—The dividend declared by the trustees for the estate of Messrs. Brordning and Gardner, lately trading as electrical engineers, of George-street, Edinburgh, is now declared, and will be paid any day after the 26th inst. The dividend is the first and final of 2s. 2d. in the £.

APPOINTMENTS.—Messrs. P. R. Jackson and Co. (Limited), engineers, of the Salford Rolling Mills, Manchester, have just made the following additions to their staff:—Mr. W. H. Ravenshaw, A.M.Inst.C.E. (of Booth and Ravenshaw, 110, Cannon-street, London, E.C.) as consulting electrical engineer; Mr. E. J. Blandy, A.M.Inst.C.E., as representative in South Wales and the Midland Counties; Mr. A. M. Shepherd, of 32, Albany-road, Ealing, W., as representative in London and Southern Counties; Mr. W. F. Jones (late of Easton, Anderson and Goolden) as assistant engineer; and Mr. Felix J. Howitt (late of the Norwich Electricity Supply Company) as assistant electrical engineer.

——— Mr. S. A. James has been appointed chief superintendent of the Telegraph Department at Glasgow, *vice* Mr. G. H. Midgley, who has resigned. Mr. James has acted on behalf of Mr. Midgley for some time past.

ELMORE COPPER MANUFACTURES.—In the report issued by the Directors of Elmore's Wire Manufacturing Company, it is stated that after an exhaustive series of comparative tests the Board of Trade has sanctioned the use of Elmore's copper pipes in passenger steamers built under their survey.

ALUMINIUM.—Another use to which aluminium readily lends itself is shown by a neatly-printed complimentary card received from the British Aluminium Company (Limited), of Victoria-street, S.W., which is very effectively printed in two colours. Both sides are printed, and although the sheet is very thin the print does not at all show through. The novelty of the thing and its extreme lightness should cause a considerable demand for this material for business cards.

HOBART ELECTRIC TRAMWAY COMPANY (LIMITED).—We learn that Mr. G. Carnaby Harrower, of College Hill-chambers, E.C., has resigned his position as manager in London of this Company. The offices of the Company are now at Mansion House-chambers, Queen Victoria-street, E.C.

CALENDARS.—Messrs. Engelbert and Co., of Bishopsgate-street, E.C., send a useful hanging calendar, copies of which the firm will be pleased to supply free on request.

MASCHINENBAU AKTIEN-GESELLSCHAFT NÜRNBERG (VORMALS KLETT).—This old-established and well-known firm send us a copy of the *Technische Revue* of November 24th which contains a description and illustrated particulars of some of their manufactures. The firm was established in 1837 by the late Herr Johann Friedrich Klett, and at the present time over 3,000 hands are employed at the works in Nürnberg and at the branch at Gustavsburg bei Mainz. The Company's manufactures include cars for electric tramways and railways; steam, gas and oil engines; boilers, pumps, electric, hydraulic and hand cranes and lifts, refrigerating machinery, material testing machinery, &c. In the article views are given of the bridge over the North Sea and Baltic Canal at Grünenthal, which is claimed to be the highest bridge in Europe, and has a span of 156 metres, and of the great central railway station at Munich, which are fine examples of this firm's workmanship. The gas and steam engine departments of the Company's works are very extensive, special attention being given to engines of both types for electric lighting work.

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DIARIES.—The publishers of the *Indian and Eastern Engineer* send a copy of the Diary and Reference Book issued in connection with that journal. The book contains a quantity of very useful information for the engineering trades, particularly in connection with business with India. A complete list of the Indian Government officials, a table of English values of foreign weights and measures, in addition to specialist engineering matter, should make the book of much value to contractors and others. The Diary and Reference Book is free to subscribers to the paper.——We have received from the Brush Electrical Engineering Company a handy diary suitable for the pocket as this actually exists in most people's coats.

PRICE LISTS.—Messrs. W. H. Allen, Sons and Co. send us copies of two new price lists of their direct-coupled steam engine and dynamo sets. These sets have been so extensively used for ship lighting for the Admiralty and mercantile services that they are too well known to require any lengthy comment from us. Both in design and construction they leave little if anything to be desired, and they are well adapted to the class of work for which they are specially constructed.

CALVERTS' MECHANICS' ALMANACK.—The twenty-third year of publication of this annual, which is edited by the editor of the *Textile Recorder*, brings before the public a very handy and useful little pamphlet almanack. The calendar part is filled with dates of important and interesting engineering and other events; general and scientific information of a useful nature is sprinkled profusely over the 64 pages, and the latter part of the pamphlet is devoted to practical hints, rules and data specially serviceable to mechanics and engineers. The published price of the Almanack is 4d.

CONCENTRIC WIRING.—We have received a copy of a new list of concentric wiring, materials, &c., from Messrs. Sharp and Kent. The list embraces a complete system of switches, fuses, sockets and lamps for use with earthed conductors. Messrs. Sharp and Kent have had considerable experience in this method of wiring, having installed something like 5,000 lights in the past twelve months on the system.

ASYLUM LIGHTING.—The expenditure of a sum of £2,600 has been sanctioned for the purpose of introducing the electric light into Purdysburn House, the Belfast district lunatic asylum.

AUDIT OF SUPPLY COMPANIES' ACCOUNTS.—The following important correspondence has been sent to *The Times*. The matter is of considerable moment for electric supply companies, as the abolition of the apparently unnecessary second audit has been, we understand, under very general consideration:—

SIR: The attention of the Council of this Institute was directed to an advertisement which appeared in *The Times* of November 29th last giving notice that at a general meeting of an electric light supply corporation a proposal would be made:—

"That in order to save the trouble and expense of a double yearly audit, it be and is hereby resolved that the auditor appointed by the Board of Trade for the official audit should also act as the shareholders' auditor."

I was instructed to write to the Board of Trade and to ask whether in their opinion an official auditor of that Board is at liberty to accept the appointment of shareholders' auditor in an electric light company, and to point out that the functions of an official auditor and a shareholders' auditor are not only different, but to some extent conflicting. In reply I have received a letter from the Board, a copy of which I enclose, and which I shall be glad if you will publish in your next issue.—I am, Sir, your obedient servant, W. G. HOWGRAVE, Secretary.

Institute of Chartered Accountants in England and Wales.

Board of Trade (Railway Department), 7, Whitehall-gardens, London, S.W., December 18, 1895.

Electric Lighting Acts, 1882 to 1890.

SIR: With reference to your letter of the 5th inst. calling the attention of this Department to a resolution dealing with the question of the audit of the accounts of the . . . which it is proposed to submit to the next general meeting of the shareholders of the . . . , I am directed by the Board of Trade to state that they hold it to be outside the province of the auditor appointed by them under the terms of the Provisional Order granted to the Company to act as auditor on behalf of the shareholders.

I am further to state that the audit conducted by this auditor is of a different character to that of a shareholders' audit, and has in view different objects, and it appears to the Board of Trade that it rests with the Company to determine whether they are acting legally if they entirely dispense with the audit contemplated by the Companies Acts.—I am, Sir, your obedient servant, FRANCIS J. S. HOPWOOD.

The Secretary to the Institute of Chartered Accountants, Moorgate-place, E.C.

BAKER-STREET AND WATERLOO RAILWAY COMPANY.—In the Bill which this Company intend to introduce in the next Session of Parliament powers are sought to abandon part of their authorised railway from New-street (Upper Baker-street) to Langham-place, and to substitute a railway to start at the eastern end of Upper Baker-street and terminating at the western end of Melcombe-place. Powers are also sought for extending the borrowing periods beyond March 28, 1896, and March 28, 1898, to acquire lands and to construct the railways authorised in their 1893 Act in three sections, each to be formed into a separate undertaking with separate capital and borrowing powers. The Bill also contains a provision for entering into working arrangements with the London and South-Western, the Manchester, Sheffield and Lincolnshire, the Metropolitan, and the Waterloo and City Railways, and for paying interest out of capital during construction.

BRADFORD.—According to the Corporation accounts for 1894-95, which have just been issued by the borough accountant, the gross income from the electricity department during the period under review was £11,737 and the expenditure £5,773, leaving a gross profit of £5,964. After deducting interest and sinking fund (£4,095), and allowing £1,063 for depreciation, there was a net profit of £806 on the year's working.——The Gas and Electricity Committee have decided to recommend the Town Council to purchase a site for the erection of new electricity works.

BRIDGWATER.—The Town Council have appointed a sub-committee to consider the question of the electric lighting of the town, and also to negotiate with the local gas company for the purchase of their works.

BRIGHTON.—At the meeting of the Town Council last week the Lighting Committee's report was discussed. This report recommends that—

"Notice be given to the Brighton and Hove General Gas Company of the intention of the Council to determine on June 30th next the existing agreement for the lighting of the public lamps in the Borough, and that the Town Clerk be instructed to negotiate with the Company for a new agreement, reserving power to the Council to discontinue the lighting of all or any of the lamps on one month's notice expiring at any time."

Councillor Stafford (the Chairman of the Committee), moved the adoption of the report, and said that the Committee were anxious to have a new agreement which would enable them to discontinue the lighting of all or any of the gas lamps at a month's notice. The present agreement was very much in favour of the Company, and, as they had many applications for the better lighting of the side streets, they wished to have the powers asked for. The report was approved.

BRISTOL.—Some time ago the electrical engineer (Mr. H. Faraday Proctor) was instructed to prepare a report on, and furnish an estimate of, the cost of lighting the Mansion House electrically. Mr. Proctor has now presented a report, in which he states that 185 lamps would be required for the efficient lighting of the entire building. An amended report is to be prepared, comprehending a smaller number of lights.

CHISWICK.—Owing to the difficulty in connection with the proposed site for the refuse destructor premises, the work of erecting the electricity generating station has been very much delayed. At the last meeting of the District Council a letter was read from the Bourne and Grant Electricity Supply Company, who are carrying out the provisions of the Chiswick Provisional Order, stating that they had expected to commence the erection of the building at the beginning of the year. There has been some delay in the matter of the agreement for the site of the proposed station.

CITY AND SOUTH LONDON RAILWAY.—In the Bill which this Company intend to introduce in the next Session of Parliament power is sought for an extension of time until August, 1898, within which to acquire the necessary lands for the extension of their electric railway to Islington; an extension of time until August 24, 1901, three years beyond the time originally granted, for the completion of the line; power to acquire additional property in the borough; and a clause empowering the Company to construct the proposed station at Lombard-street in any form that the Company think fit, instead of the "cylindrical form" in which they are bound to construct it by the Act of 1893.

CROYDON.—The Town Council have received the formal sanction of the Local Government Board to their proposed loan of £27,000 for electric lighting purposes. The period of the loan is 25 years.

DOUGLAS (ISLE OF MAN).—The work on the Douglas Southern Electric Tramways, situated on the Douglas Head Marine Drive, is now being commenced by the representatives of the General Traction Company (Limited), who executed the work in connection with the equipping of the Coventry Electric Tramways.

ELECTRICAL PLANT AT HOUGHTON MAIN COLLIERY.—The Houghton Main Colliery Company, of Barnsley have just had put down by Messrs. Crompton and Co., an electrical plant for lighting the whole of the surface, including the head offices, weigh-houses, workshops, engine houses, screens, and the pit-yard. The plant consists of six large arc lamps, four of which are 15-ampere 3,000 c.p., two 10-ampere 2,000 c.p., and 200 incandescents, with a dynamo giving an output of 240 amperes at 110 volts. The machine is driven by an engine of the ordinary horizontal type, giving about 40 H.P. The screens, which are invariably the most difficult part of a colliery plant to contend with, on account of the dampness and rough usage, are admirably equipped. One of the main features of the work is the use of concentric wiring, which is almost a new departure, it is said, in colliery work, and appears to be a system particularly adapted to mining where dampness and rough usage are to be contended with.

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FOLKESTONE.—The Corporation have decided to proceed with their application to the Board of Trade for a Provisional Electric Lighting Order.

GLASGOW.—At the last meeting of the City Council the minutes of the Electric Lighting Committee recommended that Bailie Burt and Councillors Cassells, Fife, Mitchell, Paton and Stevenson be appointed as a special sub-committee to take such action as they may deem expedient, in conjunction with the special sub-committee of the Watching and Lighting Committee, to consider the question of the electric lighting of the city, and particularly as to the kind of lamps to be used for such lighting. Bailie Burt moved the adoption of the minutes, but, after a long discussion, the matter was referred back.

HACKNEY.—The members of the Vestry met in special meeting last week to consider the report of the Sanitary Committee on the proposed dust destructors, and of the Electric Lighting Committee on the scheme for the combined installations of the electric light and dust destructor, particulars of which were set out in our issue of the 13th inst., page 238. The reports were discussed separately, the dust destructor report being first taken. Mr. Sheehan opened the proceedings with a review of the steps taken by other municipal bodies in connection with the combined electric lighting and dust destruction arrangements, especially pointing to the experience of Southampton, which after ten years had just entered into a contract for an extra destructor at a cost of £60,000. The opinion of many members was to the effect that the principle of the Committee's scheme was a good one, but that further expert assistance was required before it could be considered perfect. After a lengthy debate it was finally decided to agree to the principle of the disposition of the parish refuse by cremation, but to defer the further consideration of the details to a further meeting, when it will be again discussed in conjunction with the electric lighting report which at this meeting was not reached.

HUDDERSFIELD.—At the last meeting of the Town Council applications for current were received from Longroyd Bridge and Marsh, and the electrical engineer (Mr. A. B. Mountain) was instructed to make inquiries as to the probable demand from these districts. The charge for meter rent to customers having less than 12 lights is in future to be 7s. 6d. per annum.

KINGSTON-ON-THAMES.—At the last meeting of the Town Council a letter was received from the London and South-Western Railway Company stating that their engineer would further communicate with the Council on the question of lighting the railway station electrically. A letter was also received from Major-Gen. C. E. Webber stating that he had gone into the matter of laying a main to Ham House, but he could not advise Lord Dysart to incur the outlay; he would, however, be prepared to advise his client on any proposal the Council might have to make for supplying electric current to Ham.

KINGSTOWN (IRELAND).—At their last meeting the Town Commissioners decided to proceed with their application to the Board of Trade for a Provisional Order.

KINGSWOOD (BRISTOL).—The District Council intend to oppose the application of the Great Western Electric Light and Power Company for a Provisional Electric Lighting Order for the district.

MADRAS.—The second section of the Madras electric tramways, constructed on the overhead system, was opened for traffic on December 5th. The cars are very popular, and in addition to ordinary traffic several of the native princes are, it is stated, arranging for special trips on the new cars.

MILE END (LONDON).—At their last meeting the Board of Guardians appointed Mr. B. H. Jenkinson consulting electrician in connection with their proposed scheme for lighting the workhouse premises electrically.

NEWCASTLE.—At the last meeting of the City Council a resolution was passed that a petition be presented to Parliament for leave to introduce a Bill for the extension of the tramway system, with power to work the new sections by electricity, cable, or other motive power.

PRESTON.—At the last meeting of the Town Council a proposal of the Markets and Town Hall Committee to light the town hall and public hall electrically was referred back for further consideration.

PITLOCHRY.—The report of Prof. Forbes on the feasibility of lighting this town electrically will shortly be presented to the District Council. Under the suggested scheme water power is to be utilised.

REGENT-STREET POLYTECHNIC.—On Tuesday Mrs. Quintin Hogg distributed the prizes to the successful scholars at the Polytechnic Day Schools. Many of the prizes were awarded to lads who in the workshops of the schools had shown exceptional capacity, one of the principal subjects taken being electrical engineering. The day schools were stated to have met with such success that, although room is made for 500 boys and 200 girls, applications for admittance continue much in excess of the vacancies, some of the scholars hailing from the Colonies, and even so far afield as Japan.

SALTASH.—Trouble seems to have dogged the footsteps of the Saltash authorities in connection with their lighting arrangements. The trouble began by the acceptance of a tender for electric lighting from an undischarged bankrupt, and unless more success attends the renewed application for tenders (see last week's *Electrician*) the Council will have no other course open but to renew the arrangement with the local gas company.

STOKE-ON-TRENT.—The report of the Highways Committee on the proposal of the North Staffordshire Tramways Company to introduce a system of electric traction on the local tramways was discussed by the Town Council at their last meeting. Mr. W. J. Carruthers-Wain (manager), Mr. S. P. Sellon (electrical engineer) and Mr. E. J. Hammersley (a director), representing the Company, also attended before the Council, with the object of answering any questions on the draft agreement submitted by the Company's solicitor. After considerable discussion the Company undertook to extend the present line in London-road to Hanford Bridge within three years from August 1st last. The question of purchase at the end of 22 years was also discussed, but it was finally decided that the Town Clerk should communicate with Mr. Sellon on this point. The Town Clerk also reported that at a conference of representatives of the Hanley, Burslem, Stoke, Fenton and Longton Local Authorities, held on Wednesday last, a resolution was passed that it was desirable that combined action should be taken to oppose the proposed agreement with the tramways company for the optional purchase of the electrically-equipped tramways by the Local Authorities at the end of 22 years at a 5 per cent. reduction upon the original cost for depreciation, and asking for the substitution of a clause providing for the terms of purchase to be fixed by arbitration. He had received a notice from the Company of their intention to apply for a Provisional Order empowering them to extend the tramways, and to use electricity as the motive power. The Council decided to confirm the resolution passed by the conference of Local Authorities, and the question of the proposed Provisional Order was referred to a committee for consideration and report.

SWANSEA.—It has been decided to hold a public meeting of the ratepayers of this town in connection with the proposed electric lighting and dust destructor scheme. At the last meeting of the City Council the Mayor stated that a meeting would be held after the Christmas holidays, and that, although the Council had received tenders for the erection of the necessary works in connection with the complete scheme, these would not be opened till the final vote had been taken on the purchase of the tramways, because it was intended that one scheme should stand or fall by the other.—A reporter of *The South Wales Daily Post* has been canvassing the principal tradesmen of the High-street for the purpose of ascertaining the amount of support likely to be given to the Corporation's suggested electric lighting scheme. Several of the tradesmen interviewed announced their intention of lighting their premises electrically, and of taking current from the Corporation when it is available. Altogether the scheme is viewed with considerable favour by the leading ratepayers.

THEATRE LIGHTING.—The new theatre for Leeds, which is being built under the promotion of Mr. W. Reynolds, the lessee of the Theatre Royal, is, says *Daily Tenders and Contracts*, to be furnished with a complete electric light installation and an elaborate system of sprinklers, sliding roof, &c.

TOTTENHAM.—The District Council have appointed Mr. F. H. Medhurst to make a report on the question of the adoption of a combined electric lighting and refuse destructor scheme for the district at a fee of 50 guineas.

TRADE MARKS.—By a decision recently come to by the Patent Office officials a considerable modification has been made in Section 64, Sub-section A of the Patent Act of 1888, which regulates the use of signatures as trade marks. It has been decided that signatures, even though they be the real trading name of the company, cannot be registered as trade marks, and henceforth no signatures will be allowed unless it consist of a personal name or personal names. The Patent Office have further decided that no trade mark having no other distinctive part than a personal name, which is to be found in a directory as a surname, can be registered. Judge North has recently extended this decision to any personal name found in any book (as, for instance, the trade mark of "Trilby"), on the ground that it is a personal name in a novel, though there is no proof that it has ever been an actual surname. We are indebted to Messrs. W. P. Thompson and Co., of Lord-street, Liverpool, for the above information.

TURKEY.—It would hardly have been expected that electric light and telephone engineers and contractors would be especially interested in the present financial condition of Turkey, but the

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Sultan's embarrassment has naturally compelled him to seek additional funds from the most unlikely quarters. If the correspondent of the *Daily Chronicle* is to be believed, his Majesty is contemplating the granting of concessions to electric lighting and telephone companies to construct works and exchanges throughout European Turkey. The news is, we fear, too good to be true, for probably the last thing in the world that the Sultan would care to have diffused over the country is "more light."

WATFORD.—The Urban District Council intend to apply for a Provisional Order.

ANNUAL DINNER.—On Saturday evening last the employés of Messrs. J. H. Holmes and Co., of Newcastle-on-Tyne, held their annual dinner at the Crown Hotel, under the presidency of Mr. J. T. Thompson. In response to the toast of "The Firm," Mr. E. Holmes said that most satisfactory progress had been made during the past, as was shown by the increase in the wages bill for the previous nine months of £2,200 beyond any previous year, the wages and salaries bill of the firm now reaching about £25,000 per annum. This gratifying result had been obtained by the cordial working of the managers, foremen, and workmen, which the firm very cordially acknowledged. Considerable extensions were about to be made to their works, and large as the gathering of employés was now, with similar success in the future, this number would doubtless be largely augmented at future dinners.

ANNUAL SUPPER.—The employés of the City of London Electric Lighting Company held their first annual supper at the London Tavern last week under the presidency of Mr. D. Bates. The company at supper consisted of 180 guests, which number was considerably increased at the concert which followed.

NEW COMPANIES, STATUTORY RETURNS, &c.

DIRECT ELECTRIC GENERATOR SYNDICATE (LIMITED).—This Company was registered on December 20th, with a nominal capital of £100,000, in £1 shares, to carry into effect an agreement to be made with C. P. Shrewsbury, J. Cooper, F. L. Marshall and J. L. Dobell, and to carry on the business of electricians, generators and suppliers of electricity for the purposes of light, heat and motive power, mechanical and electrical engineers, and manufacturers of and dealers in apparatus required for the generation, distribution, supply, accumulation and employment of electricity. The first subscribers, with one share each, are: A. J. Seton, H. Dobbin, S. Spill, J. Cooper, F. L. Marshall, J. Lindsay, and E. Hills. The first Directors are: Major A. J. Seton, C. P. Shrewsbury, H. Dobbin, J. Cooper, and F. L. Marshall.

FORT WILLIAM ELECTRIC LIGHTING COMPANY (LIMITED).—This Company has been registered at Edinburgh, with a capital of £7,000 in £5 shares, to carry on business as electricians and electrical engineers, suppliers of electric current for light, heat and motive power purposes in the Burgh of Fort William. The subscribers, with one share each, are: A. S. M'Intyre, J. M'Donald, N. B. Mackenzie, D. Macniven, D. M'Leish, D. Cameron (all of Fort William), and R. F. York, electrical engineer, of Glasgow.

J. C. HOWELL & COMPANY (LIMITED).—This Company was registered on December 20th, with a capital of £10,000 in shares of £1 each, to acquire all or part of the business, goodwill, machinery, rights, privileges and other property which formerly belonged to John C. Howell, electric light engineer, New Dock, Llanelly, Carmarthen, and 24, Queen Victoria-street, London, E.C., and which recently belonged to J. C. Howell, (Limited), to acquire any letters patent, rights or monopolies relating to inventions for the production or supply of light, heat or power by means of electricity, magnetism, or other agent; to manufacture, sell and let electrical apparatus, and to contract for the lighting of any public or private place by electricity. The first subscribers, with one share, are: A. G. Hudson, S. Jordon, W. Escott, A. W. N. Stuart, T. F. Goddard, W. F. Smart and C. T. Lissenden. Mr. J. C. Howell is to act as the sole Managing Director at a remuneration of £800 per annum.

SALT CHEMICALS SYNDICATE (LIMITED).—This Company was registered on December 19th with a capital of £5,000, in shares of £5 each, to acquire patents, brevets d'invention, or licences relating to an invention for the production of caustic soda by electrolysis.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30 7/16d. per oz. (Dec. 24th). Consols (2¾ per cent.) 106 9/16—106 11/16 for money, 106⅞—106¾ for account; 2½ per cent. 103—103½ (Dec. 24th). Stock Exchange Settling Days: Consols, Jan. 3rd; Stocks and Shares Continuation Day, Dec. 27th; Ticket Day, Dec. 28th; Pay Day, Dec. 30th.

ANGLO-PORTUGUESE TELEPHONE COMPANY, (LIMITED).—Coupons No. 16 of the First Mortgage and No. 11 of the Second Mortgage Debentures of this Company will be paid (less income tax) by Parr's Banking Company at the Alliance Bank on and after January 1st.

ARMSTRONG (SIR WILLIAM G.), MITCHELL AND CO. (LIMITED).—The directors of this Company have just issued a circular to the shareholders stating that a careful valuation of the Company's property reveals the fact that the assets are greatly in excess of the figure at which they stand in the books. It has therefore been decided to increase the nominal capital of the Company, from £2,000,000 to £3,000,000. This to be alloted as fully paid to the holders of the existing ordinary stock in proportion to their present holdings. The Preference shareholders will have the option of being paid off at a premium of 10 per cent., or of taking fresh Preference shares bearing interest at the same rate. In order to give effect to these proposals a reconstruction of the Company is necessary, and a meeting of shareholders will be held on Tuesday next for the purpose of passing the necessary reconstruction resolutions. It is also stated that some of the workmen will get a bonus as a result of the reconstruction, a portion of their funds being invested in the 5 per cent. Preference stock of the Company. This Company, in addition to occupying a proud position in the shipbuilding world, are the manufacturers (for the British Thomson-Houston, Limited) of Thomson-Houston plant and apparatus in this country.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended December 22nd were £1,013, against £968 in the corresponding week of 1894, an increase of £45. The total receipts for the half-year amounted to £22,553, against £22,447 in the corresponding period of 1894, an increase of £106.

ELMORE'S AMERICAN AND CANADIAN PATENT COPPER DEPOSITING COMPANY (LIMITED).—The meeting of shareholders in this Company takes place at Leeds on the 30th inst. at 2 p.m. The Directors' report states that the improvement in the Company's finances shown in the accounts of the previous year has practically been maintained, as, after meeting the total administration expenses for the year, amounting to £165, compared with £230 last year, the Board have been able to reduce last year's debit balance from £877 to £452, making a reduction of £1,626 in two years. The unpaid balance of the loans to the French Elmore Company now stands in the books at £6,831, for which this Company holds 218,513·38 francs (equivalent to £3,740 at 25 francs to the £ sterling) of 6 per cent. First Obligations (Debentures) of the Société Francaise d'Electro Metallurgie, upon which the Company has regularly received interest half-yearly since January 1, 1894; and two of the Obligations have been redeemed at par by the Société, who annually redeem at par a certain number of the Bonds drawn by lot. The Directors regret they cannot report the sale of the Company's rights in America and Canada, as they felt that the time was not yet ripe to actively push such sale until further developments have been made in this country and in France.

ELMORE'S WIRE MANUFACTURING COMPANY (LIMITED).—The Directors' report for the year ended June 30th last, to be presented to the annual meeting to be held at Leeds on the 31st inst., at two o'clock, states that for the first half of the year the works were principally employed in completing the plant, and accordingly the greater part of the expenses, amounting to £2,720. 11s. 5d., has been charged to the old administration account, and the result of the working for the second half is a loss of £356, which cannot be considered unsatisfactory in view of the small turnover. The Directors have decided to appropriate the amounts received on forfeited shares and on share premiums (£64,282. 10s.) to the reduction in valuation of licences (£31,940) and to the writing off of administration account (£26,280. 19s. 1d.), leaving a balance as reserve for future contingencies of £6,061. 10s. 11d., out of which they now propose to provide for the £356 standing to the debit of profit and loss account, and thus enable the Company to start on the current year unencumbered by any old losses. The capital expenditure on buildings, plant, machinery, &c., amounts to £5,791. 17s. 5d., a considerable part of the outlay being for a rolling mill for the production of special sheets. Sales and deliveries to customers have steadily improved during the second half of the year. The Directors state that the Company's manufactures have given every satisfaction, and that numerous offers of orders for high-class specialities have been received, but cannot be accepted until the Company is in a position to put down the special plant and tools required. The increasing difficulties of obtaining the most suitable raw material with the present limited working capital of the Company has induced the Directors to so work the factory as to prove the practical value of the process on a commercial scale, the ultimate object being to secure capital not only to purchase raw material direct from the mines, but to provide the special plant necessary for still further developments. The Director retiring from the Board by rotation does not offer himself for re-election.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 22nd inst. amounted to £1,080. The amount for the corresponding week last year was £938, an increase of £142.

NATIONAL TELEPHONE COMPANY (LIMITED).—The transfer books of the 3½ per cent. Debenture Stock of this Company will be closed from the 23rd to the 31st instant, inclusive, for the purpose of preparing the warrants for the half-year's interest due January 1st.

SALT LAKE AND OGDEN GAS AND ELECTRIC LIGHT COMPANY.—The coupons on this Company's 6 per cent. First Mortgage Gold Bonds due January 1st next, will be paid at the National Provincial Bank of England, 112, Bishopsgate-street, E.C., or at the Farmers' Loan and Trust Company of New York.

WEST COAST OF AMERICA TELEGRAPH COMPANY, (LIMITED).—The coupons on the Debentures of this Company, due the 31st instant, will be paid by Messrs. Barclay, Bevan & Co., Lombard-street, E.C. Coupons should be left three clear days for examination.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended December 20th, 1895, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,677.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Dec. 18.		Price Monday, Dec 23.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 21.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS								
£1,012,880	Stock	10/0	Anglo-American	48	45	42	44	5 2 3	Jan., Apr., July, Oct.	..	..
£2,993,560	Stock	20 0	Do. Preferred	81½	82½	79	81	5 11 1	" "	83¾	82
£2,993,560	Stock	5/0	Do. Deferred	6	6½	5¾	6¼	..	.. ..	6½	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	101	105	101	105	3 17 6	January and July	..	..
180,000	£10	9/0	Brazilian Submarine xd	12¾	13½	12¾	13¾	5 18 2	Mar., June, Oct., Dec.	13¾	13 1/16
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111	115	111	115	4 8 6	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock xd	160	170	160	170	4 2 4	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	13	14	13	14	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	21½	21¾	20½	21½	4 13 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	3½	4½	3¾	4¼	4 8 11	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10	10½	10	10½	4 5 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104%	107%	104%	107%	4 6 9	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8	8½	7¾	8¼	4 2 4	Jan., Apr., July, Oct.	..	..
400,000	10	2/6	Eastern	16	16½	16	16½	3 18 9	" "	16½	16¼
70,000	10	6%	Do. 6 per Cent. Preference	17½	18	17½	18	3 6 8	" "	18	17⅞
£1,297,857	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	125	128	125	128	3 2 8	May and November	129½	127½
£172,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 12 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17	17½	17	17¼	4 0 0	Jan., Apr., July, Oct.	17 1/16	17¼
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	127	130	127	130	3 2 8	February & August	..	129
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	102	106	4 16 5	January and July	..	..
£30,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	103	106	102	106	4 16 5	" "	..	..
£200,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108	111	108	111	3 2 2	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112%	115%	112%	115%	3 9 9	May and November	..	..
180,227	10	1/3	Globe Telegraph and Trust	9½	10	9½	10	4 5 0	Jan., Apr., July, Oct.	9¾	9½
130,042	10	6%	Do 6 per Cent. Preference	16½	17	16½	17	3 10 7	" "	16¾	16⅝
150,000	10	5/0	Great Northern	21½	22	21¾	22½	3 16 5	Jan., April, and July	..	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	104	107	104	107	4 14 7	March & September	..	..
17,000	25	12/6	Indo-European	46	49	46	49	5 2 0	May and November	48	47
37,548	10	..	London Platino-Brazilian	..	..	..	..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106	110	106	110	5 10 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	109	112	103	112	3 19 10	.. ..	..	..
11,839	8	4/0	Reuter's	4	5	4	5	..	April and October	..	..
8,881	£100 Cert.	83/0	*Submarine Cables Trust 6 per Cent.	127	132	127	132	4 10 11	" "	..	..
15,609	10	2/0	West African Telegraph	5½	6½	5½	6½	..	January and July	6¾	..
£223,300	100	5%	* Do. 5 per Cent. Debentures (red.)	101	105	102	105	4 16 5	March & September	103	..
30,000	10	2/0	West Coast of America	1	2	1	2	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	98	103	93	103	8 0 0	June and December	93	..
88,321	10	1/3	West India and Panama	¾	1½	¾	1½	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10¾	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½	9½	8½	9½	6 6 4	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	111	114	111	114	4 9 6	June and December	..	..
64,242	15	3/0	Western and Brazilian	9	9½	9	9½	5 2 9	May and November	9¾	..
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6½	6¾	6½	6¾	..	..	..	..
33,129	7½	1/6	Do. 5 per Cent. Deferred	2¾	3½	2¾	3½	..	..	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103	107	103	107	5 14 3	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103	107	103	107	5 14 3	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	113	118	113	118	5 13 2	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100	103	100	103	5 18 3	March & September	..	..
			TELEPHONES.								
44,000	5	2/6	Chili Telephone (fully paid)	8½	8¾	8½	8¾	..	.. ..	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	7/8	1	7/8	1	..	May and November	..	..
171,504	£1	5s.15	Oriental Telephone and Electric (fully paid)	7/8	1 1/16	7/8	1 1/16	..	Yearly	..	..
484,597	5	2/6	National	5¾	6¼	5¾	6¼	4 1 8	June and December	6¾	5¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16	18	16	18	3 6 8	" "	17½	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15½	16½	15½	16½	3 12 9	" "	..	..
119,284	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6½	6¾	6½	6¾	3 16 11	.. ..	..	..
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	103	108	106	108	3 5 10	January and July	107½	107
58,000	5	3/0	United River Plate	2½	3	2¾	3	..	" "	..	..
£146,783	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	92	97	92	97	5 5 6	" "	93½	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12¼	13½	12¾	13½	1 17 9	—	13½	12¾
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15½	16	15½	16	3 16 0	—	15 15/16	..
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	132	136	132	136	3 14 9	June and December	135½	..
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	—	..	..
£80,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½	5¾	5½	5¾	..	—	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	—	..	..
8,822	£5	..	House-to-House Electric	—	—	—	—	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	—	—	—	—	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	..	..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞	8¼	7⅞	8¼	..	—	..	..
111,000	5	..	London Electric Supply	..	..	..	..	..	—	..	..
49,900	£10	8/0	Metropolitan Electric Supply (fully paid)	10½	11½	10	11	2 0 11	—	10 13/16	..
150,000	Stock	4½%	* Do. 4½% Debs.	117	120	117	120	3 16 3	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½	9	8½	9	..	—	..	..
..	..	..	Rand Electric	¾ prem	..	..	..	..	—	8 1/16	..
19,980	£5	2/0	St. James and Pall Mall	8¼	8¾	8¼	8¾	..	—	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	9	10	9	9½	3 13 3	—	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8½	8¾	8½	8¾	3 2 10	—	8⅝	8½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	2	1/6	Brush Electrical Engineering	1½	1¾	1½	1¾	10 0 0	—	..	—
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	2⅜	2⅝	2⅜	2⅝	5 13 11	—	2	—
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112	115	112	115	3 19 0	March & September	112½	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2	2½	2	2½	..	January and July	..	—
89,261	5	1/6	Edison and Swan United	1¾	2¼	1¾	2¼	..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104	107	104	107	4 5 9	..	..	..
£30,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	—	—	—	—	..	..	..	..
110,000	2	..	Electric Construction	⅝	¾	⅝	¾	..	..	..	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2	2½	2	2¼	5 13 0	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	¼	½	¼	½	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¼	½	¼	½	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	18	19	18	19	3 18 11	February & August	18½	18½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101	103	101	103	4 8 0	March & September	..	..
15,995	£10	..	International Okonite Ordinary	..	..	..	..	..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	—	—	—	—	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	⅜	½	⅜	½	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	39	41	39	41	5 17 0	March and July	41½	40½
£150,000	100	5%	* Do. 5 per Cent. Bonds	104	107	104	107	4 15 6	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	..	..	..	..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	..	..	..	..	..	..	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	13½	14½	13½	14½	4 2 9	..	14⅜	..
£30,000	10	7/0	Do. 7 per Cent. Preference	15½	16½	15½	16½	4 4 10	..	..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108	111	108	111	4 1 11	..	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1½%	City and South London Railway	40	42	40	42	2 19 6	May and November	..	..
7,650	10	5%	Do. 5% Perpetual Preference	14¾	15¼	14¾	15¼	3 5 7	.. ..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130	132	130	132	3 0 9	May and November	..	..
£7,500	£10	2½%	Liverpool Overhead Railway	11¼	11¾	11⅛	12 1/16	1 17 4	—	..	..
10,000	10	5%	Do. 5% Preference	15½	15¾	15½	15¾	3 3 6	—	..	..
115,000	Stock	4%	Do. 4% Debenture	114	116	114	116	3 9 0	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

THE collection, compilation and co-ordination of data relating to English central station enterprise which has been undertaken annually by this journal since 1889 is becoming—thanks to the steady growth of the industry every year a more onerous task; indeed, were it not for the ready assistance of central station engineers all over the country, it would be impossible to present a table to our readers bearing any close relation to the facts of the case. We do not ask questions and glean statistics in a spirit of mere idle curiosity, but in the hope that by making accurate data available to the world at large, and to electrical engineers in particular, erroneous notions may be dissipated and progress accelerated. The scientific habit which characterises the electrical industry above all others is exhibited in nothing more strikingly than in the penchant for a systematised knowledge of what is being done around them displayed by members of the electrical profession. Notwithstanding our endeavours to avoid pointless interrogatories, a few of the forms sent out have been filed in the waste paper basket; no doubt inadvertently. The half-dozen exceptions to the general rule of careful revision and prompt return of our printed slips render our thanks to the majority all the more cordial.

OF the hundred patents which figure in our list of electrical patents expiring this year more than 10 per cent. originated in the fertile brain of Mr. EDISON, and, as the papers informed us quite recently, he is as full of resource as ever, and doubtless before long the English Patent Office will be honoured with a "communication from abroad" of a method for destroying the British fleet by means of that 5,000-volt jet, upon which Lord ARMSTRONG has thrown some much-needed cold water. Glow lamp patents figured very prominently in 1882, as is witnessed by the names of CROOKES, RAWSON, WERDERMANN, MAXIM, AKESTER, LANE-FOX, CRUTO, SWAN and BERNSTEIN. Arc lamps also were much be-patented fourteen years ago, patents having been taken out by JARMAN, SOLIGNAC, WESTON, LEVER, KRIZIK and PIETTE. Among other patents with historic names attached to them we may note the one taken out by Lord ELPHINSTONE and Mr. C. W. VINCENT, the telpherage patents of Prof. FLEEMING JENKIN, the telegraphic-telephonic patent of VAN RYSSELBERGHE, and, finally, Patent No. 3,204 of ELIHU THOMSON. In July Dr. JOHN HOPKINSON'S famous three-wire patent will come to an end, and with it the royalties now being paid to its lucky owners by the majority of low-pressure systems in this country. On September 18th the Gaulard-Gibbs patent for distributing electricity by secondary generators would have expired had it not been revoked in July, 1888, by Mr. Justice KEKEWICH at the instance of Mr. FERRANTI. On the whole, the electrical industry will not be fundamentally affected by the removal of patent restrictions during 1896.

THIS week the Gülcher dynamo patent, No. 64 of 1882, terminates. In this there is the following curiously-worded passage:—"This form (U-shaped pole-pieces and V-shaped armature core) not only permits of a convenient and solid fixing of the inductor, but also allows the wires wound round it to be exposed to the inducing action of the magnetic pole-surfaces from all sides, and thereby completely obviates the production of heat, which in other machines is produced by the passage of the electric current through those parts of the wires which are not exposed to the said action."

BURKE, we believe, declared himself unable to draw up an indictment against a whole nation. A special committee of representatives of German Electric Supply Companies, however, has not flinched from drawing up an indictment of an entire industry. In another column will be found a lengthy document setting forth without circumlocution the parlous state into which the German glow lamp industry has fallen by reason of unscrupulous competition. For some years there has been an ever-increasing chorus of guttural complaint, and finally, with a view to protect the electric light supply business, a special committee was appointed to inquire into the whole matter. The investigation appears to have been carried out with characteristic German thoroughness, and the native glow lamp has been condemned *sans phrases*. Not only are the lamps of indifferent manufacture, negligently tested, and carelessly sorted, but something like wilful fraud is not uncommon. Such, indeed, has been the doleful experience of the committee, that they pronounce the 3½-watt lamp and the guaranteed life of 1,000 hours or thereabouts as figments of the makers' imagination, and they suggest that 4 or 5 watts per candle and a "useful life" of 400 hours would be more in accordance with the actual facts. So well grounded do the committee deem the complaints of consumers to be, that they are led to recommend the drastic measure of electric light concerns taking the supply of glow lamps into their own hands, supplying the lamps to their consumers for nothing.

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We do not know how this last idea will commend itself to electric light undertakers in this country; but if the advent of the cheap glow lamp leads to the same results in England that it has in Germany, they will, whether they like the idea or not, have to do something of the kind. The gratuitous supply of lamps to customers is a serious step, not to be taken except in the last resort; but electric light concerns might, in self-defence, very well take upon themselves to supply carefully-tested lamps at cost price to all consumers who may desire them.

When Prof. J. J. Thomson first announced his discovery that the ions of a gas undergoing electrolysis may become either positively or negatively electrified, quite irrespective of their normal condition of electrification, we ventured to suggest that a new field of electrostatic discovery was opened up. Hardly, however, could anyone have guessed the wealth of new phenomena which lay behind Prof. Thomson's ingenious researches, first on the electrolysis of steam, and subsequently on that of other compound gases. Yet it was not altogether hidden from view that the trend of these researches would probably lead to an important elucidation of "The Relation between the Atom and the Charge of Electricity Carried by It," which is the title of Prof. Thomson's latest publication on this line of research. We commence this week a reprint of this Paper, which embodies practically the whole of the material developed in the Paper itself. This valuable contribution to science forges one more link in the chain which connects inseparably chemical and atomic phenomena with the electrical condition and properties of atoms. And the link, like the chain itself, is all the more real from the fact that it is so directly based upon experimental evidence and so free from metaphysical cobweb-spinning.

The early part of Prof. Thomson's Paper seeks to establish the proposition that when charged atoms are close together there may be forces, partly electrical, partly chemical in their origin, in addition to those expressed by the ordinary laws of electrostatics. In fact, as subsequent parts of the Paper show, the individual relationship between pairs of atoms close together is very different from the ordinary electrostatic behaviour of atoms in the bulk; and the key to much of the anomalous in the behaviour of electrolysed gases appears to lie in the properties of thus isolated small groups or pairs of atoms. The forces between charged atoms placed very near together seem to be modified by the electro-chemical properties of the atoms; in consequence of which, as Prof. Thomson states, an electro-negative atom, if positively charged, cannot, in the absence of a strong external field of electric force, interchange its charge with the negative charge on an electro-positive atom, unless the two are connected by an external conducting circuit. The application of this theorem, by way of illustration, to the case of the oxidation of zinc, is full of interest, and particularly where the conditions which limit the extent of the chemical combination are discussed. Interesting, too, is the investigation of the minimum potential difference between electrodes which is requisite to produce a spark in a gaseous electrolyte. Prof. Thomson shows that it is highly probable that this minimum potential difference is of the same order as the potential difference between the atoms in a single molecule, when that molecule is so placed that there are no surrounding molecules to influence its electrostatic condition. Possibly the two are even identical, allowance being made for the influence between the molecules which will always be present when a volume of gas is being traversed by an electric spark.

Glasgow and West of Scotland Technical College.—The second term of this College opens on January 7th.

Cable Interruptions :—

	Date of Interruptions.
Puerto Plata-Martinique	December 19.
Aden-Zanzibar	December 24.

Transformer Patent Litigation in Italy.—The action Zipernowsky, Déri and Bláthy *v.* Siemens and Halske, relating to transformer patents, will be discussed before the Corte d'Appello of Florence next week.

Electrical Standardising, Testing and Training Institution.—Mr. James Swinburne will commence his usual course of lectures on "Dynamo and Transformer Construction" at the above Institution on Thursday, January 9th.

Appointment Vacant.—A Junior Demonstrator in Physics is wanted by the authorities of University College, Nottingham. Commencing salary £120 per annum. Applications must be sent in to the Secretary by January 9th on a special form.

New Year Honours.—Amongst the recipients of New Year honours is Mr. Henry Charles Fischer, Controller of the Central Telegraph Department of the General Post Office, upon whom the Cross of St. Michael and St. George has been conferred.

Fareham.—The ratepayers of Fareham, or the portion of them who voted—not one-half of those on the list took the trouble to go to the poll—have decided by 431 to 235 to purchase the local electric light company's undertaking.

Institution of Civil Engineers.—The new edition of the list of members of the Institution of Civil Engineers—dated January 2, 1896—shows that this Corporation has now on its roll 6,794 members of all classes, representing an increase during the last ten years of 36½ per cent.

Electrical Engineering Courses at the Oxford Technical School.—Mr. J. Hardie McLean, M.I.E.E., manager and engineer of the Oxford Electric Company, has been appointed lecturer and demonstrator of Electrical Engineering and Electric Lighting at the City Technical Schools, Oxford. A course of 20 lectures will be given during the session.

Aden-Zanzibar Cable.—This cable was unfortunately interrupted on December 24th, and no notification of its repair had come to hand up to the time of going to press. The repairing ship was expected on the ground yesterday (Thursday). Messages from the Transvaal are being dealt with as promptly as possible by the Western route. Owing to the heavy Government traffic over the lines at the present time some delay is caused to private messages. But for the serious news from the South African Republic, little inconvenience would have been caused to the public.

The South Staffordshire Tramways.—As a result of the efforts of the Streets Committee of the Walsall Town Council, arrangements have been come to between the South Staffordshire Tramway Company and the Electrical Construction Company by which the electric cars will be continued until January 31st. This is with a view to a permanent arrangement being made, and the Mayor (Councillor Noake), who acted as mediator between the two companies last year, has consented to meet their representatives again in order to assist them in arriving at a settlement.

Electric Traction for Teheran.—A Reuter's agent at Teheran, writing under date November 18th, says: "A concession for the construction of a road which is to join Baghdad with Teheran has just been granted to Mr. Felix Moral, the representative of a number of important German houses. It is expected that

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the road will become the principal trade route between Persia and the West. The concession is for 75 years from the date of signature (November 7, 1895), and concedes the right of constructing the road, levying tolls on it, and working a transport service. The work must be completed in two years and a-half. Mr. Felix Moral also obtained a concession for the construction and working of a steam or electric tram from Teheran to the villages north of the city, a distance of about ten miles. This concession is for 90 years."

The Requirements of Deaf Telephone Subscribers.—Judgment was given at Glasgow on Friday last in an action raised by the National Telephone Company against Mr. H. Wilkie, watch and chronometer maker, Duke-street, Glasgow, for payment of £7s. 15s., the rent of a private telephone wire, and a further sum of £10, the rent of an exchange wire. Defender was somewhat hard of hearing; but this was explained to the Company's canvasser, and it transpired the latter quite understood that the instrument was to be used by defendant personally. The Court held that it was an implied condition of the contract that the wire and instrument should be fit and serviceable for defendant's special case, and that the Company had failed to make it so in spite of repeated complaints by him. It therefore gave a verdict for the defendant and granted him expenses.

Test Box Explosion.—"Late on Monday night." says a morning paper, "residents of Crucifix-lane, Long-lane, Bermondsey, were startled by a very loud report. Immediately a deep hole was discovered in the street beneath the railway arch, and some kerb and pavement box-covers, the property of the London Electric Supply Corporation, were damaged. Mr. Targett engineer of the outdoor department of this Company, inspected the place. Captain Simonds attributes the explosion to 'the failure of the insulation of the main.'" We are informed by Mr. d'Alton that this account is greatly exaggerated. The cause of the explosion was the failure of one of the Company's test boxes on the trunk mains. There were no pavement or kerb stones disturbed in any way by the explosion. The Company's men had been working at the spot the same day, making some alteration in the boxes.

High-Voltage Glow Lamps.—The following letter appeared in the *Builder* of December 28th:—

SIR: I have read with interest your notes on the Edinburgh Electric Lighting Works, especially those relating to the introduction of high-voltage lamps. The gain to the supplying agents is manifest. The gain to the consumer is, to say the least, doubtful, and where corporations or vestries undertake the work, I think the latter deserve some consideration. This house is supplied by the St. Pancras Vestry; but though the mains were laid several months before I adopted the light, no notice was sent of any intended change in the conditions of supply, and the house was partly wired as for 110-volt lamps, when I found out the change. Unlike Edinburgh, there was no option in the matter, or most certainly I should not have agreed to use the higher pressure. The candle-power does deteriorate more rapidly (unless, that is, the Vestry do not maintain the proper voltage in their mains), and I have had to change some after about 500 hours' use. There are other drawbacks to their use besides the higher charge (English lamps are 2s. each). There are no 5 c.p. lamps to be had; there are no obscured lamps yet made. The lamps are larger than the 110 and 100-volt lamps, and will not go in many shades. The meters are not specially made for the higher voltage, though this may be, after all, no real objection.—"ST. PANCRAS." P.S.—I enclose card.

A Polyphase Transmission Plant for Guatemala.—Messrs. Siemens and Halske, of Berlin, have in course of construction a long-distance transmission plant which is to be operated by the "Empresa Eléctrica de Guatemala," and which is intended to carry electric energy for light and power purposes to the town of Guatemala from a waterfall 22½ miles distant. The system of transmission is the three-phase, at a pressure of 10,000 volts, with step-up and step-down transformers at either end of the line. Power is to be derived from the outlet of a lake giving 2,000 litres per second, with a fall of 87 metres. At present, therefore, some 1,300 H.P. is available. But it is contemplated in the near future to carry out works permitting the water of the lake to be accumulated during the daytime; this will bring the available power to 5,000 or 6,000 H.P. The plant now in view consists of a set of two horizontal Nagel and Raemp turbines of 520 effective horse-power each, running at 200 revolutions per minute. Each turbine is coupled direct to a Siemens and Halske three-phase alternator capable of generating 425 kilowatts at a pressure of 350 volts. The current is transformed by a set of four transformers from the pressure of 350 to 10,000 volts, then transmitted to the town by a three-conductor aerial line having an aggregate section of 105 sq. mm., the maximum loss in the line amounting to 10 per cent. On reaching the town the pressure is lowered again by another set of four transformers from 9,000 to 1,000 volts, the current being then distributed to the supply network of the town. The distributing conductors are overhead, carried on iron poles.

Alternate-Current Transformers.—The following is the syllabus of the course of Cantor Lectures on "Alternate-Current Transformers," which are to be delivered at the end of this month by Dr. J. A. Fleming:—

January 20th.—Lecture I.—"The Action of the Transformer."—Real and imaginary transformers—Transformer diagrams—Alternate-current curve tracing—Various forms of curve tracers—Discussion of transformer diagrams—The harmonic analysis of diagrams—The curves of induction and hysteresis—Magnetic leakage—Core and copper losses—Effect of variation of form of the electromotive force curve on Core losses—Variation of core losses with temperature—The power factor. *January 27.*—Lecture II.—"The Construction of the Transformer."—The core—Sheet iron stampings—Building the core—Prevention of core losses—Selection of iron—The coils—Coil winding—Insulation of coils and core—The case—Ventilation and surface radiation—The terminals—Primary and secondary fuses and switches—Sizes and forms of transformers in practice—Open and closed circuit transformers. *February 3rd.*—Lecture III.—"The Testing of Transformers."—The measurement of the power taken up in an inductive circuit—The theory of the wattmeter—The construction and use of the alternate-current wattmeter—Various methods of measuring alternating-current power—The testing of transformers—Testing by curve tracing—Testing by the wattmeter—Differential testing—Practical tests in the sub-station and workshop efficiency curves—Core losses for various sized transformers—Specifications for transformers—Measurement of copper losses and drop—Iron testing. *February 10th.*—Lecture IV.—"The Employment of the Transformer."—Defects in transformers—Causes of failures—Current rushes into transformers—Variation of core losses, with time and temperature—House transformers—Sub-station transformers—Two and three-phase transformers—Transformer distribution—Importance of large power factor—Influence of load factor on annual losses—Capacity—Effects in case of large transformer systems—Designs for alternating-current stations—Conclusion.

The Annual Awards of the Académie des Sciences.—The last number of the *Comptes Rendus* is taken up with announcements of the 1895 prizes awarded for scientific, mathematical, and engineering work. We append a list of the prizes awarded for electrical researches:—The MONTYON PRIZE of 700fr. has been awarded to M. Galliot for his successful introduction of an electrical towing arrangement for a distance of 6 kilometres on the Burgundy Canal. Some two years ago M. Galliot decided to electrically utilise the head obtainable between the feed-water reservoir and the third lock on either side of it, and since then all barges have been towed up and down by a motor-barge deriving its current from a trolley wire running along the banks of the canal, and connected to turbine-driven dynamos. The water necessary for the operation of the locks is not interfered with, the turbines being fed by the large volume of water necessary to make good the losses by infiltration.—The LA CAZE PRIZE of 10,000fr. was awarded to M. Edmond Bouty, Professor at the Paris Faculty of Sciences. M. Bouty discovered a curious phenomenon connected with electro-plating, to which he gave the name of "electrostriction." For instance, if a thermometer bulb be copper-plated an appreciable permanent displacement of zero is found to take place, corresponding to a pressure of several atmospheres. M. Bouty's explanation is, that this phenomenon of expansion or contraction is due solely to abnormal temperature, caused by the Peltier effect. Recently M. Bouty has investigated the influence of the layer of air left between the metal plates of a condenser and the solid dielectric, and, finding it considerable, M. Bouty now silvers the faces of his mica condenser sheets.—Another LA CAZE PRIZE was awarded to M. H. Le Chatelier, well known for his work on the electric pyrometer. By the aid of this instrument he has, amongst other things, observed that at 580°C. quartz suddenly expands, though its molecular composition is not modified; the process is reversible.—As we have already announced, the LECONTE PRIZE of 50,000fr. was awarded to Lord Rayleigh and Prof. Ramsay for their discovery of argon.—The GASTON PLANTÉ PRIZE, a biennial one of 3,000fr., was awarded to MM. J. and P. Currie for their work in "piezoelectricity."—The KASTNER-BOURSAULT PRIZE of 2,000fr. was awarded to M. Baudot, the inventor of the well-known multiple-writing telegraph so much affected in France.

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(*Continued from page 215*).

The Gas Engine in Relation to Electric Power.

The following *schema* indicates the uses which have hitherto been made of the gas engine for electrical power purposes:—

I. Private electric light and power plants.

II. Public electric supply
- (1) As auxiliary motors in steam stations.
- (2) In secondary stations feeding mains chiefly supplied by power from steam stations.
- (3) In gas engine electric supply stations.

III. Electric traction generating stations.

Private Plants.—The use of the gas engine for driving private electric light plants is almost as old as the dynamo itself. In combination with a capacious storage battery, the gas-driven dynamo is admirably adapted to the majority of cases. The chief merits of a gas engine thus used are: (1) convenience of starting and stopping; (2) small attendance required during running; (3) low initial cost of plant; (4) small risk of explosion or fire; and (5) low cost of fuel where town gas is cheap or where Dowson gas can be used.

Auxiliary Motors.—Many electric supply stations are provided with gas engines covering a small percentage of the total capacity of the station, the purpose of these being to relieve the steam plant of the very low loads which occur during the daytime, and to supply the extra power which may be required for a very brief time during a sudden rise in the demand for power. It has been found that this practice very considerably improves the load factors of the engines and boilers; and, owing to the ease with which gas plant may be started and stopped and the absence of loss during idle hours, the practice has been recommended by the highest authorities.

Secondary Stations.—An example of a gas engine secondary station is to be found at Brussels, where the network of electric supply mains is chiefly fed from a large steam driven station, but where, recently, a gas engine station has been erected to supplement the supply. This secondary station is situated at some distance from the main station. It will ultimately consist of five 120 H.P. sets. Each set, of which two are now erected, will consist of a twin cylinder horizontal gas engine, working on the Otto cycle, direct coupled to two ten-pole dynamos; and the speed of the set is 150 revolutions per minute. The two dynamos are coupled through Raffard clutches to the two ends of the crank shaft. There is a storage battery of 500 Board of Trade units capacity. The gas engines have proved to an economy of 23·1 cubic ft. of gas per brake horse-power per hour at full load, and 33·25 cubic ft. per brake horse-power per hour at half load. It should be mentioned that although the normal load is 120 H.P., each set has been built to stand a maximum of 135 H.P.

Main Stations.—Up to the present time there have been but three public electric supply stations wholly dependent upon gas power, in the United Kingdom. These are the Morecambe, the Coatbridge and the Belfast stations. At Leicester, the Midland Railway Company have a gas-engine station for supplying the light in their railway station and goods yards. Various systems are represented by these four stations, as will be seen by the summary given in Table XXXI.

Similar stations have been long in existence on the Continent and in the United States. The first to be erected was that at Dessau, in Germany, in September, 1886. This station was established by the Imperial Continental Gas Association, in the belief that it would not only promote the use of their gas in the daytime, but also cheapen the production of light. The great success of this station led to the rapid introduction of others. Direct-coupled gas engines and dynamos are a feature of these Continental stations; but until recently this type of engine has been absent from the United Kingdom. A direct-coupled set is, however, about to be placed in the Belfast station.

Table XXXI.—*Gas-Engine Electric Supply Stations in the United Kingdom.*

Place.	Capacity of station.	Gas supply.	Equipment.
Morecambe...	3,000 lamps (wired). 5,200 lamps (possible).	Dowson gas.	1 Dowson gas plant of 150 H.P. 2 Ditto of 75 H.P. each. 1 Storage tank of 1,500 cubic ft. capacity. 2 Small vertical boilers. 1 "Crossley" gas engine of 100 H.P. 3 "Stockport" gas engines of 25 H.P. Storage cells.
Coatbridge ...	3,756 lamps (wired). Output= 11,623 units in winter quarter.	Gas of same composition as Dowson gas.	2 Dick, Kerr and Co.'s gas generators of 120 H.P. each. 1 Gas holder, 15ft. diameter, 10ft. deep. 3 Dick, Kerr and Co.'s side-by-side gas engines of 120 H.P. each (rope coupled to alternators).
Belfast.....	8,500 lamps (wired). 6,100 to be maximum of actual load.	Town gas.	4 "Kilmarnock" tandem gas engines of 120 H.P. each. 2 Ditto of 55 H.P. each. 2 Storage batteries, each of 63 E.P.S. cells of 34-K type.
Leicester, M.R. Station.	1,200 B.T. units per diem. of 24 hours.	Dowson gas and occasionally town gas.	2 Dowson gas plants of 100 H.P. each when using coke. 1 Gas holder. 4 "Crossley" gas engines of 50 H.P. each. 2 "Crossley" gas engines of 27 H.P. each.

Electric Traction.—The use of the gas engine in electric traction work has been limited to a few small instances. The only example in this country is the light railway along Brighton beach, which derives power from a single 12 H.P. "Crossley" gas engine. Accurate figures of results are difficult to obtain, but it would seem that the gas engine is well adapted to this class of work. This type of electric traction station is, however, more commonly met with on the Continent than in this country. At Zurich there is an electric line 2¼ miles long, on which 14 motor cars are run, the current for which is derived from two dynamos driven by an equal number of gas engines, aggregating 240 H.P. At Lausanne an electric railway is operated from a power house, in which the dynamos are driven by two 180 H.P. "Crossley" gas engines. Producer gas, generated from anthracite is used, the best consumption being 1·2lb. of fuel per horse-power per hour. The engines are run from 18 to 20 hours per day, and an average consumption of 4·5lb. of anthracite per car-mile is attained.

Initial Costs.—The initial cost of a Dowson gas plant varies from £138, for a plant capable of generating 900 cubic ft. per hour, and suitable for 8½ B.H.P., to £273, for a plant capable of generating 7,000 cubic ft. per hour, and capable of driving 80 B.H.P. These prices include the generator, cooler, scrubbers, holder, &c., complete. The cost of erection will vary with local conditions; but it may be taken as averaging £15 for the smaller size mentioned, and from £20 to £30 for the larger size.

The cost of a gas engine depends largely upon the type and maker selected. A 10 H.P. engine will average about £140, complete with water tank and pipes; an engine of 100 H.P. will probably cost between £500 and £550 complete, including cost of erection. These costs are for engines using town gas of good quality. Where diluted gas has to be used the engine will have to be somewhat larger for the same amount of power, and will therefore cost more.

Gas Engine Testing.

Before adopting any particular gas engine for electrical work it should be subjected to a number of short tests or trials. Some of these will be of a general character; others

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will be based upon the special claims advanced by the makers, or upon the nature of the work to which the engine is to be put. In the matter of general testing, it would be difficult to find a better model upon which to base operations than the Society of Arts' Trials of Motors for Electric Lighting, 1888-9; and a brief account of these will be given in the present section.

Society of Arts' Trials.—During these trials, which were undertaken by Profs. J. Hopkinson and A. B. W. Kennedy and Mr. Beauchamp Tower, in September, 1888, three gas engines, besides one steam engine, were tested. We will confine our attention to the gas-engine trials. The following is an abstract of the introductory portion of the Report*:—

"The trials were carried out in a building specially erected for the purpose, on a portion of the site of the Imperial Institute at South Kensington. The tests comprised an efficiency test during a six hours' run for each engine at full power, a three-hours run at half power, and a test running light. In addition to these, one or two tests were made at the request of the exhibitors themselves, under conditions varied from the conditions of competition. In the case of the gas-engine tests, the quantity of gas consumed in the engine itself and in the ignition was separately measured, the readings of the meters being taken every quarter of an hour. The meters were Wright's standard wet meters, one of 100 and the other of 20-light size. The pressure and temperature of the gas were measured in the meter, and in each case samples of the gas were taken from time to time, were mixed together for each test, and were analysed by Mr. C. J. Wilson, F.I.C. The results of these analyses will be found in Appendix I., at the end of this report. Indicator diagrams were taken at intervals of a quarter of an hour, the diagrams being taken approximately midway between the times at which the gas was read. The indicator used for the Crossley engine was an improved Richards, made by Elliott and Co., and the same indicator and spring, with another similar one, was used for the Griffin engine. For the Atkinson engine a strengthened Crosby indicator was used. In all cases the indicator springs used have subsequently been tested. The errors being exceedingly small, a correction is not applied in calculating the results given later in respect to each engine. The brake horse-power was in all cases ascertained by means of a rope brake upon the flywheel or flywheels of the engine. Two ropes were used for each wheel; they were kept at the proper distances apart and in fixed position upon the flywheel by means of transverse wooden distance pieces. The dead load was applied by means of weights, and the back tension necessary to put the friction on the brake, by means of a spring balance. The spring balance was read every five minutes, and its tension was deducted from the dead load applied. This brake was found to work perfectly satisfactorily, and its results are certainly beyond suspicion. It is important, however, if any metal be used for attaching the wooden cross pieces to the ropes, it shall not rub against the rim of the flywheel; if this should occur, the metal becomes exceedingly hot, and is liable to burn the rope. The quantity of water used for cooling the cylinder of the engine during the run was measured by means of a Schonheyder water meter, and its temperature on emergence from the engine was ascertained by a thermometer. The meter was tested after the trials and found to be without sensible error. The number of revolutions made by the engine was measured by means of a counter continuously geared on to the crank shaft of the engine. This counter was read every quarter of an hour, at the exact instant at which the gas-meter was read.

In addition to the efficiency tests of the engines, tests were made to ascertain the regularity of running and of governing. For this purpose the engines were employed to drive a dynamo machine, and the current from this machine was taken through a metallic resistance controlled by switches; an incandescent lamp was also connected to the machine. The amount of cyclic variation occurring in the driving was ascertained by direct observance of the lamp. For electric light motors this is of course a sufficient test, as an engine running so regularly that the variation can not be detected in a lamp may be taken as being perfectly satisfactory for the production of the electric light. The resistances gave a great facility for speedily varying the load upon the engine. The speed of the engine was ascertained when fully loaded, and when running with the dynamo machine upon open circuit: it was also ascertained when running at half power. Observations were made of the effect of throwing off the load as the engine was running, and the hunting of the governor was judged by the pulsations, if any, which ensued in the incandescent lamp.

Appended to the account of the experiments on each engine will be found what may be appropriately described as a heat table. In the case of the gas engines this gives the heat of combustion of the gas, the quantity of this heat accounted for by the indicator diagrams, and the heat carried off by the cooling water. This leaves a balance which will be mainly accounted for by the loss due to the heated exhaust gas, together with a small amount due to loss by radiation and convection from the surfaces of the engine. If the quantity of gas and its temperature of exhaust were known, the former and larger of these amounts would be calculable. A very excellent approximation can be made to the quantity of waste gas from the known volume of the cylinder, the only doubtful point being the temperature of the charge when the cylinder is just filled. It is not likely that this temperature will exceed the temperature of the cooling water. Taking this to be the true temperature of the charge immediately before compression begins, the temperature is calculable at which this gas must enter the exhaust to account for the balance.

* This valuable Report is published in pamphlet form by the Society of Arts.

"As the temperatures in the gas engines can be estimated by the method just mentioned, the trials enable us to say what proportion of the heat received would have been turned into work by an engine working as a "perfect" engine between those temperatures, and therefore, to find the actual efficiency of the engine as compared with this standard."

A Typical Trial.—The course of testing indicated in the foregoing was followed in the case of all three engines, but we will here notice only one instance—viz., the trials of the Atkinson "Cycle" engine:—

"Five experiments, in all, were made with this engine, and they will be distinguished by the letters A, B, C, D, and E. Trial A was a full-power trial of six hours' duration, and trial B a half-power trial of three hours. In trial C the engine ran without load for half an hour. Trials D and E were special short trials with full brake load, but at speeds below the normal."

The principal results of these five trials are summarised in Table XXXIV. The maker elected to run the engine at 9½ B.H.P. normal load, and at 130 revolutions per minute normal speed. A rope brake was placed on each of the two pulleys, the ropes being worked perfectly dry—without lubricant or cooling water. It should be mentioned that care was taken to keep the loads of the two brakes as nearly equalised as possible.

Table XXXIV.—*Atkinson Gas Engine Trials.*

Date (1888)	Sept. 21	Sept. 22	Sept. 22	Sept. 24	Sept. 24
Trial	A	B	C	D	E
Duration	6 hours	3 hours	½ hour	½ hour	½ hour
Power	full	half	empty	full	full
Revolutions per minute	131·1	129·6	131·9	110·5	100·5
Explosions " "	121·6	69·1	23·8	—	—
Mean initial pressure	166·0	166·5	145·5	—	—
Mean effective pressure	46·07	47·60	48·59	—	—
Indicated horse-power	11·15	6·59	2·3	—	—
Brake load nett	130·5	66·0	—	135·4	127·1
Brake horse-power	9·48	4·74	—	8·29	7·08
Mechanical efficiency	0·850	0·719	—	—	—
Gas per hour, main	209·8	127·1	47·2	188·60	157·8
" " ignition	4·5	5·9	—	5·42	5·1
" " total	214·3	133·0	—	194·02	162·9
Gas per indicated horse-power per hour, main	18·82	19·29	20·50	—	—
Gas per indicated horse-power per hour, total	19·22	20·18	—	—	—
Gas per brake horse-power per hour, main	22·14	26·80	—	22·75	22·29
Gas per brake horse-power per hour, total	22·61	28·10	—	23·40	23·01
Water per hour (jacket)	680lb.	260lb.	—	—	—
Rise of temperature (jacket water)	50·0°	67·8°	—	—	—
H.P. in driving engine	1·67	1·85	2.3	—	—
Mean pressure during working stroke, equivalent to work done in pumping strokes, about	1·0	—	—	—	—
Corresponding indicated horse-power	0·26	—	—	—	—

Steadiness in Running.—An important matter affecting the suitability of a gas engine for electrical work is the amount of variation in speed of the engine which takes place during one cycle, when the load is constant. The variation is presumably greater than in a steam engine, owing to the lesser frequency of the impulses in the gas engine. Several methods have been proposed for determining the amount of this variation, and some of these have been actually used. The judges in the Society of Art's trials, just referred to, have appended to their Report a recommendation of the instrument shown in Fig. 81, though this instrument was not actually adopted for any of the results given in the Report. The judges give the following description of its construction and use:—

"This instrument was designed by Mr. H. B. Ransom in the engineering laboratory at University College. It consists of a drum covered by a prepared and blackened (smoked) paper, which drum revolves with the shaft whose velocity is to be measured. Near to the drum a tuning-fork is kept in vibration by means of an electric current. This tuning-fork is carried on a slide rest, and actuated by a screw in such wise as to travel parallel

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to the axis of the drum. One limb of the tuning-fork carries a light style of sheet brass, which rests in light contact with the drum. As the drum revolves, and the tuning-fork vibrates, a wavy line is a traced upon the paper. The number of waves in any length is a measure of the time taken by the drum in turning through a corresponding angle."

Another method has been used with, it is said, considerable success, this consisting in illuminating the flywheel of the engine at regular intervals by means of an electric spark. If the sparking is perfectly regular, then, when the engine is

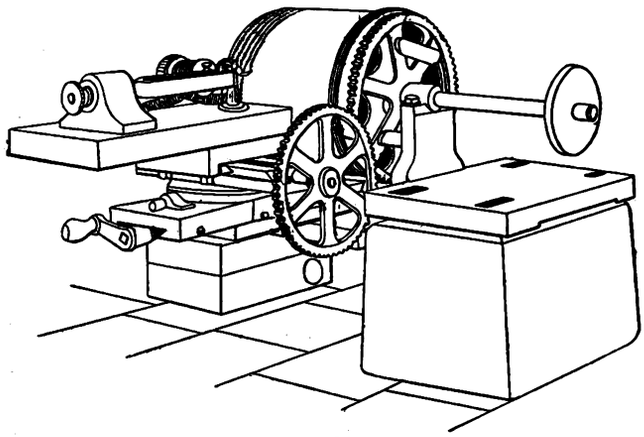

FIG. 81.

running also quite regularly, the spokes of the flywheel will appear to be stationary or else will appear to advance or recede at a regular rate; but if the engine alters in speed a corresponding change will take place in the successive displacements of the spokes, as revealed by the instantaneous sparks. The method is capable of considerable development; and the chief source of error which must be guarded against is liability to irregularity in the frequency of the sparks.

(To be continued.)

DANGER OF ELECTRIC SHOCK.

BY ALBION T. SNELL.

There appears to be much uncertainty in the minds of both experts and the public as regards the dangers of electric currents, and the decision of the Committee recently appointed by the Board of Trade to consider what shall be defined as high pressure does not seem to have met with general approval. Without questioning the wisdom of the decision arrived at by the eminent experts who have seen fit to place 500 continuous volts on a level, as regards danger, with 250 effective alternating volts, there does seem reason for asking upon what grounds the decision has been made. The extension of the maximum limit of low pressure continuous current supply to 500 volts appears to be warranted by comparative immunity hitherto from serious accidents in numerous plants in which a pressure of from 400 to 500 volts has long been used, chiefly for power purposes, but also for lighting in several supply stations.

Some ten years ago I had to select the pressure most suitable for large power plants in mines, and after a number of trials, both as regards the plant and the effects on the workmen, I fixed upon 500 volts as a convenient pressure, giving a sufficiently economic size of conductor, causing no serious trouble from leakage difficulties, and also, so far as my experience went, likely to occasion no serious accidents from shock *under working conditions*. In fact, the worst that have come to my notice during the past ten years have been small burns and shocks, which though unpleasant at the time, have resulted in no lasting damage.

I have had no special opportunity of studying the effects of a 500-volt shock on the human subject with contacts arranged to reduce the resistance of the skin to the lowest limits; but I have seen men with their boots soaked with water, and thus making good earth, knocked down by accidental contact with the conductor which happened to be insulated at the time. Speaking from my own experience and observation, I do not think that the strongest man could live for many minutes when subjected to a 500-volt current through good contacts. Fortunately in power work the conditions are usually well understood, and the plant is shielded from all persons except those in charge, who, of course, have to take their chance of a well-recognised danger, for which there are proper safeguards. It is due to these conditions rather than to any inherent safety of the 500-volt pressure that accidents are practically unknown in mines using electric power.

As regards the use of this pressure in buildings off the mains of a supply company, I have grave doubts, and the Committee of experts have also apparently viewed the matter with cautious reserve, for they advise the earthing of the middle wire of a three or five-wire system of mains, so that the maximum difference of pressure between any part of a consumer's electric fittings and earth cannot exceed 250 volts. In such cases we have to bear in mind that the switches, &c., are not to be handled exclusively by more or less skilled men, who know at least to some extent the danger of a shock, but these fittings are liable to be touched daily and at all hours by our wives, our servants, and even by chance our children. The question arises: Is a pressure of 250 volts, even if continuous, likely to be harmless to the ordinary user of electricity? I think it will be difficult to answer this question off-hand in the affirmative. In Manchester and St. Pancras the five-wire system has worked admirably, and there have been no complaints of serious shocks so far as I know, but surely no one denies the possibility of their happening at any time. I am not an alarmist, and have handled alternating pressures of 12,000 volts, but then I know the necessity for caution. *Apropos* of the dangers of a 250 volt continuous current, I recollect that a linesman had his hand burnt very badly in a mine where the pressure was about 235 volts, and the return conductor was a bare iron rope laid along a wet road; and, if my memory serves me rightly, a lad got hold of the positive conductor one day, and had to be dragged away by force, having lost the power of unclenching his fingers.

It does not appear quite clear whether the Committee recommended a pressure of 250 effective alternating volts as the maximum to be allowed within a building, or whether the old limit of 125 volts is to be retained. For my part, I do not think that our present knowledge of the physiological effects of electric currents warrants the drawing of a difference between continuous and alternating currents, so far as danger to life is concerned. Indeed, judging from accidents which have come under my notice, and also from a number of personal experiences incidental to my work, I believe the alternate current to be the least dangerous, on account of the well recognised repellant action on the fingers, whereas continuous currents contract them. Of course, if one falls on a conductor charged by either a continuous or an alternating current there may be little chance of escape unless help be at hand.

I am glad to find the Committee recommend that the middle wire of a three- or a five-wire system be earthed at one spot. This is the only way of fixing the maximum pressure on a given system of mains, and it gives the best possible safeguard against danger to workmen engaged on line work, because the limiting pressure is known. It is also important to the users of electric power, for it permits of the use of concentric wiring with an earthed outer—on three-wire systems at any rate—although its use would not appear to be feasible on a five-wire system, except in houses wired between the earthed centre main and one of the two adjacent mains.

THE GLOW LAMP QUESTION IN GERMANY.*

It is a general experience, and one which is confirmed almost every day, that glow lamps at present in the market are not, with regard to quality and life, all that could be desired. Since electric light has found a wider application little has been done which could be described as real improvements in glow lamp manufacture. Of course the price of lamps is at present only $\frac{1}{10}$th of the price of 10 or 12 years ago, when it was about 6s., but unfortunately this

* Report of a Commitee of Representatives of German Electric Supply Undertakings. From the *Elektrotechnische Zeitschrift* of December 5th.

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reduction in the price has been made at the expense of the quality. It can certainly not be said that the watt consumption has not become less than it was 10 to 12 years ago, and it must be borne in mind that the life of lamps has fallen considerably. As it is of great importance to electric supply undertakings to have good lamps in order to prevent the electric light from coming into disrepute, it was the duty of the Committee to find out a way to always furnish consumers with good lamps, and by which makers could be compelled to supply good lamps.

The first question was, first of all, to settle what faults did lamps possess. With regard to this the Committee made a number of tests and asked for information from various sources. It would, however, take too much space to describe all the experiments in detail, and hence only the results will be considered. In general, these experiments have shown that the complaint of consumers. viz., the lamps were bad and of no value, are quite justified. The reason for this is careless sorting, careless marking, low efficiency, and short life. Every electrician who is accustomed to make photometrical tests will have found that the sorting and marking of lamps of nearly all makers leaves much to be desired. In fact, nearly always candle power and watt consumption differs from the figures guaranteed.

Tests made on about 70 16-c.p. lamps for 110 volts, and supplied by eight different German firms, showed a variation in the candle-power from 7·82 to 22·85 c.p. (*Normal-Kerze*). While the lamps were marked for a watt consumption of 3½ to 3½ watts per candle, the current absorbed varied from 0·43 to 0·63 ampere, and the watt consumption per candle from 2·8 to 6·3 watts.

Tests made on another 20 16-c.p. lamps for 110 volts, supplied by a well-known firm, showed a variation in the candle-power of from 10·21 to 21·6 candles, or more than 50 per cent. These lamps were specially supplied for testing purposes, and consumed 4·1 watts per candle.

Of five 16 c.p. 3½ watt lamps by another well-known firm, which were picked out of a larger quantity, one gave out at once, another emitted only 10·21 c.p., a third 13·6, and the remainder 16·02 and 16·63 c.p. The average watt consumption was 3·7 watts per candle.

In the case of another 10 16 c.p. 110 volt lamps by a third well-known firm, which were also taken from a larger quantity, the candle-power ranged from 15·9 to 22 candles, and the average consumption was 3½ watts, but after 48 hours the candle-power had fallen by 40 to 60 per cent., while the average watt consumption had risen to 5·6 watts per candle.

In 2½ watt lamps examined the conditions were found to be the same. Only a few lamps gave one candle for every 2½ watts, and most makers supplied 3½ watt lamps as 2½ watt lamps without any scruple.

From the above it will be seen that, as a rule, figures given by lamp makers cannot be trusted, as it is just as likely one will get an 8 or a 20 c.p. lamp as the 16 c.p. lamp asked for. It might be thought that so large a variation in the candle-power could be detected at once, but everyone who has carried out photometrical work will know that even for a trained eye it is difficult to do so. The reason for this is mainly that the specific luminous power, *i.e.*, the luminous power per unit of surface is generally the same in lamps of different candle power. If a 16 c.p. lamp is placed into a group of 20 c.p. lamps of the same specific luminous power, then for most eyes it is difficult to observe the difference, and for the general public it is most likely impossible. If the sorting and marking of lamps is in a bad state, examinations of lamps as to economy and life show no better results.

When the cost of the electric light is compared with other kinds of lighting 3 to 3½ watts per candle is generally accepted as normal consumption. Formerly the German or English standard candle was always used, but now the "Hefner lamp," which is 10 to 12 per cent. smaller, is employed almost exclusively. Full advantage of this has been taken by lamp makers, who now mark the same lamps as 3 watts, which formerly were 3½ watt lamps. How difficult it is at the present time to obtain really good lamps, which require at the beginning less than 3½ watts per candle is known to all electricians. After 300 hours most lamps require 4 watts, and after 500 hours 4½ watts. Later the watt consumption runs up very quickly to 5 and 6 watts per candle, and sometimes even higher before the lamp has burned out. In inferior lamps the watt consumption rises after 100 hours to 5 to 5½ watts per candle. It is therefore entirely wrong to take the average consumption of energy at 3½ watts without regard to the decrease of brightness, but it will come nearer the actual figure if 4 to 5 watts is accepted, especially if we consider that most consumers do not renew lamps till they give out.

Lamps having a smaller consumption than 3 watts per candle, and 2½, 2, and 1½ watt lamps play at the present time a very small part, as owing to their very short life the saving in the consumption of energy does not outweigh the cost for the renewal of the lamps. The estimates of such lamps, furnished by their makers, are usually only of theoretical interest, as the life is generally taken too long, and the candle power and watt consumption, which form the basis of these calculations, only apply to the first few hours. For an independent calculation we require to know the curves for light and energy consumption for the whole life of the lamp in order to be able to arrive at the average consumption. If this be done a quite different result is obtained, which also is far more in favour of the 3 and 3½ watt lamps. Further, experience teaches that at the present time the use of 3 watt lamps is the most advisable and the most profitable.

With regard to the life of lamps, this is found very different in lamps of different makers. Generally 800 to 1,000 hours is given for 3 to 3½ watt lamps. Formerly 1,000 hours was the usual figure, but this has now been somewhat reduced. Less than 800 hours is however not given as a rule. Such life can easily be attained in high vacuum lamps when life is understood to be the time from the first use of the lamp to the giving out of the same. On several occasions lives of 1,500 to 2,000 hours have been obtained. Such figures are, however, of absolutely no value, as all lamps before giving out have already reached a small candle-power and are inefficient.

By "life" the "useful life" (*Relative Brennzeit*) should always be understood, that is to say, the time which the candle-power of the lamp takes to fall a certain percentage. This percentage would be about right when taken at 20 per cent., and lamps, the candle-power of which has fallen that amount, should considered used up.

By a "candle-power" the "mean candle-power" should be understood measured in two directions vertical to each other. The candle-power varies, as is well known, according to the position of the lamps, and can vary as much as 20 per cent. between two positions. It is difficult to say in which position a lamp possesses its largest candle power, even if the lamps are of the same kind. It will be nearly correct if the lamp is placed in such a position on the photometer that an imaginary straight line passing through the terminals of the filament is at right angles to the photometer bench. By "mean candle-power" will then be understood the average attained by this measurement, and a second one in which the imaginary line is rotated through 90°.

If this "useful life" and "mean candle-power" be employed for calculations, then bad results are obtained with all lamps at present in the market. As an instance, it may be mentioned that in 10 16 c.p. 3½ watt lamps by well-known makers the average actual life was 1,450 hours and six lamps even attained a life of over 2,000 hours. The "useful life," however, was only about 400 hours. Five lamps of the same size by another maker had an actual life of 741 hours and a "useful life" of 366 hours. Ten lamps of the same size by a third firm gave an average actual life of 1,435 hours, six lamps burned for more than 2,000 hours, the "useful life," however, was only 150 hours. If from this two extra good lamps are deducted, the actual life was only 680 and the useful life only 17 hours. If lamps of the better class firms show such results, what may be expected of small makers? As a general rule their lamps must obviously be less economical and have a shorter life. The same holds good for lamps with a watt consumption of 3 watts and less. Seldom does the average "useful life" rise higher than 100 hours and the actual life higher than 300 to 400 hours. There are, however, a few exceptions, especially when makers know that the lamps are to be tested after delivery. What is mentioned here therefore applies to lamps sold in the market.

In ordinary lamps, such as consumers buy in shops, the "useful life" should never be taken above 400 hours, and, therefore, in calculation this figure should be employed instead of 800 to 1,000 hours.

It is remarkable that glow lamps, during the 15 years of their existence, have not improved, but rather deteriorated. The reason for this state of things is not difficult to discover. With the rapid development of the electric light the demand for lamps rose enormously. In consequence the makers were able to pay but little attention to careful manufacture; rapid manufacture was needed to meet the increased demand. This great demand for lamps resulted in the erection of a great number of lamp factories, the owners of which, without much preliminary knowledge, and without paying heed to the requirements of a good glow lamp, swamped the market with a cheap make, and forced the older manufacturers to reduce their prices also. Severe competition brought the price gradually down to one-tenth of the original price, so that even honest firms, who had the desire to introduce improvements and to carefully sort lamps, had to give up their good work if they wished to make a little profit on their work. Again, the ordinary consumer knows, as a rule, little as to how to judge the candle-power and economy of a lamp, and relies upon the promises made by the seller who sells the cheapest article. And frequently the seller is not very particular as to the voltage of his lamps, and then complaints are made to Electricity Works of insufficient pressure, while all the time it is no fault of the supply station. It is therefore of great importance to furnish consumers with the best possible lamps, as otherwise they might be driven back to gas, the more so as electric light is still more expensive than gas light.

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In the last few years great efforts have been made in the gas industry to improve burners, and it is well known that the Auer burner has been of great advantage to gas companies. Electricity Works would profit in the same way if their whole influence was brought to bear on the manufacture and supply of good lamps. At all events, every pressure should be brought to bear in order to gradually suppress the large quantity of inferior stuff now in the market; only good lamps should be allowed, even if a rise in the price should be the consequence.

The question is now, what can electric supply undertakers do to attain this end? The Committee is of opinion that it could be more easily achieved than is perhaps thought possible.

First of all, Electricity Works must take the supply of lamps to consumers into their own hands, as was formerly the custom, and is still done by a few supply stations, and must not allow any lamps bought elsewhere. This could be done by either selling lamps at such a low figure that ordinary sellers could not compete, or, what would be better still, by following the example of Altona and Mulhouse, and supplying lamps gratis. It certainly does not suffice for Electricity Works to supply good lamps at the same price as the ordinary seller, unless no connection is made until the consumer signs an agreement only to buy lamps of the Company. But as electric light undertakers cannot very well indulge in much advertising, an agreement of the kind mentioned would arouse in the already suspicious consumer a suspicion that large profits were connected with the sale of glow lamps. The only way out of the difficulty is to supply lamps free of charge, or at least very cheap, perhaps below the cost price. The cost of such a gratuitous supply of lamps, which appears larger than it actually is, could easily be born by every electric supply concern, as it would not exceed 2 to 3 per cent. of the income derived from the sale of current. This loss would, however, be amply compensated by the increase in the number of consumers. There can be no doubt that by such a measure the electric light would gain in popularity. No inferior lamps, which are at present only kept on for reasons of economy, would be about, and all complaints and disagreeable remarks about the electric light would disappear, and better relations between consumer and supplier would be attained.

There is, however, one condition without which the matter could not be brought to a successful issue, and that is, Electricity Works must continually test and examine the lamps supplied by the manufacturer, and reject everything which is not in accordance with specification. Only a concerted move can effectively influence the manufacture of lamps, and to this end the Committee has drawn up a number of rules which may serve as a basis for contracts for the supply of lamps.

Specification for the Supply of Glow Lamps.

(1). Glow lamps must have on a test the required voltage and candle-power as well as the required watt consumption per unit of light. A variation is, however, permitted:—Voltage $\pm$ 2 per cent.; candle-power $\pm$ 6 per cent.; watt-consumption $\pm$ 6 per cent. All lamps which are not in accordance with these conditions are to be returned. Also lamps which show other faults or are badly mounted.

(2). The lamp supplier, in his tender, has to give a binding declaration as to the "useful life" of the lamps tendered. By "useful life" is to be understood the number of hours of burning in which the candle-power falls on an average by 20 per cent. of the original value. The watt consumption at the end of the "useful life" must not have increased more than 25 per cent. As unit of light the Hefner lamp will be taken.

(3). Tests are to be made in the laboratory of the Electricity Works, but can also, if desired by the lamp maker, be made at his cost at the Reichsanstalt. The fundamental conditions of the test are, however, to remain the same. Before delivery the maker must decide whether the test is to be made by the Reichsanstalt or the Electricity Works. When this is decided neither side can afterwards appeal. If the test be made in the testing department of the Electricity Works, the instruments of the same are to be considered as standards, but the lamp maker has the right to have the instruments tested from time to time.

(4). The test for the determination of the "useful life" is to be made in the following way: (*a*) Of each lot of lamps 1 per cent. is to be taken out for test; at least five lamps, however, must be taken. These lamps are to be tested photometrically at the beginning and at the end of the guaranteed "useful life." (*b*) The test is, if possible, to be made without stoppage, and the lamps are to stand upright or be suspended. (*c*) The lamps are to be tested photometrically either standing upright or suspending vertically, in such a fashion that an imaginary straight line passing through the connecting points of the filament coincides at one time with the longitudinal axis of the photometer bar, and the other time forms an angle of 90deg. with the same. The mean of the two tests is to determine the candle-power. (*d*) If one of the test lamps gives out during the first 24 hours it can be replaced by another one. No other lamps giving out before the end of the test can be replaced.

(5). The guarantee given by the seller with regard to the life of the lamps is to be considered as fulfilled, if after the expiry of the agreed "useful life" the sum of the candle-powers of all the test lamps has not diminished more than 20 per cent. of the original figure, and the watt consumption per unit of light has not increased more than 25 per cent. of the original.

THE CONTINUOUS RAIL IN STREET RAILWAY PRACTICE.*

BY RICHARD M'CULLOCH.

In the horse-car days, flat tram-rail laid on stringers was used almost entirely, and when the girder rail was rolled it was supposed that all that could be desired in the way of track had been produced. But when electric cars were put on the horse-car tracks, and when the length of these cars was increased from 18ft. to 35ft., the weights from 5,000lb. to 24,000lb., the speeds from 8 to 20 miles per hour, and the headway decreased from 5min. to less than 1min., the rail manufacturer found himself a thorough sympathiser with Jules Verne's armour-plate maker. For every inch that he added to the depth of his girder rail, and for every improvement in its manufacture, an additional length was added to the car and an additional weight to the trucks and motors. The life of a girder rail is supposed to continue until the head becomes so worn that the flanges of the wheels begin to run on the tread. But as a matter of fact, few street railway tracks last until this takes place, for long before the head is worn off the joints have become so rough that the rail must be renewed to save wear and tear on passengers and cars.

Exactly who was the first man bold enough to suggest having no joints at all is hard to say, but it is pretty certain that the first experimenting in this line was done by Mr. Philip Noonan, a railroad engineer of Lynchburg, Va., who several years ago built about three miles of steam-railroad track leaving no openings between the rails and fastening the joints with hot-rivetted plates. This track was in actual use for several years, and was the first demonstration of the continuous rail. Early in 1892, the Johnson Company, of Johnstown., Pa., began experimenting with the continuous rail. One rail of a section of track 1,160ft. long was joined by heavy bars and machine-fitted bolts so that there was no possibility of movement. Carefully-fitted wedges were driven into the spaces between the ends of the rails, and every precaution taken to have the joint absolutely immoveable. The other rail of the same track was laid in the ordinary manner, with fish-plates and openings between the rails, so that any deviation of the continuous rail from a straight line would be noticed in the change of gauge. The rail used was the Johnson 6in. 78lb. girder, and the track was in actual use during the time of experimenting. At five points along the line stakes were set opposite marks on the rails, so that any change in the length of rail would at once be noticeable. During the period of experiment the air temperature varied from 10 to 89 deg., and absolutely no movement could be detected in the rails, either longitudinally or laterally. This experiment satisfied the Johnson Company that the continuous rail was practicable; and having proved its feasibility they at once set about finding the best method of uniting the rail ends.

The method adopted by this Company for connecting the rail ends was that of welding them electrically. A machine for this purpose was built by the Thomson Welding Company, and in the spring and summer of 1893, about three miles in Johnstown and about eight miles of track in Boston were electrically welded. During the winter of 1893-4 about 6 per cent. of these joints broke. Having remedied some apparent defects in the method, the Johnson Company in the spring of 1894 sent their machine to St. Louis, where 6½ miles of track were electrically welded. From St. Louis the machine was sent to Cleveland, where about 5 miles were welded, and then to Brooklyn, where 32 miles of track were joined together by this method. The first track electrically welded, that is, that in Johnstown and Boston, was not welded directly at the joint, but the rail ends were joined on each side by means of a span which was welded to the web of the rail about four inches back of the end. The breaks did not occur at the joint or in the span, but the rail itself broke where the span had been welded on. This was supposed to be due to the fact that when the rail at this point cooled after the welding process, internal strains were produced which seriously impaired the tensile strength of the rail at this point. A new form of joint was devised, by means of which an actual butt weld is made at the joint, and this is the method which has been applied in St. Louis.

The Baden Division of the St. Louis Railroad Company, where the electric welding in this city was done, consists of 3½ miles of

* From the *Street Railway Review*. Abstract of a Paper read before the Engineers' Club of St. Louis.

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double track. The track throughout is laid in a macadam street, no paving being used either inside or outside the rail.

Cast Welding.

As soon as the fact was demonstrated that a continuous rail buried in the ground was a possibility, other methods besides the electric welding of the joints were proposed. The particular one which will be described here is what is known as the "cast-welding" process, and is being exploited by the Falk Manufacturing Company, of Milwaukee. This, to briefly describe it, consists of clasping the ends of the rails for about 8in. on each side of the joint by means of a mould, and then pouring the mould full of molten iron. The iron solidifies on the rails around the joint, and makes a partial union with it. In order to compare the two methods, the St. Louis Railroad Company, in the fall of 1894, had three miles of track in the southern part of the city connected by the cast-welded process. As the furnace was not ready at the time the rails were laid, the track work was finished and the trench filled in, leaving the joints temporarily connected by fish-plates. Some three months later, when the furnace arrived, the macadam around the joints was dug up, the fish-plates removed, and the rails united by means of the cast joint. The track was laid in July and August, and the rails were welded in October and November. No cars were operated over this track during the winter of 1894-95, but at present the cars of the South Western Railway are running regularly over this route. On account of the excellent record made by this track during last winter, the officers of the Citizens Railway Company, of this city, decided in relaying the old cable track, to use the cast-welded joint.

The apparatus for casting the joints consists of a cupola furnace mounted on a heavy truck. The cupola is 2ft. in diameter, brick-lined, and the blast is furnished by a No. 5 Sturtevant blower, driven at 1,800 revolutions per minute, by a 5 H.P. motor, which receives its current from the trolley. The cupola is operated as is usual in a foundry, and the iron used is one-half best soft gray pig and one-half selected scrap. The scrap consists of old gear wheels, manhole covers and frames, an abundance of which are found in the scrap heap of the railway. The furnace works very rapidly, and in 20 minutes after the blast is turned on the iron is ready to pour. It may then be tapped as long as the charging is continued at the top. The preparation of the joint for casting is as follows: The fish-plates are first taken off and the rail ends for about 8in. back polished with garnet paper. If there is any opening between the rails it is closed by shims. The moulds, consisting of two castings made to fit the rail, are then placed about the joint and clamped in position. A heavy clamp is placed on top of the rail and screwed up as tightly as possible to hold the joint immovable while being poured. This clamp is left on the rail until the casting has cooled. Preparatory to the pouring the moulds are lined with a mixture of linseed oil and plumbago, and are heated to drive out any moisture in them or on the rail. The pouring operation is very simple. The melted iron is run from the cupola into a ladle and then slowly poured into the mould. This final operation is very quickly performed, as it usually takes only about three hours to pour 40 joints. The casting weighs 137lb. and extends back on the rail 7in., taking in two of the bolt holes in the ends of the rails. In this way four bolts are cast through the rail. It is undoubtedly the case that a sort of welding action takes place between the iron and the steel rail, as on examination of a joint sawed in two it will be difficult to tell the exact junction of the iron and the steel.

Having described the modes of applying these two processes, let us see what they have done in actual operation. The Baden road, constructed in the spring of 1894, which had its rail ends connected by the electric method had, in all 2,203 joints, and of these 72, or 3·27 per cent., have broken. Thirty-seven broke during the cold weather of the first part of the winter, and these were repaired by the cast-welding method. During a later cold snap 35 more were broken. These have not yet been repaired. During the heat of the summer no trouble whatever was experienced with the alignment of the track. From the weather bureau reports the average temperature while the construction was in progress was 63deg., ranging from 14deg. as a minimum to 99deg. as a maximum. During the last winter the lowest temperature was 12deg. below zero, and the hottest day in the summer was 100deg., making the range of temperature through which the track has passed 112deg., or a maximum deviation from the average welding temperature of 75deg. Seven of the joints on breaking opened nearly 2in., but in many the opening was so small as barely to be perceptible, the average opening being about ¼in. During the warm weather of this summer the openings were diminished slightly, but the openings have never completely closed. Every joint which has broken has shown itself to be an imperfect weld. There has never yet been an instance of a good weld breaking. In all cases the rail ends have simply pulled apart, the lugs sticking to that rail which held them tightest. In a few instances small pieces of rail pulled off with the lugs, but in no cases have the rails themselves broken, and we have never had a joint to break which looked as if it had ever been really welded. There are several reasons for this. On account of the great distance from the power house, the voltage was necessarily low while the weld was being made. The work at that time was new and not very well understood; and the workmen who had the machine in charge were often careless and hurried. The result of this experiment is far from being discouraging, and the officers of the railway company are satisfied that with the additional knowledge we now possess, and with the improvements which have been made in the welding machine, by which a fairly constant voltage is maintained while the welding is in progress, that it is possible to construct a track by this method with an insignificant trouble from breakage.

In regard to experiments elsewhere, Mr. C. W. Wason, electrical engineer of the Cleveland Electric Railway Company, has been kind enough to furnish information as to results obtained in Cleveland. During the summer of 1894, 3,400 joints were made electrically, two-thirds of which were on 56lb. rail and the remainder on 90lb. rail. Of this number the total breakage during last winter was six, four of them being on 56lb rail and the remainder on 90lb. rail. The percentage of breakage was 0·18 per cent. which is a much better record than that made in St. Louis. All the joints which broke showed themselves to be imperfectly welded. Mr. Wason expresses himself as highly in favour of the electric method of welding, and states that the breaks and rough joints on his track were due to carelessness on the part of the workmen operating the machine.

The cast-welded track of the South-Western Railway on Chippewa-street was welded during the months of October and November of the same year. The average temperature while this work was in progress was 51deg., with a maximum of 84deg. and a minimum of 18deg. There were 744 joints in all, and during the winter only three, or 0·43 per cent., broke. As stated in the case of electric-welded track, no deviation whatever has been perceived in the alignment. Since this track was laid the temperature has ranged from 100deg. as a maximum to 12deg. below zero as a minimum—a range of 112deg. and a deviation of 63deg. from the welding temperature.

The Falk Manufacturing Company, who are making the cast joint, have this summer operated in Chicago, St. Paul, Minneapolis and Newark, besides the work done in St. Louis. In Chicago, for the Chicago City Railway, 11,903 joints were made on 4½in and 7in. rail, and for the West Chicago Street Railroad Company, 8,867 joints were made. In St. Paul, Minneapolis, and Newark, work has recently begun, and up to the present time about 2,000 joints have been made in each place. The results so far have been very satisfactory, both to the railroad companies and to the contractors.

It seems difficult to those accustomed to steam railroad tracks to reconcile themselves to the use of a continuous rail. They instinctively call to mind certain experiences they have had with rails creeping and getting out of place on account of temperature variations. It must be remembered, however, that street railway tracks differ in one very important particular from those of the steam railways, that is in having a road bed firmly packed about the rail. The perimeter of a 7in. rail is 29in. of which only 6½ or 22·4 per cent. is exposed to the air, while the remaining 67·6 per cent. is covered up and firmly gripped by the road-bed. No one can understand how firm this grip is who has not seen a rail which has lain in a macadam street several years taken up, when the whole buried surface of the rail is found to be covered with a hard cement composed of stones and mud requiring considerable work with a pick to remove. There is a great tendency on the part of the rail to change its length with the temperature variations, but there is also the ability of the road-bed to hold it in place.

The strain on rails due to the variations of temperature may be estimated as follows. Assuming a coefficient of expansion for steel of 0·0000065, and multiplying this by 75, which is a liberal figure for the number of degrees of maximum deviation from the welding temperature, we get 0·000487, which is that part of its length which a rail would expand due to a rise of 75 degrees, or contract due to a fall of 75 degrees in temperature. A steel bar will expand 0·00003 of its length due to a load of 1,000 pounds per square inch. Dividing the estimated expansion by this figure we get for the strain 16,200 pounds per square inch. As the rail is 8½ inches in cross section, the total pull due to a fall of 75deg. in temperature is 137,700lb. As 40,000lb. per sq. in. is a safe value for the elastic limit of steel it can readily be seen that in this climate at least the elastic limit will never be reached, and this means that these expansions and contractions may go on indefinitely, and as long as the joints remain unbroken no harm will be done to the rail, for it is a well-proven fact that stresses within the elastic limit work no harm. Assuming 80,000lb. per sq. in. as the ultimate strength of steel, we see that so far as the strength of the rails themselves is concerned, we have a factor of safety of five.

An interesting calculation may be made showing the friction with which the rail is held by the road-bed. Taking the figures for the contraction of the rail due to a fall of 75deg. in temperature,

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each rail of the Baden track should have contracted 8ft. 6in. As a matter of fact, when the joints broke the openings in none of these exceeded 2in., and the combined openings of one rail the length of the road did not exceed 6in. This would seem to show that the pull which broke the joint was not a transmitted, cumulative effort extending all along the line, but was more the result of a local strain, not extending for a great distance on either side of the joint. Reasoning from the same data, it would appear that the strain at other points along the track has not been relieved, and that the joints at these other places have shown themselves strong enough to endure the pull.

The strength of the cast-iron joint may be shown to be fully equal to the strength of the rail. The area of its cross section at the joint is 61·6 sq. in. In order to make a perfectly safe estimate, let us assume that its cross section is reduced 25 per cent., or to 45 sq. in. by blow holes and imperfections. Taking for the tensile strength of cast iron 18,000lb. per sq. in., we have as the ultimate strength of the joint 810,000lb., which is largely in excess of the rail.

Comparison of Methods.

The two methods just described are the only processes of actualiy welding rails yet put into operation. The electric welding is scientifically a beautiful process, and when skilfully done we have no hesitation in saying that the joint is stronger than the rail itself. It has the disadvantage, however, of requiring considerable care and intelligence to operate it, qualifications which are sometimes difficult to find in workmen. It is also impossible to tell simply by looking at a joint whether or not it is really welded. On ordinary railway circuits when the voltage fluctuates continually it is difficult to operate the processes successfully. This, however, it is proposed to remedy by using a storage battery, which takes current from the line when the welding machine is idle, but which is thrown into parallel with the line and assists in maintaining the voltage while the welding is in progress. The welding machine with its accessories is exceedingly heavy and cumbersome, and difficult to move from place to place where track is not already laid. The great expense of an outfit prohibits almost any railroad company owning one and this complicates the question of repairs, for if the machine is gone and some of the joints break, how are they to be repaired?

Without wishing to make any invidious comparisons, it would be well to call attention to some of the advantages which the cast-welding process possesses. The first is, the relative simplicity and cheapness of the apparatus employed and the ease with which men may be procured who are used to this kind of work and capable of doing it well. The machine is not very heavy, it does not run on the track and can be transported easily and quickly from place to place. While as yet no difficulties have developed, the weak points of the process would seem to be: First, that the joint is a casting, subject to blowholes, chilling, imperfections and all the ills of a casting, any one which might greatly impair its tensile strength; and second, the fact that the steel rail and the cast-iron joint possess different coefficients of expansion, and that under variations in temperature internal strains might arise in the joint itself, which might finally result in its rupture. As has already been stated, however, no troubles of this kind have as yet developed, and these are merely considerations which suggest themselves in the examination of the process.

The cost of either of these methods is not greatly in excess of the old fish-plate method; but even if it was, the advantages gained by the abolition of joints would be of such value that no progressive railroad man would hesitate on that account. If either method will remedy for all time trouble with joints, the cost of repairs to the track after being down a few years, if laid with fish-plates, would soon pay the extra first cost, without considering the prolonged life of the rolling stock, and the prestige given to the road on account of its smooth riding track. If joints are abolished, the life of a track instead of being limited by the life of the joints will be the life of the rail itself, and this will far outweigh any considerations as to the cost of making the joints.

An additional advantage which should be mentioned is that any form of welding obviates the necessity of bonding the joints of electric roads. Tests which have been made on welded joints show that the electric conductivity of the joint is as great as that of the rail itself. Assuming the conductivity of steel to be one-seventh that of copper, an 85lb. steel rail would have a carrying capacity equal to a copper bar 1·2 sq. in. in section, or, as feed wire is usually rated, of 1,500,000 circular mils. A double track, consisting of four of these rails, would thus have a conductivity equal to 6,000,000 circular mils. This is largely in excess of the feeder section of any one line of railway in St. Louis. For instance, the combined section of the feeders which run to the Citizen's line, which was calculaied for 60 cars allowing a drop of 50 volts at full load, is 3,200,000 circular mils. To one who is engaged in the actual operation of street railways this means a great deal. Given a track with a conductivity equal to that just cited, it is necessary only to establish a low-resistance connection between the rails and the 'bus bar in the power house, when all the troubles due to low voltage along the line, and all the dangers of electrolysis, would be a thing of the past.

It is not to be supposed that the millennium in track-construction has already been reached, but what has been demonstrated is this: First, that the use of a continuous rail for street-railway practice is feasible, and, second, that it is possible to make joints of sufficient strength to stand changes of temperature.

NEW PUBLIC COMPANIES OF 1895.

The following are the more important limited liability companies connected with the electrical engineering and allied industries registered during the past year, with their capital:—

	Capital.
Acetylene Illuminating Company	£21,900
Alliance Meter Company	5,000
Alternate Current Electromotor Syndicate	6,000
Amazon Telegraph Company	250,000
Apostoloff Automatic Telephone Patent Syndicate	10,000
Automatic Electric Sign Company	5,000
Automotive Syndicate	5,000
Bartlett (J. G.) and Co.	20,000
Battery and Motor Company	12,000
Bentley and Jackson	40,000
"Best" Miners' Safety Lamp Company	25,000
British Electric Traction (Pioneer) Company	100,000
British Electrical Manufacturing and Engineering Company	20,000
British Electrozone Corporation	250,000
British Motor Syndicate	150,000
Broadbent (Thomas) and Sons	25,000
Capital and Counties Electricity Supply Company	5,000
Cambridge Scientific Instrument Company	10,000
Celline Art Metal Works	5,000
Cheshire Electric and Steam Yacht Company	2,000
Connolly Brothers	20,000
Cork Electric Light and Power Company	1,000
County of London Tramways Syndicate	5,000
Cramp Manganese Bronze Company of Great Britain	50,000
Davy Electrical Construction Company	10,000
Direct Electric Generator Syndicate	100,000
"D.P." Battery Company	10,000
Douglas Southern Electric Tramways	50,000
Electric and General Exploring Syndicate	5,000
Electric Guest Call Company	5,000
Electric Installation Syndicate	5,000
Electric Organ Company	110,000
Electric Ozone Syndicate	12,000
Electric Sign and General Advertising Company	5,000
Elliott's Moulding and Joinery Company	30,000
Electrical Oil Refining Company	5,000
Electrolytic Research Syndicate	1,000
Empire Economic Steam Producer Company	80,000
English Automobile Horseless Carriage Syndicate	5,000
Evans, O'Donnell and Co.	45,000
Evershed and Vignoles	10,000
Farmer (Sir James) and Sons	15,000
Fielding and Platt	50,000
Fort William Electric Lighting Company	7,000
Galloways	115,000
General Electric Tramways Company	50,000
General Traction Company	50,000
Gilbert Gilkes and Co	£20,000
Grenfell, Hubert	12,500
Harrington Electric Light Company	3,000
Harrow Electric Light and Power Company	25,000
Headland's Patent Electric Storage Battery Company	15,000
Horseless Carriage and Motor Cycle Company	100
Howell (J. C.) and Co.	10,000
I.E.S. Accumulator Company	100,000
Improved Electric Glow Lamp Syndicate	5,000
Industrial Inventions Development Company	50,000
Irwell Rubber Company	30,000
Jandus Arc Lamp and Electric Company	20,000
Johnson Miners' Safety Lamp Company	5,000
Keighley Electrical Engineering Company	5,000
Lamp Manufacturing Company	20,000
Lightning Express Railway Syndicate	100,000
Lighting Corporation	250,000
Liverpool District Lighting Company	2,000
London and Provincial Traction Company	100,100
Machinery Insurance Company	200,000
Madeira Electric Lighting Company	20,000
Magic Box Company	5,000
May's Metals Separating Syndicate	2,000
Manchester Suburban Electric Supply Company	25,000
Mevagissey Electric Lighting Company	1,500
McPhail and Simpson's Dry Steam Patents Company	416,000
Milver Portable Electric Battery Syndicate	20,000
New Electric Light Syndicate	2,000
Newmarket Electric Light Company	30,000

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	Capital.
New-Mayne Electric Rudder Motor Syndicate	£20,000
New Phonopore Telephone Company	10,000
New Rubber Company	35,000
Pearson's Automatic Fire Indicator Company	5,000
Phœbus Electric Battery Syndicate	3,000
Pierpoint (F.) and Co.	5,000
Portable Electric Lamp Company	50,000
Pure Carbon Company	12,000
Railway Wagon and Engineering Company	10,000
Rand Central Electric Works	300,000
Recovered Rubber Works	20,000
Reflector Syndicate	2,000
Road Vehicle Starter Syndicate	18,000
Robinson (W. and J.) and Co.	40,000
Salt Chemicals Syndicate	5,000
Silveroid Company	400
Smelting Company of Australia	500,000
Smillie Patent High-Pressure Pipe and Tube Company	75,000
Standard Electro-Galvanising Company	4,000
Stirling Boiler Manufacturing Company	60,000
Sykes (Robert) and Sons	20,000
Telautograph Company	42,000
Thames Valley Launch Company	10,000
Town and Village Electric Light and Power Company	100,000
Tramways Construction Company	100,000
Tramways Electrical Traction Company	172,500
Tupper's Advertising Company	2,000
Universal Electric Carriage Syndicate	5,000
Universal Electrical Fittings Company	6,000
Val d'Aosta Electric Power Company	80,000
Vaughan and Brown	40,000
West Australian Electrical Trunk Power and Lighting Company	510,000
Westralian Electric Lighting and Supply Company	80,000
Wheeler Hill	62,500
Windsor Electrical Installation Company	10,000
Wilson (E. K.) and Sons	12,000
Woking Electric Supply Company	20,000

PUBLIC COMPANIES WOUND UP, DISSOLVED, &c., IN 1895.

The following are amongst the limited liability companies which have been wound up during the past year, the asterisk denoting that the company was wound up by order of the Court :—

Akester Electric Syndicate.
Albert Lighting Company.
British Volta Glow Lamp Company.
Collier-Marr Telephone and Electrical Manufacturing Company.
Electric Lighting and General Development Syndicate.
Electric Trust.
Electrolytic Caustic Soda and Chlorine Trust.
European Sims-Edison Electrical Torpedo Company.
Farmer (Sir James) and Sons.
Forbes (D. W.) and Co.
*Ford-Lloyd Manufacturing Company.
Froggatt's Electric Lighting Company.
Galloways (*reconstructed*).
Hemming and Co.
*Herculite and Electrical Manufacturing Company.
Hope-Jones Electric Organ Company.
Howell, J. C. (*reconstructed*).
Hughes, Sutton and Digby.
International Electric Storage.
Inventions Development Syndicate.
Johannesburg Lighting Company.
Keighley Electrical Engineering Company (*reconstructed*).
Planet Electrical Engineering Company.
Lamp Manufacturing Company (*reconstructed*).
Lowcock, Hill and Co.
*Medical Electrical Institute.
*Martiny Limited.
Metallurgical Patents Company.
*New British Electrical Installation Contractors.
Otis Steel Company.
Printing Telegraph and Construction Company of the Agence Havas.
Railway Automatic Electric Light Syndicate.
*Scott, Ronald A.
St. Martin's Electrical Manufacturing Company.
Telpher Cable and Cliffe Railway Syndicate.
*J. G. Statter and Co.
Universal Electric Lighting Company.
Wray Electrical Engineering Company.

The following companies have been dissolved, or have ceased to exist, in most cases nothing having been done beyond registration, and no business having been commenced :—

Association for the Protection of Telephone Subscribers.
Baily and Grundy (London).
Bicester Electricity Supply Company.
Bishop's Stortford Electric Light and Steam Laundry Company.
Boardman's Electric Sun Lamp Patents.
British Electrolytic Syndicate.
British Electric Tramways and General Syndicate.
Brompton Electrical Fittings Company.
Cambridge University and Town Electric Lighting Company.
Carbon Electric.
Central Electrical Company.
City of Waterford Electric Supply Company.
Croydon Electric Supply Company.
Devonshire Electric Light and Power Supply.
Dominion Electrical Company.
East Coast Electric Light and Power Supply.
East London Electric Supply Company.
Electrical Finance Corporation.
Electrical Inventions Company.
Electricity and Electrical Engineering Newspaper Company.
Electric Stores.
Electro-Automatic Fire Extinguishing Company.
"Eston" Arc Lamp Syndicate.
Froggatt's Inventions Syndicate.
Gloucester Electricity Supply Company.
Hampstead Electric Light and Power Supply.
Ipswich Electricity Supply Company.
Islington and General Electric Supply.
Lancashire and Yorkshire Electric Lighting Company.
Lancashire Electric and Engineering Company.
Lane Fox Electrical Company.
Laing Electric Light and Power Company.
London Electrical Tramways Company.
Middlesborough Electricity Supply Company.
Nonpareil Electric Syndicate.
Paddington and Bayswater Electric Light and Power Supply.
Patent Electro-Magnetic Clock Syndicate.
Pontypridd Electric Lighting Company.
Provincial Electric Light and Power Supply.
Putney and Hammersmith Electric Light and Power Supply Company.
Rochdale Electricity Supply Company.
South-Western District and Thames Valley Electricity Supply Company
St. John, Hampstead, Electric Supply Company.
Stoke-on-Trent Electricity Supply Company.
United Electric Sewage and Chemical Syndicate.
Woking Electric Supply Company.
Wyndham Electric Light Company.
Wynne's Electric Closed-Tube Tramways.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

MONDAY, January 6th.

SOCIETY OF CHEMICAL INDUSTRY.
8 p.m. Meeting at Burlington House.

SATURDAY, January 11th.

ASSOCIATION FOR THE IMPROVEMENT OF GEOMETRICAL TEACHING.
11 a.m and 2 p.m. Meeting at University College, Gower-street.

Electricity and Vegetation.—Two important Papers, says *Nature*, have recently been published on the effect of the electric light and of electricity on vegetation. The first is by M. Bonnier in the *Revue Générale de Botanique*. He states that a continuous electric light promotes the formation of chlorophyll, and brings about, at the same time, a simpler anatomical structure of the leaves. Under a continuous electric light the distribution of the chlorophyll in the tissues is more extended than in ordinary daylight; chlorophyll grains make their appearance in the cortex as far as the endoderm, and even in the medullary rays and the pith. The palisade tissue of the leaf is reduced, or entirely disappears, and the epidermall cell walls are thinner. The bark is less developed, and the various tissues of the stem are less differentiated. When the electric light is discontinuous, as, for example, when turned on 12 hours out of the 24, the effect on vegetation is intermediate between that of normal sunlight and that of a continuous electric light. Alpine plants cultivated under a continuous electric light exhibit points of structure identical with those of Arctic plants, which are exposed to almost continuous sunlight in the summer. The other Paper is by Prof. A. Aloi in the *Bulletino* of the Italian Botanical Society. He adduces evidence in favour of his view that both terrestrial and atmospheric electricity exercise a favourable influence on the germination of seeds and on the growth of plants, and predicts that the employment of electricity will be a most important factor in the agriculture of the future.

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NOTICE.

With the current number of "The Electrician" is issued as a Supplement (Gratis) a Tabulated Statement, giving complete details of Electric Supply Stations in London and the Provinces; showing at a glance towns in which the Electric Light is supplied, either by a Local Authority or Private Company, and the System adopted (Continuous or Alternate-Current), &c., &c Complaints of non-receipt should be at once sent to the Publisher.

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1895.

In accordance with an inexorable custom, we once more devote the first leading article of the New Year to a review of the electrical events of the Old Year. Time was when our annual offering consisted mainly of a string of reports on the past year's work, supplied by the comparatively small group of firms which then constituted the entire English electrical industry. The tone of genial optimism which uniformly characterised these returns, even in the days of deepest commercial depression, did credit to the stoicism and businesslike diplomacy of their compilers; but as reliable historical records they were not all one could wish. To-day, were we to attempt the same style of disjointed chronicle, its size would be truly monumental; a conclusive, if not an altogether pleasing, evidence of growth. Yes; quiet prosaic progress has been the predominant feature of 1895 as of its immediate predecessors. For the moment the purely scientific electrician is outwardly somnolent, and the electrical engineer proper makes no effort to disguise the fact that he has eschewed the evil habits of his early youth; he has slackened his hot pursuit after mechanical and electrical novelties, and has betaken himself to devising economical and efficient combinations of "old instrumentalities"; his talk is of 220-volt lamps and the earthing of the "neutral," and his mind is in labour with cunning methods of charging his customers and with plans for defeating the devious ways of jerry wirers.

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The main element of growth in the electrical industry still continues to be afforded by the electric light supply business. New stations continue to come steadily into operation, and old ones continue to add steadily to their lamp connection. Neither the cost price nor the selling price of the Board of Trade unit has as yet found bottom, and the return upon capital expenditure, especially in the case of provincial municipal ventures, is most encouraging. Amongst the more important municipal stations that have got to work during the past twelvemonth we may mention those at Belfast, Blackburn, Coventry, Edinburgh, Leicester, Newport, Salford, Stafford, Sunderland and Tunbridge Wells. One of the most noteworthy events in connection with central-station enterprise has been the 220-volt lamp crusade. Inspired apparently by Mr. BAYNES' vigorous initiative, first at Bradford and then at St. Pancras, those responsible for the success of electric supply undertakings have with one accord declared that the salvation of "low-pressure" systems lies in the adoption of what is uncommonly like "high pressure," and the expert committee—that after-math of the recent Board of Trade Conference at Westminster—has complaisantly decided to recommend the Department to swim with the stream, and to allow 250-volt pressures inside houses and 500 volts (continuous) across "outers," and to concede at the same time the long-urged demand for the earthing of the "neutral." There are, of course, restrictions and conditions attached to these unexpected concessions, and there are, too, some who are disposed, so long as these restrictions and conditions are maintained, to accept the concessions in a grudging spirit. However, the principle of high "low pressures" and earthing the "neutral" once accepted by the powers that be, it is improbable that on either side there will be much difficulty as to details. Indeed, the only point which seems in any way likely to threaten the almost angelic harmony now prevailing between the Board of Trade and those under its benign jurisdiction is the undue penalisation of low-pressure alternating currents which the Department seems inclined to impose. The anger of an Englishman quickly subsides if his advice is asked and his grievances are freely aired. The inevitable red-tape tendencies of a Government Department can only be counteracted by contact with men and things as they exist outside. Penetrated with these two ideas, Sir COURTENAY BOYLE's relations with the electrical industry have not been the least of his administrative successes.

In central-station practice there has been, during the past twelve-month, a marked tendency to combine an alternating system for outlying districts with continuous current for the central area, motor-alternators being usually employed. Mr. FERRANTI's bold expedient of rectifying alternating currents for use in street arc lights is also finding great favour with alternate-current station engineers,—photometric measurements, indoors and out, rendering it evident to all unbiassed persons that the alternate-current arc can scarcely hold its own against good modern gas lighting, not to mention its more regular electrical rival. Another combination which bids fair to become an integral feature of all fashionable English municipal central stations is that of dust destruction and steam raising for electrical purposes. Enough has recently been vaticinated as to the advantages of this idea. By this time next year data garnered from actual experience may possibly be available, and further discussion will then be profitable. Not the least valuable of the many recent discoveries in central-station economies is the method—hit upon by Mr. ARTHUR WRIGHT, and rendered possible by his cheap and simple demand-meter—of charging the consumer for current in such a manner that it pays *him* (and consequently the central station) to burn comparatively few lamps fairly continuously, rather than big banks of lamps in spasmodic bursts. The sweet-reasonableness of the "Wright" system of charging has now become evident to all, and its adoption is becoming general in the provinces. The annals of the central-station industry are not, however, without a reverse to the pleasant obverse just briefly sketched. Two serious fires at large London generating centres and another at a small provincial station show that more consideration requires to be given to fireproof construction and to fire drill. It will never do for English electric light stations to earn the bad name their American congeners have acquired for themselves. The difficulties of stations situated in crowded districts are already sufficiently great without this additional burden. The discovery also that metallic sodium and potassium had been electrolytically formed in the St. Pancras conduits was not calculated to make glad the heart of the electrical engineer, nor to decrease the feeling of insecurity engendered in that favoured neighbourhood by recurring explosions. Investigation, however, showed that the peculiar conditions which obtained in a portion of the St. Pancras conduits were alone to blame. The public alarm soon subsided, and with the carrying out of the needful remedies the only saleable by-product of the central station has ceased to be formed.

Electric traction still tarries—retarded, may be, by the recent extension of the Monroe doctrine to all things that even so much as smack of America. An interesting mountain railway was opened in August in the Isle of Man, and two months later the Bristol-Kingswood line was inaugurated amidst the blowing of trumpets and the beating of drums, the echoes of which have scarcely yet died away. These two enterprises, plus a few miles of track at Coventry, represent the sum total of our achievements in electric traction during the past twelve months. Of work actually in hand the line between Dublin and Dalkey and the line at Hartlepool are in the most forward stage. The Central London Railway has (at last) been commenced, and the Waterloo and City tunnel is stealthily burrowing its way under river and road. But the half-dozen other London electric lines are in the same state of suspended animation that they were this time last year. *Per contra*, the air is thick with electric traction "proposals," the most important and the most likely to come to maturity being, perhaps, those entertained by the Leeds City Council. The Tramway Act of 1870 and the recent judicial pronouncements as to the exact meaning of its purchase clause have obviously rendered tramway development in this country almost impossible unless under municipal ægis. There are signs that our municipalities are awakening to the fact that they cannot in common justice continue indefinitely to arrest private tramway enterprise without supplying a municipal equivalent, and there are unmistakable indications that in the coming rush those who have for years preached the advantages of electric traction to deaf ears will get a hearing. We can only hope, firstly, that those who have sown will reap; and, secondly, that we English will take full advantage of the experience bought at such a high price across the Atlantic. There is no need for *us* to grope our way in a blind, haphazard fashion towards the best type of truck, track, gearing, motor-suspension, line, generator and engine.

The materials for a telegraphic chronicle have in the past year, as previously, been supplied by the submarine branch. A few weeks since the "Faraday" left the Thames laden with the cable which is to form a telegraphic network connecting the various rubber stations along the banks of the Amazon from Para to Manaos. The whole scheme is somewhat of an experiment though a very interesting one, it is true. Amongst

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other things it is proposed to make considerable use of the telephone as a means of transmission, in order to avoid as far as possible the expense of skilled operators. Another event of note was the signing, early in October, of a contract between the French Government and the Compagnie Française des Câbles Télégraphiques for the laying and working of a new direct French-made French-laid transatlantic cable from Brest to Cape Cod. It is also proposed to lay a cable connecting the French transatlantic cable system with the French West Indian cable system, and generally to render France, as far as may be, telegraphically self-supporting. Whether the thing is possible, and if possible, whether the game is worth the candle, it is for our "*bons voisins*" to decide—and pay the piper. In English cable circles we may further note the remarkable growth of the Australasian traffic, which has brought the revenue derived therefrom back once more to the figure at which it stood before the wholesale reductions made some years ago under Government guarantee, and the deputation to Mr. Chamberlain anent the Pacific cable scheme, with its resultant promise of an Imperial Commission to inquire into the whole question. In connection with submarine telegraphy it will not be out of place to recall here the commercial utilisation of "induction" telegraphy which was made in April last when the cable broke down between the Isle of Mull and the mainland, and the successful establishment and maintenance of telegraphic communication with the Fastnet Rock on the "discontinuous cable" system. Automatic working also, is coming rapidly to the fore, and notwithstanding the apparent quiet, plenty of progressive technical work is being done in the submarine cable world.

In the telephonic branch of the electrical industry there is not much technical advance to be chronicled. Early in the year the municipalities lodged protest after protest against the signing of the Agreement between the Post Office and the National Telephone Company. Finally, on March 1st, the Postmaster-General consented, under pressure, to the appointment of a Committee, not to discuss the Agreement, which the Government "could not, and ought not, to consider other than a binding obligation," but "to consider and report whether the provision now made as to the telephone service in local areas is adequate, and whether it is expedient to supplement or improve this provision either by the granting of licences to the Local Authorities or otherwise." The proceedings of this Committee opened on March 22nd, and the Committee reported formally to the House on June 15th, suggesting nothing but its own reappointment this year. The Post Office view of the question and the National Telephone Company's view were admirably presented, but the case for municipal exchanges and national trunk lines, for which so much can be said, was very inadequately set forth, and, if the inquiry is ever resumed, it is to be hoped the supporters of this idea will see to it that arguments calculated to carry weight are forthcoming. In this relation it is curious to observe how the trend of fashion is forcing the great practical applications of electricity one by one into the hands of Government and municipaldom. The telegraph was born and attained a healthy maturity under the invigorating influence of capitalist competition. The Government in 1870 seized upon it, and straightway all the life went out of the business. The telephone arose next, under much the same influence. The Government promptly claimed it as its own, and the courts of law upheld the claim, and officialdom and monopoly have between them rendered all outward manifestation of life and progress impossible. Then the electric light came upon the scene. Private capital gave this also an initiatory impulse, but, thanks to the Act of 1882, the municipalites are rapidly taking up the running. Lastly, some five years ago, electric traction began to make decided progress in the United States, and then tried to force an entrance into this country. Once again, thanks to the paralysing influence of the Tramway Act of 1870, private enterprise is being kept at arm's length, and it is now beginning to be generally recognised that if we are to have electric tramways at all, we shall be obliged to accept them at the hands of the municipalities. Prof. Vernon Boys remarked the other evening at the Society of Arts, in connection with horseless carriages that, "the community at large are not competent to form an opinion upon conditions of life which differ widely from those to which they are accustomed," and we will not, therefore, risk a prophecy as to the probable net ultimate result of this nationalisation and municipalisation of electrical engineering. One institution, however, we feel sure will be completely transmogrified. All the members of the Institution of Electrical Engineers will *then* be as tongue-tied as its telegraphic and telephonic members are now. There will be no discussions because there will be no Papers to discuss—for official reasons. There will be but three gatherings of the Institution every year: an Annual Meeting to silently receive and adopt an annual report, which will be taken as read, an Annual Dinner and an Annual Conversazione. Such is "the sad presage of its future years"!

The subsidiary applications of the electric current have not witnessed any remarkable development during 1895, but there has been healthy progress, nevertheless. The advocates of electric coal-cutting and electric welding continue to peg out their claims, but with no very startling result. Electric heating and cooking, thanks to hard experimenting and hard pushing, are coming satisfactorily to the fore. The electric furnace is finding many new industrial applications. In electro-chemistry there is much scientific activity, as witness, for instance, the abortive Börchers battery, and equally great commercial activity, more especially in the direction of the electrolytic production of caustic soda and bleach.

Patent litigation, which has been such an unpleasantly prominent episode of each electrical year, still retains this prominence, but the locus of the disturbance is no longer in this country, but in America. There, a vigorous assertion of legal rights by the owners of the Tesla polyphase patents is pending, and a similar enforcement of the law is threatened in France and Germany. In Italy the Zipernowsky-Déri-Blathy transformer patents have been upheld. In America the Thomson-Houston arc-light-dynamo-regulator patent and the Sawyer-Man glow-lamp patent have been invalidated, and the Van Depoele under-running trolley patent has been upheld. With us the threatened litigation between the E.P.S. Company and the Chloride Electrical Storage Syndicate ended in a compromise. In August Mr. Justice Stirling seconded the well-meant efforts of the Board of Trade by declaring that the term "street-box," contained in all recent Electric Lighting Orders, included excavations under the pavements intended to contain transformers, and thus, for once, the law lent a little assistance to electrical enterprise.

A year in which the Institution of Electrical Engineers has received communications such as that of Prof. Ewing on his beautiful magnetic hysteresis-meter, Dr. John Hopkinson's interesting address on the propagation of magnetism in iron, and Mr. Mark Robinson's Paper on the high-speed engine, cannot be deemed unfruitful. On the other hand, the Northern Society of Electrical Engineers continues to obtain Papers, many of which compare well with those read in Great George-street, and the newly-formed Association of Municipal Electrical Engineers, although intended mainly as a social

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organisation, will doubtless drain away some more practical Papers to the loss of the parent society. With these and other still more important considerations in view, it is not altogether surprising that there should exist a widespread feeling in favour of more vigorous administration. A little more youth at the prow might result in a little more skill and energy at the helm.

As we have already remarked, there would appear to have been something in the nature of a lull in the scientific electrical world as well as in the engineering electrical world. Electromagnetic waves are becoming more and more manageable in size, and more and more analogous in their behaviour to the so-called light waves. Much good work has been done, and is being done, in investigating the influence of alternate-current waves of different shape on the efficiency of the arc, on the iron losses in transformers, &c., &c. We have already alluded to Dr. JOHN HOPKINSON'S elaborate research on the time taken by magnetism to penetrate into the interior of large iron cores, and to the ingenious device of Prof. EWING for measuring hysteresis in sheet iron. The valuable work which has been done by Mrs. AYRTON in connection with the electric arc is well known to our readers. An event of mingled scientific and practical import was the Ipswich report of the Electrical Standards Committee of the British Association on magnetic units and the interesting discussion in our columns which preceded it. The recommendations of the Committee were, as our readers may recollect, to the effect that the unit of magnetic flux should be 10^8 C.G.S. lines and should be denominated the *weber*, and that the unit of magneto-motive force should be the same as the present C.G.S. unit, and should be denominated the *gauss*.

No record of the past twelvemonth would be complete without at least some passing mention of those who have fallen out of the ranks. Four well-known telegraph men have passed away—namely, Mr. J. H. GREENER and Mr. T. FULLER in England, and Col. HOSKIÖR and Mr. ROYAL E. HOUSE, the former well known in Scandinavia, the latter in America. The band of world-famous dynamo constructors is poorer, also, by the deaths of SIGMUND SCHUCKERT and RUDOLPH EICKEMEYER. Lastly, we would call to mind the sad end of the universally-popular FRANKLIN LEONARD POPE.

But the year 1895, if it be deemed electrically noteworthy at all by those who come after us—which is doubtful—will not in all probability be remembered by any of the events we have hitherto chronicled, but rather by reason of the fact that the great Falls of Niagara were for the first time in their history seriously and scientifically converted to a utilitarian purpose in a manner which gives promise of future great developments.

SUMMARY OF ELECTRICAL EVENTS FOR 1895.

JANUARY.

Berlin-Memel telephone trunk line opened to the public, 632 miles (1st).
Liverpool Town Council decide to purchase the undertaking of the Liverpool Electric Supply Company (9th).
Presidential Address of Mr. Crompton to the Institution of Electrical Engineers (10th).
Faure "Pasted Plate" Patent No. 129 of 1881 expired (11th).
Lane-Fox Glow Lamp Patent No. 225 of 1881 expired (18th).
The threatened litigation between the E.P.S. Company and the Chloride Electrical Storage Syndicate compromised.
Belfast Municipal Electric Lighting Station started (23rd).
Hartlepool Corporation sanction the adoption of electric traction.
The City and South London Railway Company adopt the motor-car train system.
Great strike of motormen and others on the Brooklyn trolley lines.
Death of Mr. Rudolph Eickemeyer (23rd).
Deputation of the Municipal Corporations Association to the Postmaster-General to protest against the Draft Agreement (24th).
London County Council refuse to sanction the "trolley" system on the Shepherd's Bush-Acton line (29th).
Opening of the Wolverhampton Municipal Electric Lighting Station (30th).
Light Railway Conference Committee presents its report, which is adopted (31st).
Dividends declared: Anglo-American Telegraph Company, $2\frac{1}{10}$ per cent.; City and South London Railway Company, $1\frac{1}{4}$ per cent.

FEBRUARY.

Important decision by Mr. Justice Kekewich in Farmer *v.* Waterloo and City Railway Company, in which he laid down that the Company's Act did not entitle it to use the subsoil without payment (1st).
Deputation of the London County Council to the Postmaster-General to protest against the Draft Agreement and to suggest the granting of a telephone licence to the County Council (3rd).
Serious fire at the Kensington Court electric lighting station (12th).
Completion of the laying of the Cadiz-Canary Islands cable laid by the "Dacia" (13th).
Paper on "Reversible Regenerative Armatures and Short Air-Space Dynamos" read before the Institution of Electrical Engineers by Mr. W. B. Sayers (14th).
Double refraction with Hertzian waves shown by Herr K. Mack.
Opening of the Blackburn Municipal Central Station (18th).
Important experimental Paper on "The Propagation of Magnetism in Iron" read before the Institution of Electrical Engineers by Dr. John Hopkinson (21st).
Death of Mr. Royal Earl House, one of the early American telegraph pioneers and inventors of a printing telegraph (23rd).
Expiry of the Edison "electro-plated joint" Glow Lamp Patent (No. 768 of 1881) (23rd).
The Intercolonial Postal and Telegraph Conference at Hobart results in the renewing on a modified basis of the Australian cable guarantee.
Expiry of the Ayrton and Perry Electric Railway Patent No. 783 of 1881 (24th).
Dividends declared: Notting Hill Electric Lighting Company, 1 per cent.; Cambridge Electric Supply Company, $2\frac{1}{2}$ per cent.; City of London Electric Lighting Company, 5 per cent.; Chelsea Electricity Supply Company, 5 per cent.; Charing Cross and Strand Electricity Supply Corporation, $4\frac{1}{2}$ per cent.; Isle of Man Tramways and Electric Power Company, 15 per cent.; Liverpool Overhead Railway, 2 per cent.; Westminster Electric Supply Corporation, 5 per cent.; Kensington and Knightsbridge Electric Lighting Company, 5 per cent.; Telegraph Construction and Maintenance Company, 20 per cent.; Yorkshire House-to-House Company, 4 per cent.; St. James's and Pall Mall Company, $6\frac{1}{2}$ per cent.; Liverpool Electric Supply Company, $5\frac{1}{2}$ per cent.; Newcastle and District Electric Lighting Company, 6 per cent.; India Rubber, Gutta Percha and Telegraph Works, 10 per cent. (comparing with $12\frac{1}{2}$ per cent. in 1894.)

MARCH.

In consequence of a resolution moved in the House of Commons by Mr. Benn, the Postmaster-General consents to the appointment of a committee to inquire into the adequacy, or otherwise, of the telephone service (1st).
Metallic sodium discovered in the conduits of the St. Pancras Vestry; appointment of a committee composed of members of the Royal Society and Institution of Electrical Engineers to advise the Board of Trade on the matter.
Decision given by the United States Supreme Court in the Bate Refrigerator Patent case. Judgment that an American patent dates from its issue and not from the date of application. This decision involved the termination of several important electrical patents (4th).
Sunderland Municipal Electric Lighting Station opened (6th).
Completion of the Indo-Chinese land line (16th).
An important Paper, entitled "A Method of Preventing Armature Reaction," read before the American Institute of Electrical Engineers by Prof. Ryan and M. E. Thompson (20th).
Burning out of Mr. Nikola Tesla's laboratory.
First meeting of the Select Committee of the House of Commons appointed to consider the condition of the telephone service in Great Britain (22nd).
The Chemical Society confers its Faraday Medal on Lord Rayleigh in recognition of his discovery of Argon.
Zipernowsky-Déri-Blathy Transformer Patents upheld in Italy.
Paper on Railway Electric Lighting read before the Institution of Electrical Engineers by Mr. W. Langdon (28th).
Dividends declared: Birmingham Electric Supply Company, 4 per cent.; Hove Electric Lighting Company, 3 per cent.; W. T. Henley's Telegraph Works Company, 6 per cent.; Eastbourne Electric Light Company, $7\frac{1}{2}$ per cent.; British Insulated Wire Company, 7 per cent.

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APRIL.

Mozambique-Majunga cable completed (1st).
Reduced cable rates to South Africa came into operation (1st).
Cable between Isle of Mull and the mainland having broken down, signals by induction were successfully transmitted.
Westinghouse and General Electric Companies of America "pool" their patents.
Prof. Elisha Gray brings out a *two*-wire telautograph.
Death of Mr. J. H. Greener (7th).
Report of the Committee appointed by the Board of Trade to inquire into the cause of the alkaline deposits in the St. Pancras conduits (10th).
Edinburgh Municipal Electric Lighting Station opened (11th).
Important Paper on "A Magnetic Tester for Measuring Hysteresis in Sheet Iron" read before the Institution of Electrical Engineers by Prof. J. A. Ewing (25th).
Opening of the Leicester Municipal Electric Lighting Station (25th).
Light Railways Bill introduced (26th).
Expiry of the Brush Current-Regulator Patent No. 1,835 of 1881 (28th).
Opening of the Chicago Elevated Electric Railway.
Dividends declared: Southampton Electric Light and Power Company, 2½ per cent.; Great Northern Telegraph Company, 8·6 per cent.; Indo-European Telegraph Company, 10 per cent.; Oriental Telephone and Electric Company, 4¼ per cent.; Oxford Electric Company, 1 per cent.; Metropolitan Electric Supply Company, 3 per cent.; Norwich Electricity Company, 3 per cent.; Eastern Extension Telegraph Company, 7 per cent.

MAY.

Treasury and London County Council agree to grant electric lighting loans for a term of 42 years, provided all renewals and repairs are paid out of revenue.
"James Forrest" lecture on "The Development of the Experimental Study of Heat Engines" delivered by Prof. W. C. Unwin (2nd).
Death of Mr. Thomas Fuller (3rd).
Paper on "The Recent Development of the Single-Acting High-Speed Engine for Central Station Work" read before the Institution of Electrical Engineers by Mr. Mark Robinson (9th).
Expiry of the Gülcher Arc Lamp Patent No. 2,038 of 1881 (10th).
Settlement of the Muirhead Duplex Patent cases; the Commercial Cable Company paying the plaintiffs a large sum of money by way of royalties, &c. (14th).
Photometric Standards Committee recommend the adoption of a 10-candle Methven-pentane standard.
Death of Lieut. Peral, of the Spanish Navy, designer of an electrically-driven submarine boat (25th).
Dividends declared: London Platino-Brazilian Telegraph Company, 1¼ per cent.; Western and Brazilian Telegraph Company, 3 per cent.; Consolidated Telephone Construction and Maintenance Company, 1½ per cent.

JUNE.

Death of Rear-Admiral Fleuriais.
Death of Col. O. V. Hoskiär (23rd).
Fire at the Sardinia-street Station of the Metropolitan Electric Supply Company (24th).
Public invited to subscribe to the Central London Railway (24th to 26th).
The Commissioners of Sewers decide to carry out a series of experiments in connection with the electric lighting of the side streets of the City (25th).
Report of the Select Committee on the Telephone Service (25th).
Dividends declared: Chatham, Rochester and District Electric Lighting Company, 2½ per cent.; Electric and General Investment Company, 20 per cent.; Telegraph Manufacturing Company, 7½ per cent.

JULY.

Niagara Electric Power Station comes into operation (1st).
Expiry of Dr. John Hopkinson's "Series-Parallel Control" Patent No. 2,980 of 1881.
Central London Railway ordered to be commenced.
Unveiling of the Ohm Statue at Munich (5th).
President and Council of the Royal Society decide to call together an International Conference in July, 1896, to discuss the question of an International Catalogue of Scientific Papers (5th).
Post Office Telephone Trunk Wires opened to the public (16th).
The whole tramway system of Budapest to be equipped electrically; in town, on the conduit system; in suburbs, on the overhead wire system.
Formation of the Amazon Telegraph Company for the purpose of laying a sub-fluvial cable network at the mouth of the Amazon.
Purchase of the business of the Liverpool Electric Supply Company by the Liverpool Corporation for the sum of £400,000.
Telegraphic communication effected with the Fastnet by means of a "discontinuous" cable (18th).
Expiry of the Maxim Glow-Lamp Patent No. 3,189 of 1881 (21st).
Dividends declared: Electrical Power Storage Company, 5 per cent.; United River Plate Telephone Company, 3 per cent.; National Telephone Company, 5 per cent.; Direct United States Cable Company, 2 per cent.; Eastern Telegraph Company, 6½ per cent.; Chili Telephone Company, 2½ per cent.; Globe Telegraph and Trust Company, 4⅛ per cent.; Edison and Swan United Electric Light Company, 5 per cent.; National Telephone Company, 5 per cent.

AUGUST.

Mr. Justice Sterling, in the action brought by the Wandsworth District Board of Works against the County of London and Brush Provincial Company, decided that the Board of Trade was entitled to extend the term "street boxes" so as to include "transformer pits" under the pavement (3rd).
Opening of the Salford Municipal Electric Light Station (7th).
Opening of the Snaefell electric tramway (16th).
Working arrangements entered into between the Westinghouse Electric and Manufacturing Company of Pittsburg and the Baldwin Locomotive Works of Philadelphia combine.
Dividends declared: Cuba Submarine Telegraph Company, 8 per cent.

SEPTEMBER.

Expiry of the Sellon "Corrugated Plate" storage battery patent, No. 3,926 of 1881 (10th).
M. M. Schneider et Cie., sole concessionaires for France of the Tesla rotary-field patents, commence infringement suits against a large number of French firms.
Meeting of the British Association at Ipswich (11th). Electrical Standards Committee recommend that the practical unit of magnetic flux be 10^8 C.G.S. lines, and be called a *weber*, and that the practical unit of magnetomotive force be the same as the C.G.S. unit, and be called a *gauss*.
An annual subsidy of $40,000 and exclusive American cable landing rights for 20 years granted by the Hawaiian Government to an American sugar planter.
Death of Herr Schuckert (16th).
Opening of the Stafford Municipal Electric Light Station (25th).
Expiry of the Swan "Carbon-joint" Glow Lamp Patent No. 4,202 of 1881 (29th).
St. Pancras Vestry announce that all future customers must be prepared to receive a 220-volt supply.
Exeter Town Council decide to purchase the local electric lighting company's undertaking.

OCTOBER.

Tunbridge Wells Municipal electric light station opened (9th).
Death of Mr. Franklin Leonard Pope (13th).
Newport (Mon.) Municipal electric light station opened (14th).
Contract signed for the laying of a new French cable from Brest to New York.
Bristol-Kingswood electric tramway opened (14th).
Leeds City Council adopt the principle of electric traction (15th).
Publication of Major Cardew's Report on the Portrush accident.
"Jandus" 200-hour carbon arc lamp brought before the public (24th).
Invalidation of the Thomson-Houston Arc Light Dynamo Regulator Patent sustained by the United States Circuit Court of Appeals at Chicago.
Dividends declared: Brazilian Submarine Telegraph Company, 7 per cent.

NOVEMBER.

Royal Medal awarded to Prof. Ewing for his investigations on magnetic induction in iron and other metals.
Paper on "Municipal Telephony" read before the Northern Society of Electrical Engineers by Mr. A. R. Bennett (11th).
United States Supreme Court of Appeal invalidate the Sawyer-Man Glow-Lamp Patent (11th).
Dinner to Mr. W. T. Ansell to celebrate his jubilee in the telegraph service (14th).
Coventry Municipal Electric Light Station opened (16th).
Deputation of Colonial representatives to Mr. Chamberlain in connection with the Pacific Cable scheme; a Joint Commission promised (19th).
Conference at the Westminster Town Hall in connection with the Board of Trade Revised Electric Lighting Regulations (19th and 20th).
Destruction of the Crompton Works by fire (22nd).
A paper on "The Use of Dust Destructors as Steam Producers for Electricity Supply Stations," read before the Northern Society of Electrical Engineers by Mr. E. Manville (25th).
Coventry Electric Tramway came into operation.

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DECEMBER.

Publication of the Report of a Special Committee of Representatives of German Electricity Works on the state of the glow-lamp industry in Germany; electric light undertakers recommended to take the supplying of glow-lamps to their customers into their own hands in order to protect their own interests.

Publication of the Report of the Board of Trade expert committee on the definition of "low pressure" and cognate matters: 500 volts continuous and 250 volts alternating recommended as the limit of "low pressure"; earthing of the neutral of a three-wire system and a maximum house pressure of 250 volts also recommended for adoption (2nd).

Shrewsbury Central Station opened (10th).

Annual General Meeting of the Institution of Electrical Engineers; the question of reform raised (12th).

Van Depoele Under-Running Trolley Patent sustained in the United States.

LAMP-CONNECTION DIAGRAMS.

The diagrams given below will, we trust, render the statistics published this week in our central-station table somewhat more digestible, and at the same time serve to bring out their significance.

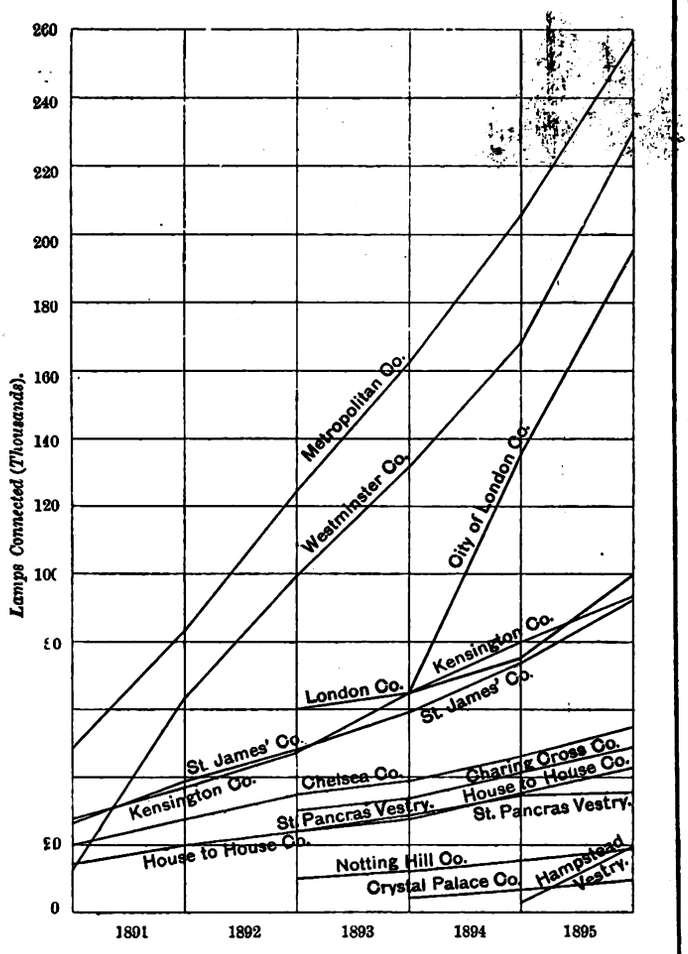

DIAGRAM 1.—Lamp Connections of the London Companies.

It will be seen from Diagram 1 that the Metropolitan Electric Supply Company still maintains its position of the premier electric supply company of London, the Westminster Electric Supply Corporation making an excellent second, and the City of London Electric Lighting Company a good third, the rest being nowhere (in the Pickwickian sense, of course). None of the curves, however, with the exception of that relating to St. Pancras, show any signs of the approach of the elastic limit. Indeed, the Metropolitan and Westminster curves look as if they were making an asymptotic approach to an infinitely great lamp connection, and the steep ascent of the City curve is positively alarming. The total lamp connection of London is now 1,178,600, as against 925,100 last year and 180,000 in 1890.

In Diagram 2 are given the lamp connections of London and the Provinces from 1890 onwards. The rapid manner in which the Provinces have caught up the Metropolis is strikingly

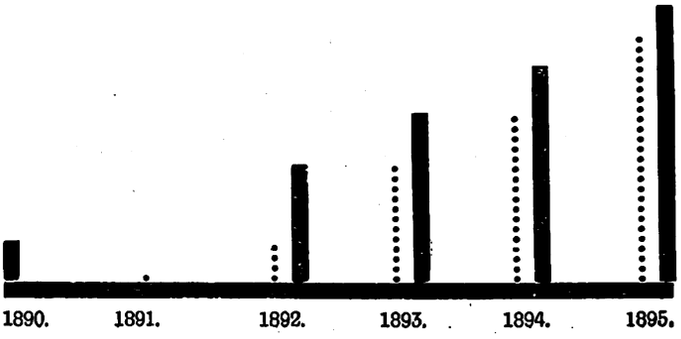

DIAGRAM 2.—Lamp Connections of London and Provinces.
London ———. Provinces .....
Scale (approx.) 1 inch = 800,000 Lamps.

shown; they now have, in round figures, 1,100,000 lamps, against London's 1,178,000. The provincial total last year was 670,000; the lamp connections of the metropolis have, therefore, only increased by 27 per cent., those in the provinces by 64 per cent.

DIAGRAM 3.—Alternate-current (.....) and Continuous-Current (———) Lamp Connections.
Scale (approx.) 1 inch = 800,000 Lamps.

In Diagram 3, the relative lamp connections of the alternate-current and of the continuous-current systems at the end of 1895 are represented. It will be observed that the alternate-current now leads the way in London.

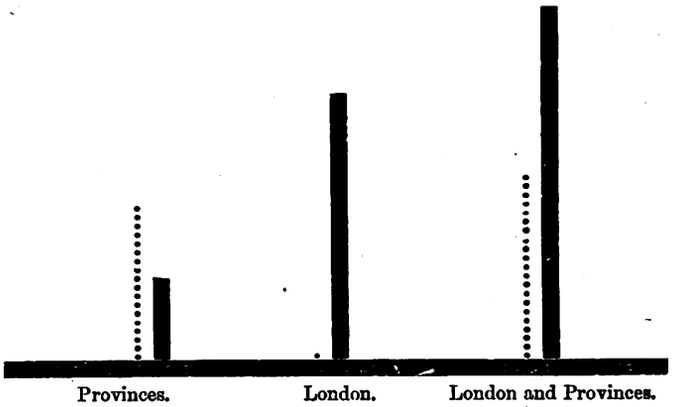

DIAGRAM 4.—Municipal (.....) and Company (———) Lamp Connections.
Scale (approx.) 1 inch = 800,000 Lamps.

In Diagram 4, the relative lamp connections of municipal and company networks at the end of last year are set out diagrammatically. Although municipal electric lighting now takes the leads well in the provinces, it is very much of a negligible quantity in London.

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Below the totals are set out in tabular form :—

Table I.—*Alternate-current and Continuous-current Lamp Connections.*

—	∿	⎓	Totals.
London	614,100	564,500	1,178,600
Provinces	476,100	624,200	1,100,300
Totals	1,090,200	1,188,700	2,278,900

Table II.—*Municipal and Company Lamp Connections.*

—	Municipal.	Company.	Totals.
London	56,000	1,122,600	1,178,600
Provinces	724,400	375,900	1,100,300
Totals	780,400	1,498,500	2,278,900

SOME ELECTRICAL PATENTS EXPIRING THIS YEAR.

The following is a list of important or otherwise interesting electrical patents which, having been acquired during 1882, will, on the assumption that they have not been allowed to lapse, expire during the present year :—

Dated 1882.	No.	Name.	Subject.
Jan. 4	49	John Hopkinson	Measuring and recording quantity of electricity.
Jan. 5	55	John Perry	Apparatus used in the distribution of electrical energy.
Jan. 5	64	R. J. Gülcher	Magneto and dynamo-electric machines.
Jan. 10	129	W. H. Preece and Jabez James	Electrically lighting railway trains.
Jan. 12	178	C. E. Spagnoletti.....	Signalling upon railways.
Jan. 17	245	A. de Khotinsky	Apparatus for regulating electric currents.
Jan. 18	252	Tommasi	Electrical accumulators.
Jan. 21	319	John S. Sellon.....	Construction of secondary batteries.
Jan. 23	339	B. A. Abakanowicz...	Regulating electric lamps.
Jan. 24	346	R. E. B. Crompton...	Arc lamps.
Jan. 26	386	W. T. Henley	Cores for telegraph cables.
Jan. 31	489	G. Skrivanoff	Primary batteries.
Feb. 2	513	C. V. Boys	Electric meters.
Feb. 6	563	A. J. Jarman	Arc lamps.
Feb. 9	626	A. A. Common	Arc lamps.
Feb. 11	661	H. H. Eldred	Telephone exchange systems and apparatus.
Feb. 11	677	W. E. Langdon	Interlocking electric signalling apparatus.
Feb. 11	686, 687, 688, 689	G. M. Hopkins	Telephone call or signalling apparatus.
Feb. 15	730	C. A. Faure	Apparatus for measuring and registering electric currents.
Feb. 15	740	Solignac and Co.....	Arc lamps.
Feb. 16	758	F. J. Cheesbrough ...	Telegraph instrument.
Feb. 16	760	E. W. Siemens	Dynamo-electric machine.
Feb. 21	831	John Rapieff	Arc lamps.
Feb. 24	898	James Brockie...	Improvements in arc lamps.
Feb. 27	941	John Richardson.....	Electrically controlling the speed of engines employed for driving electric machines.
March 3	1,023	T. A. Edison	Indicating and regulating the current of electric generators.
March 6	1,079	W. Crookes	Incandescent electric lamps.
March 8	1,137	W. H. Davies and F. H. W. Higgins	Street fire alarms.
March 10	1,163	E. Weston	Arc lamp.
March 17	1,303	F. van Rysselberghe	Telegraphic and telephonic systems.
March 21	1,368	A. E. Dolbear	Electric cables.
March 25	1,412	O. E. Woodhouse and F. L. Rawson	Incandescent lamps.
March 25	1,444	R. Werdermann	Incandescent lamps.
March 27	1,464	F. de Lalande	Primary battery.
March 28	1,496	T. A. Edison	Dynamo machines.
March 29	1,516	Berthoud, Borel et Cie.	Insulation.
April 3	1,614	E. Weston	Dynamo armatures.
April 3	1,619	H. Maxim	Carbons for incandescent lamps.
April 5	1,642	W. H. Akester.....	Incandescent lamps.
April 5	1,647	St. G. Lane-Fox	Incandescent lamps.
April 13	1,769	C. A. Faure	Secondary batteries.
April 17	1,830	Fleeming Jenkin.....	Telpherage.
April 20	1,895	A. Cruto	Incandescent lamps.
April 20	1,896	A. C. Brown and H. A. C. Saunders.	Telephonic and telegraphic signalling.
May 2	2,072	T. A. Edison	Arc lamps.
May 3	2,092	C. Lever	Arc lamps.
May 11	2,237	A. d'Arsonval	Microphonic transmitters.
May 18	2,340	Baron Elphinstone and C. W. Vincent.	Dynamo electric machines.
May 27	2,526	J. J. Wood	Dynamo.
May 27	2,531	J. J. Wood	Dynamo armatures.
May 31	2,578	S. P. Thompson	Telephone instruments.
June 3	2,618	R. E. B. Crompton...	Dynamo.
June 5	2,642	W. E. Ayrton and J. Perry.	Electric meter.
June 8	2,694	E. Weston	Dynamo armatures.
June 9	2,712	F. Krizik and L. Piette.	Arc lamp (Pilsen).
June 14	2,807	L. Epstein	Secondary batteries.
June 15	2,818	J. S. Sellon	Secondary batteries.
June 15	2,830	W. E. Ayrton and J. Perry.	Electric motors.
June 17	2,871	J. E. H. Gordon	Dynamo. [lamps.
June 19	2,898	J. W. Swan	Manufacture of incandescent
July 6	3,204	E. Thomson.....	Dynamo machinery, &c.
July 10	3,271	T. A. Edison	Electric meters.
July 11	3,296	G. Planté.....	Preparing sheet lead plates for secondary batteries.
July 17	3,380	W. E. Ayrton and J. Perry.	Electric haulage.
July 18	3,419	S. Z. de Ferranti and A. Thompson.	Dynamo alternator.
July 27	3,576	J. Hopkinson	Distributing electricity (3-wire system).
Aug. 4	3,710	P. B. Elwell and T. Parker.	Electric lighting machinery and apparatus.
Aug. 5	3,752	T. A. Edison	Transmitting electricity.
Aug. 5	3,755	T. A. Edison	Electric meters.
Aug. 5	3,756	T. A. Edison	Dynamo.
Aug. 8	3,770	L. Epstein	Preparation of lead for secondary batteries.
Aug. 9	3,803	S. P. Thompson	Telephonic apparatus.
Aug. 17	3,950	S. Z. Ferranti and A. Thompson.	Dynamos.
Aug. 18	3,955	T. A. Edison	Incandescing glow lamp filaments.
Sept. 1	4,178	D. G. FitzGerald and T. J. Jones.	Secondary batteries.
Sept. 9	4,303	E. Frankland	Secondary batteries.
*Sept. 13	4,362	L. Gaulard and J. D. Gibbs.	"A new system of distributing electricity for the production of light and power."
Sept. 14	4,376	M. Deprez	Dynamos.
Sept. 15	4,390	J. W. Swan and C. Swan.	Incandescent lamp holders.
Sept. 16	4,421	A. C. Brown and H. A. C. Saunders.	Telegraphic and telephonic apparatus.
Sept. 19	4,460	G. G. Skrivanow.....	Primary batteries.
Sept. 23	4,536	C. Zipernowsky and M. Deri.	Dynamos.
Sept. 23	4,548	F. Jenkin	Telpherage.
Oct. 4	4,718	J. Hopkinson	Electric traction.
Oct. 10	4,810	R. E. B. Crompton and G. Kapp	Dynamos.
Oct. 14	4,884	T. A. Edison	Electrical distribution (feeder system).
Oct. 20	5,001	G. L. Anders	Telephonic apparatus.
Nov. 15	5,438	R. E. B. Crompton ...	Conduction and distribution of electric currents.
Nov. 24	5,594	B. Abdank-Abakanowicz & C. Roosevelt	Dynamos.
Nov. 29	5,669	J. Blyth	Ammeter.
Nov. 29	5,673	R. S. Waring	Electric cables.
Dec. 8	5,870	A. E. Dolbear	Telephonic apparatus.
Dec. 15	6,002	G. Trouvé.....	Primary battery and system of interior lighting.
Dec. 20	6,075	A. Bernstein.....	Incandescent lamps.
Dec. 27	6,185	La Société Solignac...	Arc lamp.
Dec. 28	6,193	T. A. Edison.....	Incandescing lamp filaments.
Dec. 28	6,199	T. A. Edison.....	System of elec rical distribution.

* Revoked July, 1888.

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THE ELECTRIC RAILWAYS AND TRAMWAYS OF THE UNITED KINGDOM.

Place.	Length.	System.	Worked by.
In Operation :—	Miles.		
Bessbrook—Newry ..	3½	Third Rail (Dr. E. Hopkinson)	Bessbrook and Newry Tramway Company.
Birmingham	3	Accumulator Cars	Birmingham Central Tramways Company.
Blackpool	3	Holroyd - Smith's Conduit	Blackpool Corporation
Brighton.....	1	Third Rail (Volk)	Mr. Magnus Volk.
Bristol—Kingswood	4¼	Side Trolley	Bristol Tramways and Carriage Company.
Carstairs.....	1¼	Two Side Bars (Anderson-Munro)	Mr. J. Monteith, of Carstairs (Private).
London—			
City and South London Railway (King William - street—Stockwell)	3½	Third Rail (Dr. E. Hopkinson)	City and South London Railway Company
Coventry	5¾	Overhead Trolley.	Coventry Electric Tramways (Limited)
Douglas—Laxey (I. of Man)	7	Under-running "Bar" (Dr. E. Hopkinson)	Isle of Man Tramways and Electric Power Company.
Douglas (I. of Man)..	2½	Overhead Trolley.	DouglasSouthernElectric Tramways (Ltd).
Guernsey	2¾	Overhead (Siemens)	Guernsey Railway Company
Leeds (Roundhay Park Line)	3¾	Thomson-Houston Overhead Trolley	Thomson - Houston International Electric Company.
Liverpool Overhead Railway	6¼	Third Rail	Liverpool Overhead Railway Company.
Portrush — Giant's Causeway	8	Third Rail (Siemens)	Giant's Causeway Electric Tramway Co.
Ryde	¾	Third Rail (Siemens)	Ryde Pier Company.
Snaefell Mountain Railway	4¾	Overhead underrunning Bar (Dr. E. Hopkinson)	Snaefell Mountain Railway Association.
Southend Pier	1¼	Third Rail(Crompton)	Southend Corporation
Walsall, Wednesbury, Bloxwich, and Darlaston	8	Overhead Side Trolley	Electric Construction Company.
In Progress :—			
Brighton — Rottingdean	3	Overhead Trolley	Brighton and Rottingdean Seashore Railway Company.
London—			
Central London Railway (City and Shepherd's Bush)	6½	...	Central London Railway Company.
Waterloo—City.....	1½	...	South-Western Railway Company.
Dublin—Dalkey ...	8	Overhead Trolley.	Dublin Southern District Tramways Company.
Hartlepool	2½	Overhead Trolley.	Electric Construction Company.
Projected :—			
Birmingham (Nechells Line)	3	Side Trolley	Birmingham Central Tramways Company.
Blackpool — Fleetwood	...	Overhead Trolley.	...
Blackpool—Lytham.	...	...	Blackpool—St. Annes and Lytham Tramways Company
Bray—Bray Head ...	...	Overhead Trolley.	...
Colwyn Bay-Conway	10	Side Trolley	Conway-Llandudno & Colwyn Bay Tramway Company.
Derby—Ashbourne..	12	Side Trolley	Derby and Ashbourne Tramways Company.
Dover	..	...	Dover Corporation.
Dublin.....	32	...	Dublin United Tramways Company, and Dublin Southern Tramways Company.
Dublin	23	...	Dublin Southern District Tramways Company
Halifax	8	Overhead Trolley. (Holroyd-Smith.)	The Halifax & District Tramways Company.
Kidderminster—Stourport	4¾	Side Trolley	Kidderminster and Stourport Electric Tramway Company.
Leeds	...	Overhead Trolley.	Leeds Corporation.
Liverp'l & Birkenhead	4½	...	Mersey Railway Co.
Llandudno — Great Ormes Head	7	...	Manchester Edison-Swan Company.
London—			
City and S. London Rail. Extensions—			
Clapham	1	Third Rail (Dr. E. Hopkinson)	City & South London Railway Company.
Islington	2¾		
Finsbury Park & City	3¼	...	...
Finsbury — Walthamstow	3½	...	...
Hampstead, St. Pancras, & Charing-cross	5¼	...	...
Waterloo-Baker-st.	3	...	...
North Staffordshire..	...	...	North Staffordshire Tramways Company.
Portsmouth	...	...	Provincial Tramways Company.
Sheffield	...	...	London & Provincial TramwaysSyndicate.
Swansea	...	...	Swansea Tramways Company.

ELECTRIC LIGHTING NOTICES.

(SESSION 1896.)

The eliminating effect of the £50 cheque which has to be deposited with the Board of Trade by December 21st, has not been very pronounced this year, only three concerns having dropped out from the list published by us on p. 196 of our issue of December 6th. This time last year there were in all 29 applications for electric lighting powers; this year the total is 38, no less than 25 notices originating from Local Authorities.

THE METROPOLIS.

District.	Names of Applicants.
Parish of St. Mary, Newington, S.E.....	Vestry.
Parish of St. Mary, Battersea, S.W.	Vestry.
District of the St. Saviour's District Board of Works, Parishes of St. Mary (Newington), St. Mary (Lambeth), St. Giles (Camberwell), and St. Mary (Battersea), London	County of London and Brush Provincial Electric Lighting Company (Limited).

THE PROVINCES.

Allerton, Childwall and Garston (Lancs.)	Liverpool District Lighting Company (Limited).
Ambleside	Windermere and District Electricity Supply Company (Limited).
Ashton-on-Mersey	Altrincham Electric Supply (Limited).
Bath	Corporation.
Bath	City of Bath Electric Lighting and Engineering Company (Limited). [Extension of area.]
Bray	Township Commissioners.
Colwyn Bay and Colwyn	Urban District Council.
Cork	Corporation.
Cowes (Isle of Wight) ...	Urban District Council.
Devonport	Corporation.
Folkestone	Corporation.
Gloucester	Corporation.
Godalming	Corporation.
Great Berkhamsted and Northchurch	Bedford Electric Light Company (Limited).
Great Crosby & Waterloo, with Seaforth, ...	Liverpool District Lighting Company (Limited)
Huddersfield	Corporation. [Extension of area.]
Ipswich	County of London and Brush Provincial Electric Lighting Company (Limited).
Keswick	Urban District Council.
Ditto	Keswick Electric Light Company (Limited).
Kettering	Urban District Council.
King's Lynn	Corporation.
Kingstown	Township Commissioners.
Liverpool	Corporation.
Manchester.....	Corporation. [Extension of area.]
Margate	Corporation.
Merthyr Tydfil.....	J. C. Howell (Limited).
Middleton	Corporation.
Newmarket.....	Newmarket Electric Light Company (Limited).
Pembroke (Ireland)	Township Commissioners.
Prescot	British Insulated Wire Company.
Queenstown	Township Commissioners.
Rathmines and Rathgar (Dublin).....	Improvement Commissioners.
St. George, Kingswood, Stapleton and Warmley (Bristol)	Great Western Electric Light and Power Company, (Limited).
Sale	Urban District Council.
Wells	Corporation.

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THE RELATION BETWEEN THE ATOM AND THE CHARGE OF ELECTRICITY CARRIED BY IT.*

BY J. J. THOMSON, M.A., F.R.S.

In the electrolysis of solutions, the persistency of the sign of the electric charge carried by an ion is almost as marked a feature as the constancy of the magnitude of the charge. Thus the hydrogen ion always carries a positive charge, the chlorine ion a negative one. In the electrolysis of gases, however, the sign of the charges carried by the atoms of different elements is much more variable: here an atom of hydrogen does not always carry a positive charge, nor an atom of chlorine always a negative one; each of these atoms sometimes carries a negative charge, sometimes a positive one. But though in the gaseous state the atoms do not restrict themselves to charges of one sign, there are many phenomena which prove that even in this state the atoms of the different elements behave differently with respect to positive and negative charges. v. Helmholtz explained this behaviour of the elements by supposing that there is a specific attraction between the atom and its charge; that the zinc atom, for example, attracts a positive charge more powerfully than it does a negative one, while an atom of chlorine, on the other hand, attracts a negative charge more powerfully than it does a positive one.

The connection between ordinary matter and the electrical charges on the atom is evidently a matter of fundamental importance, and one which must be closely related to a good many of the most important chemical as well as electrical phenomena. In fact a complete explanation of this connection would probably go a long way towards establishing a theory of the constitution of matter as well as of the mechanism of the electric field. It seems therefore to be of interest to look on this question from as many points of view as possible, and to consider the consequences which might be expected to follow from any method of explaining, or rather illustrating, the preference which some elements show for one kind of electricity rather than the other.

The following method of regarding the electric field seems to indicate that this effect may be illustrated by simple dynamical appliances. The charges on the atoms are regarded as the ends of Faraday tubes (*see* J. J. Thomson, "Recent Researches in Electricity and Magnetism," p. 2): each unit of positive charge is the origin, each unit of negative charge the termiuation of such a tube. The magnitude of the unit charge is here taken equal to the charge carried by a monovalent ion. When these tubes spread into the medium they give rise to Maxwell's *Electric Displacement*, and the motion of the tubes through the medium produces a magnetic field.

Now suppose that the medium forming these tubes possesses rotatory motion: we may imagine, for example, that the tubes are bundles of vortex filaments, the axis of rotation being parallel to the axis of the tube. The total amount of vorticity which starts from any solid totally immersed in a liquid is zero; to satisfy this condition, we may suppose that there is slipping between the walls of the bundle of vortex filaments and the surrounding liquid, or, what amounts to the same thing, that there is on the surface of the bundle a film of negative vorticity whose strength is equal and opposite to the positive vorticity of the core. To fix our ideas, let us suppose that the rotation in the core is related to the direction of the axis of the tube (the line running from the origin to the end of the tube) like rotation and translation in a right-handed screw.

Now let us consider the atoms on which these tubes end. Let us suppose that these atoms have a structure possessing similar properties to those which the atoms would possess if they contained a number of gyrostats all spinning in one way round the outwardly drawn normals to their surface. Then one of these atoms will be differently affected by a Faraday tube, and will possess different amounts of energy according as the tube begins or ends on its surface. For if, when the tube starts from the atom, the rotation in the core of the tube is in the same direction as the rotation of the gyrostats, then when a tube ends on the atom the rotation in the tube will be in the opposite direction to that of the gyrostats. Thus in the first case the tube will tend to twist a gyrostat in the same direction as that in which it is already spinning, while in the second case it will tend to twist it in the opposite direction. Now if we try to rotate a gyroscopic system, its behaviour when we try to make it rotate in the direction in which the gyroscopes are spinning is quite different from its behaviour when we try to spin it in the opposite direction.

Thus let Fig. 1 represent a balanced gyrostat which can rotate as a whole about the vertical axis A B; the heavy flywheel C D is supported so that its axis can move freely in a vertical plane. Let this flywheel be in rapid rotation with its axis vertical; the framework of the gyrostat will not tend to rotate. Now if we set the framework rotating about the vertical axis, the behaviour of the system, if we make the framework rotate in the direction in which the flywheel is spinning, will be very different from its behaviour when we make the framework rotate in the opposite direction. If the framework rotates in the same direction as the flywheel, the axis of the wheel remains vertical, and the whole system goes on rotating quietly until stopped by friction. If, however, we attempt to set the framework rotating in the opposite direction to the flywheel, the axis of the wheel begins to wobble about, the disturbance gets more violent until finally the flywheel topples right over; then the flywheel is rotating in the same direction as the framework, and the rotation goes smoothly on. If the axis of the flywheel were held in its original position by springs, then in the first case these springs would not be stretched; but in the second case they would, and the axis of the flywheel would take up a position inclined to the vertical, the angle it made with the vertical depending on the stiffness of the springs and the moment of momentum of the flywheel. Thus in the second case the attempt to make the framework of the gyrostat rotate would be accompanied by the storing up of potential energy in the system due to the stretching of the springs, while there would be no such storage of potential energy in the first case.

Suppose, now, that an atom of hydrogen possesses a structure analogous to this gyroscopic system with springs, the gyrostats rotating in the same direction as the fluid in a Faraday tube *leaving* the atom. Then, since a charge of negative electricity on the atom implies the *incidence* of a tube on the atom, when the hydrogen atom is charged negatively the rotation in the tube connected with the atom is in the opposite direction to that of its gyrostats. The negative charge will thus cause an increase in the potential energy of the atom, whereas a positive charge when the rotation in the tube is in the same direction as that of the gyrostats does not cause any such increase. Thus the internal potential energy of the

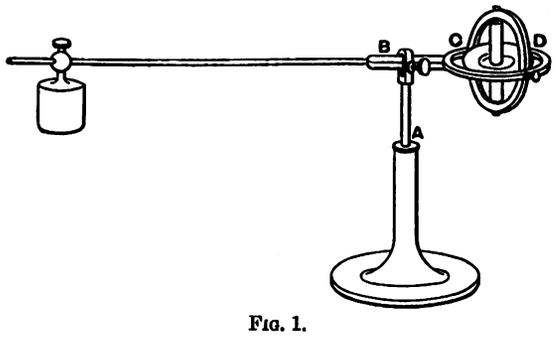

FIG. 1.

hydrogen atom will, *cæteris paribus*, be greater when it has a negative charge than when it has a positive one. In the case of a strongly electro-negative element such as chlorine, we suppose that the gyrostats in the atom are rotating in the opposite direction to those in the hydrogen atom, *i.e.* that in the chlorine atom the rotation in the gyrostats is in the *opposite* direction to that of the liquid in a Faraday tube *leaving* the atom: thus the chlorine atom will, *cæteris paribus*, have more internal potential energy when charged with positive electricity than it has when charged with negative.

The existence of the property conferred by these gyrostats would call into play forces between two charged atoms placed very close together, in addition to those given by the ordinary laws of electrostatics; it would make, for example, the attraction between a negatively charged hydrogen atom and a positively charged chlorine one less than that between a positive hydrogen atom and a negative chlorine one at the same distance apart. For imagine, in the first case, the atoms to approach a little closer together, then, besides the diminution in the potential energy due to the ordinary electric forces between the atoms, there will be an *increase* in the potential energy from the increase in the effect on the gyrostats due to the rotation in the Faraday tubes; while in the second case, when the hydrogen is positive and the chlorine negative, this increase will not take place. Thus the diminution in the potential energy due to a given diminution in the distance between the atoms is less in the first case than in the second, and consequently the attraction between them is smaller in the first case than in the second. If we could reach a place where, as the distance between the atoms diminished, the increase in the potential energy due to the effect of the gyrostats was numerically greater than the diminution in the potential energy due to the electrostatic attraction, then the oppositely-charged atoms would repel instead of attracting each other.

Hydro-dynamical Illustration.

The following illustration also indicates that the force between two electric charges may be modified by the electro-chemical properties of the atoms carrying the charges.

In a cylindrical column of rotating fluid the pressure increases with the distance from the axis of rotation, so that the average

* Abstract from the *Phil. Mag.*, Vol. XL., December, 1895.

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pressure over a cross-section of the cylinder is less than the pressure at the surface of the cylinder. When a solid is immersed in a liquid where the pressure is uniform, the pressures of the liquid on the solid form a system of forces in equilibrium. Now suppose that a column of the liquid abutting on the solid acquires rotation, the pressure on the part of the solid in contact with the column will be less than the pressure outside, the pressures on the solid will no longer be in equilibrium. The defect in pressure over the cross-section of the column will give rise to a tension acting on the solid. This tension is equal to the excess of the pressure over the cross-section when the pressure is uniform and equal to that at the surface of the cylinder, over that actually exerted over the area by the rotating liquid. If the rotating column is a cylinder containing a number of vortex filaments mixed up with irrotationally moving liquid, the pressure over a cross-section of the cylinder will depend upon the distribution of the vortex filaments in the cylinder. Let the cylinder be a right circular one. Let v be the velocity, and p the pressure at a distance r from it axis, ρ the density of the liquid; then we have

$$\rho \frac{v^2}{r} = \frac{dp}{dr}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The pressure over the cross-section of the cylinder is equal to

$$\int_0^b 2\pi r p \, dr,$$

where b is the radius of the cylinder. Integrating this by parts, we find that the pressure Π over the cross-section is given by the equation

$$\Pi = P\pi b^2 - \int_0^b \pi r^2 \frac{dp}{dr} dr$$

$$= P\pi b^2 - \int_0^b \tfrac{1}{2}\rho v^2 2\pi r \, dr \quad . \quad . \quad . \quad . \quad (2)$$

by equation (1); P is the pressure at the surface of the cylinder.

The tension Δ exerted by the cylinder on the solid is given by the equation

$$\Delta = P\pi b^2 - \Pi$$

$$= \int_0 \tfrac{1}{2}\rho v^2 2\pi r \, dr \, . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$= \text{kinetic energy per unit length of the cylinder.} \quad (4)$$

Since $2\pi r v$ = vorticity inside a circle of radius r, we can, if we know the distribution of vorticity, easily calculate by means of equation (3) the value of Δ.

Let us suppose that if all the vortex filaments were collected round the axis to the exclusion of the irrotationally moving liquid, they would occupy a cylinder of radius a. Let ζ be the rotation in the vortex filament, and let

$$\int_0^b 2\pi r \zeta \, dr = m.$$

Then we find that when the vortex filaments are as close to the axis of the cylinder as possible,

$$\Delta = \frac{\rho m^2}{16\pi} + \frac{\rho m^2}{4\pi} \log \frac{b}{a}.$$

When the vorticity is uniformly distributed over the cross-section of the cylinder,

$$\Delta = \frac{\rho m^2}{16\pi}.$$

When the vorticity is all as near to the surface of the cylinder as possible,

$$\Delta = \frac{\rho m^2}{16\pi}\left\{1 - 2\frac{(b^2-a^2)}{a^2}\left(1 - \frac{(b^2-a^2)}{a^2}\log\frac{b^2}{b^2-a^2}\right)\right\}.$$

We may expand the right-hand side of the last equation, and get

$$\Delta = \frac{\rho m^2}{8\pi}\left\{\frac{1}{3}\frac{a^2}{b^2-a^2} - \frac{1}{4}\frac{a^4}{(b^2-a^2)^2} + \frac{1}{5}\frac{a^6}{(b^2-a^2)^3} - \ldots\right\},$$

so that when a is small compared with b,

$$\Delta = \frac{\rho m^2 a^2}{24\pi b^2}.$$

In this case the tension in the cylinder is very small compared with its value in the two previous cases: the value of Δ in the first case is greater than that in the second; the more the vortex filaments are concentrated at the axis the greater will be the value of Δ. Now let us suppose that a Faraday tube contains a given amount of vorticity distributed among irrotationally moving liquid; the axes of the vortex filaments being parallel to the axis of the tube. The moment of momentum of the fluid in the tube about its axis will depend upon the distribution of vorticity in the tube: the more the vorticity is concentrated near the axis of the tube the greater will be the moment of the momentum. Now suppose we apply a couple to the Faraday tube, the couple acting in such a direction as to increase the moment of momentum; this couple will cause the vortex filaments to concentrate more at the axis of the tube, and will consequently increase the tension in the tube. If, however, the couple on the Faraday tube acts in the opposite direction to the moment of momentum of the fluid in the tube, the action of the couple will cause the vortex filaments to spread out and get nearer the boundary of the tube: this will diminish the value of Δ, and consequently diminish the tension in the tube. If we suppose that the solid on which the tube abuts is an atom containing gyrostats, then when the gyrostats are rotating in the same direction as the fluid in the tube, we may regard the action between the gyrostats and the tube as equivalent to a couple tending to increase the moment of momentum of the fluid in the tube, and thus to increase the pull exerted by the tube on the atom. When, however, the rotation of the gyrostats is in the opposite direction to that of the fluid in the tube, the action between the atom and the tube will be equivalent to a couple tending to diminish the moment of momentum of the fluid in the tube, and thus to diminish the pull exerted by the tube on the atom. Thus if, as before, we suppose that the gyrostats in the hydrogen atom are rotating in the same direction as the fluid in the Faraday tube of which it is the origin when it carries a positive charge, whereas the gyrostats in the chlorine atom are rotating in the same direction as the fluid in the Faraday tube of which it is the termination when it carries a negative charge, we see that the attraction between a positively charged hydrogen atom and a negatively charged chlorine one will be greater than that between a negative hydrogen and a positive chlorine atom separated by the same distance.

The object of these illustrations is to call attention to the point that when charged atoms are close together, there may be forces partly electrical, partly chemical, in their origin in addition to those expressed by the ordinary laws of electrostatics.

There are one or two points in connection with the theory of the electric field which can be illustrated by the conception of a Faraday tube as a bundle of vortex filaments, which, though not connected with the main object of this Paper, may be briefly pointed out.

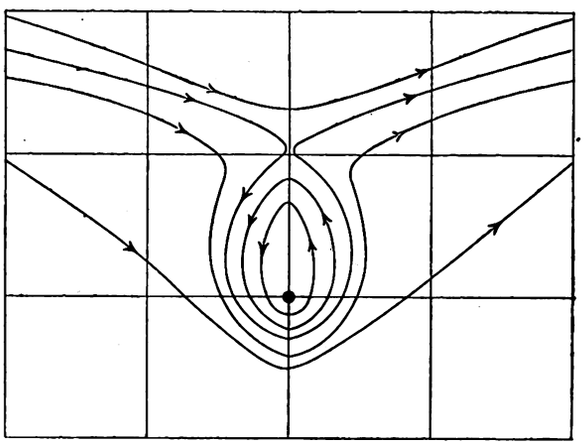

FIG. 2.

The first of these arises from equation (4), which indicates that the tension exerted by a vortex column is equal to the kinetic energy of the fluid in unit length of the column. Now we know that the forces on a charged body in the electric field are such as would be produced if there were a tension along the lines of force equal per unit area to the electrostatic energy in unit volume of the field. If we suppose the tension to be exerted by the Faraday tubes and the energy to reside in these tubes, this is equivalent to saying that the tension exerted by each of these tubes is equal to the energy in unit length of the tube. This exactly coincides with the result indicated by equation (4), if we suppose that the Faraday tubes are bundles of vortex filaments.

The other point is in connection with the view that magnetic force is due to the movement of the Faraday tubes: the magnetic force being at right angles to the direction of the Faraday tubes, and also to the direction in which they are moving, the magnitude of the force varying as the product of the "polarisation" and the velocity of the tubes at right angles to their direction (*see* "Recent Researches in Electricity and Magnetism," by J. J. Thomson, p. 8). On this view the energy per unit volume in the magnetic field when the tubes are moving at right angles to themselves is (*see* "Recent Researches," p. 9)

$$\frac{\mu}{8\pi} P^2 V^2,$$

where μ is the magnetic permeability, P the polarisation, and V the translatory velocity of the tubes. This expression would represent the kinetic energy due to the translatory motion of the tubes if the expression for the effective mass of the tubes contained a term proportional to the square of the "polarisation." Now, if we have a vortex column moving about in a fluid which is subject

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to other disturbances, the following considerations would seem to show that the expression for its effective mass would contain a term proportional to the square of the vorticity in the vortex column.

The lines of flow when the vortex column is stationary in a liquid moving so that at an infinite distance its velocity is uniform and horizontal are represented in Fig. 2.

We see that some of these lines of flow in the neighbourhood of the column are closed curves; now the liquid inside any one of these curves will always remain in the neighbourhood of the column, and if the column is moved will move with it; thus the effective mass of the column will be that of the column plus that of the liquid enclosed by the largest of the closed lines of flow. The linear dimensions of the curve are proportional to m/u, where u is the velocity of the fluid at an infinite distance from the column, and m the strength of the vortex; (the equation to the bounding line of flow is easily seen to be $r=\frac{m}{u}e^{-\frac{uy}{m}}$), thus the area enclosed by the line of flow, and consequently the mass of fluid inside a cylinder of which it is the cross-section, is proportional to m^2/u^2; thus, as the effective mass is increased by this mass of fluid, the expression for the effective mass of the vortex column will contain a term proportional to the square of the vorticity. Hence, if we regard a Faraday tube as a bundle of vortex filaments, we can by this analogy see that its effective inertia might involve a term proportional to the square of the polarisation.

Relation of the preceding Analogies to the Electro-chemical Properties of the Atoms.

To return, however, to the relation between the electric charge and the electro-chemical properties of the element whose atom carries the charge. Fig. 1 suggests that when an atom is charged with electricity it acquires a certain amount of potential energy depending upon the sign of the charge and also upon the kind of atom carrying the charge. Let us suppose that when an atom of an element A carries unit charge of positive electricity, its potential energy, in consequence of the connection between the internal motion of the atom and the motion of the fluid in the Faraday tube, is greater by σ_A than when it has no charge, while when the atom has the unit negative charge its potential energy is less by σ_A than that of the uncharged atom. The quantity σ depends upon the nature of the atom; in "Recent Researches in Electricity and Magnetism," p. 64, it is called the Volta potential of the substance, since the difference of potential between two metals A and B when placed in contact can be proved to be equal to $\sigma_A - \sigma_B$.

If the substance A has a charge Q of positive electricity, then in the expression for its potential energy there will be the term $\sigma_A Q$. If we consider this term alone, then if σ_A is positive an increase in the positive charge will involve an increase in the potential energy, while an increase in the negative charge would diminish the potential energy; if σ_A is negative the converse is true. Now a dynamical system behaves so as to facilitate any change which causes a diminution in the potential energy. Thus those substances for which σ is negative will tend to acquire a charge of positive electricity, while those for which σ is positive will tend to get a charge of negative electricity. Thus the existence of the property expressed by the coefficient σ would produce the same effect as von Helmholtz's specific attraction of the elements for the two electricities.

Suppose, for example, that we have two metals A and B in contact, and that σ_A, σ_B are the values of the Volta coefficients for A and B respectively; let σ_A be greater than σ_B. Then if A acquires a negative charge equal to $-Q$, and B a positive charge equal to Q, the potential energy of the two metals will be diminished by $(\sigma_A - \sigma_B)Q$. If this were the only source of potential energy, the transference of positive electricity from A to B, and of negative from B to A, would go on indefinitely, as each transference would involve a diminution in the potential energy. The separation of the electricities will, however, produce an electric field the potential energy due to which will increase as Q increases, so that the diminution in energy due to the Volta effect will be accompanied by an increase in the energy due to the electrostatic field. Let us suppose, for example, that the two metals form the plates of a condenser whose capacity is C, then when A has a charge $-Q$ and B a charge $+Q$, the energy in the electrostatic field is equal to

$$\frac{1}{2}\frac{Q^2}{C},$$

while the energy due to the Volta effect is

$$-(\sigma_A - \sigma_B)Q.$$

The flow of negative electricity into A and of positive into B will go on until the increment in the energy of the electrostatic field due to an increase δQ in the charge on B is equal to the decrement of the energy due to the Volta effect produced by the same displacement of electricity.

Since the total energy is

$$\frac{1}{2}\frac{Q^2}{C} - (\sigma_A - \sigma_B)Q,$$

the increment when Q is increased by δQ is equal to

$$\delta Q\left\{\frac{Q}{C} - (\sigma_A - \sigma_B)\right\};$$

or, if V is the difference of potential between A and B, the increment of the potential energy is equal to

$$\delta Q\{V - (\sigma_A - \sigma_B)\}.$$

Thus, so long as V is less than $\sigma_A - \sigma_B$, an increase in Q will be accompanied by a decrease in the potential energy, so that Q will tend to increase; while, on the other hand, when V is greater than $\sigma_A - \sigma_B$, an increase in Q will be accompanied by an increase in the potential energy, so that Q will tend to diminish: there will be equilibrium when $V = \sigma_A - \sigma_B$.

We see from this that if an atom of A has a unit negative charge, an atom of B a unit positive one, these atoms will retain their respective charges even though connected by a conductor, unless the potential of B exceeds that of A by more than $\sigma_A - \sigma_B$. If, on the other hand, A had a positive charge, B a negative one, they would, if connected by a conductor, interchange their charges unless the potential of B exceeded that of A by more than $\sigma_A - \sigma_B$.

Thus, assuming that σ is positive for chlorine and negative for hydrogen, an atom of hydrogen could retain a positive charge, and an atom of chlorine a negative one, even though the two were immersed in a conductor, provided the potential of the hydrogen atom did not exceed that of the chlorine atom by more than a certain limit; whereas if the hydrogen were negatively electrified and the chlorine positively, they would, if immersed in a conductor, interchange their charges unless the potential of the hydrogen atom exceeded that of the chlorine by the same limit as before.

Chemical Combination.

Thus, if we have a number of hydrogen atoms and an equal number of chlorine atoms immersed in a conductor, and if initially half of both the hydrogen and chlorine atoms were positively and half negatively electrified, interchange of charges between the atoms would go on until all the hydrogen atoms were positively and all the chlorine atoms negatively electrified.

For this interchange of charges to go on, however, it would seem necessary that a negatively electrified hydrogen atom and a positively electrified chlorine one should be connected by a conducting

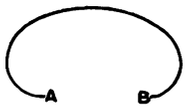

FIG. 3.

circuit. From the mechanical illustrations previously given, it seems unlikely that the atoms would interchange their charges by coming into contact, the positive charge passing from the chlorine to the hydrogen atom and *vice versâ*. From these illustrations we should rather expect that if a negative hydrogen atom came very near to a positive chlorine one, the two, if alone in the field, would tend to repel rather than to attract each other, the Faraday tube connecting the atoms ceasing to be straight, and bulging out into the surrounding medium somewhat in the manner shown in Fig. 3.

If in addition to the two atoms there were other charged bodies producing a very intense field tending to push the hydrogen and chlorine atoms together, then the interchange of their charges might take place by the ends of the Faraday tube gliding from one atom to the other after these atoms had been forced into contact by the external field. There are indications that the external field would have to be such as to produce a potential difference of a large number of volts between the two atoms before this method of exchanging their charges took place. In the absence of this potential difference, the atoms would not exchange their charges unless the medium into which the Faraday tube spread contained some conductor along which the ends of the Faraday tube could glide from one atom to the other. The necessity for this conducting circuit is perhaps one of the reasons why the presence of a third substance seems necessary for the continuance of many chemical reactions. How much a third substance able to act as a conductor could facilitate chemical combination may be seen from the following example. Suppose we have a mixture of hydrogen and chlorine molecules, and that by some external cause we split up these molecules into atoms; half of the hydrogen atoms produced by the dissociation of the hydrogen molecules will be positively electrified, while the other half will be negatively electrified; the same will also be true of the chlorine atoms. This condition will be permanent if the negative hydrogen atoms have no opportunities of interchanging their charges with the positive chlorine atoms, and a positive hydrogen atom would thus not be limited to combining with a negative chlorine one to form a molecule of hydrochloric acid, but might instead combine with a negative hydrogen atom to form a hydrogen molecule. If, however, conducting circuits, able to connect atom with atom, were present,

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the circumstances would be much more favourable to the formation of hydrochloric acid. For if the conducting circuit stretched from a positive hydrogen atom to a negative chlorine one, these atoms would retain their charges; whereas when the circuits stretched from a negatively electrified hydrogen atom to a positively electrified chlorine one, the atoms would interchange their charges. Thus the effect of these conducting circuits would be to cause all the hydrogen atoms to be positively electrified, and all the chloride ones negatively; this would of course increase the tendency for the hydrogen and chlorine to combine.

In the preceding case we have supposed the molecules to be already split up into atoms; when, however, we consider the case of a mixture of molecules not already decomposed, we see that something more than the stretching of a conductor from one atom to another is required to effect the interchange of their charges. For suppose H, H, Cl, Cl (Fig. 4) represent respectively a hydrogen and a chlorine molecule, and suppose that the negative hydrogen atom is connected with the positive chlorine one by a conducting circuit. Then, if the negative charge of the hydrogen and the positive one of the chlorine were interchanged, the diminution in the potential energy due to the Volta effect would be $2(\sigma_{Cl}-\sigma_H)$, where σ_{Cl}, σ_H are the Volta coefficients of chlorine and hydrogen respectively, σ_H being negative. To set off against this diminution in the potential energy due to the Volta effect, we have the increase in the energy produced by tearing the $-$charge on the H atom from its proximity to the $+$charge, and forcing it close to the $-$charge on the Cl atom. The increase in potential energy due to this cause will be of the order $2(V_1+V_2)$, where V_1 and V_2 are the potential differences between the atoms in the hydrogen and chlorine molecules respectively. Thus the diminution in the potential energy when the charges are interchanged is

$$2(\sigma_{Cl}-\sigma_H)-2(V_1-V_2),$$

and the interchange will not go on unless this quantity is positive. Now the potential difference due to the contact of two substances is equal to the difference of their Volta coefficients, so that the σ's will not exceed a small number of volts. To estimate the V's is more difficult, but we may remark that when we produce a spark through a gas, in which case there is strong evidence that we split

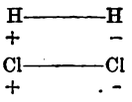

Fig. 4.

up some of the molecules into atoms, then, no matter how short the spark may be, or what may be the pressure of the gas, the potential difference between the electrodes must exceed a certain value, which is very large compared with the potential differences developed by the contact of heterogeneous substances, amounting in the case of hydrogen to between 190 and 200 volts. This minimum potential difference required to produce a spark is so constant under very varying physical conditions, such as pressure, spark length, and so on, as to suggest that it represents some property of the molecule; and I am inclined to think, and some experiments recently made at the Cavendish laboratory seem strongly to support the view, that the potential difference between the atoms in a molecule placed so as to be free from the action of other molecules is of the order of the minimum potential difference required to produce a spark. In the few cases where a direct estimate has been made of the work required to split up the molecule into atoms, such as that made by E. Wiedemann of the work required to decompose the hydrogen molecule, and that by Boltzmann for the iodine molecule, the potential difference indicated by these estimates far exceeds that produced by the contact of heterogeneous substances.

It would thus appear that in the case of gases where the molecules are free, the condition

$$2(\sigma_{Cl}-\sigma_H) > V_1+V_2$$

is not fulfilled; so that, on the electrical theory, chemical combination would not proceed. To produce chemical combination in such cases there must be some means of lowering the potential difference between the atoms in the molecules. Two methods by which this might take place at once suggest themselves. The first of these is that the combination, instead of taking place between a single pair of molecules, really takes place between aggregates of the molecules, physical aggregation preceding chemical combination.

Thus suppose that a number of molecules form themselves into a chain, such as that represented in Fig. 5; then, if we consider a $-$H atom and the adjacent $+$Cl one, we see that the disposition of the charges on the atoms of the other molecules in the chain will diminish the work required to separate the $-$ charge on the H atom from the $+$ charge on the neighbouring H atom, and also that required to separate the $+$ charge on the Cl atom from the $-$ charge on the atom with which it is paired. Thus, this disposition of molecules, by diminishing the electrostatic attractions, increases the chance for the $-$H and $+$Cl to interchange their charges in response to the "Volta effect": after this interchange has taken place the adjacent H and Cl atoms will have respectively $+$ and $-$ charges; *i.e.*, charges suitable for the formation of the HCl molecule; if such molecules form, the ring will be disposed as in

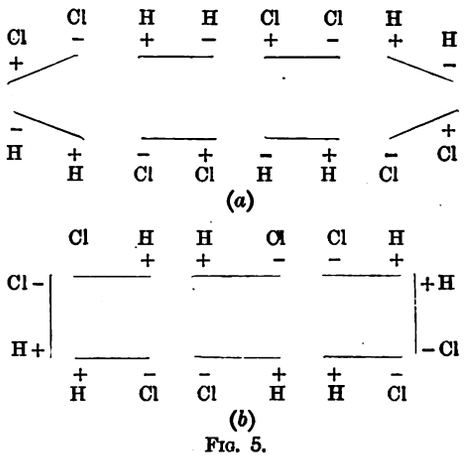

Fig. 5.

Fig. 5 (*b*). This disposition will not be stable, since the lines joining the negative to the positive atoms in the molecule do not all point in one way; the ring will consequently break up into separate HCl molecules.

(To be concluded).

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December 20, 1895.*

An Extensive Trolley Strike.—At the time of writing the street-car traffic in Philadelphia is almost entirely paralyzed through a strike of electric railway employés. The strike was caused by the refusal of the Union Traction Company, which has a practical monopoly of all street-car lines in the city, to accede to the demands of its employés, which are substantially as follows:—First, 10 consecutive hours shall constitute a day's work, for which $2 shall be paid; second, all work on snow ploughs or "trippers" shall be considered special work, for which extra compensation shall be allowed; third, the Company shall exercise every care for motormen, this referring to the "vestibule" compartment at ends of cars; fourth, no employé shall be discharged from the Company for his connection with labour organisations, and the large number recently discharged for such affiliation shall be reinstated. The strike was commenced on December 17th; during the first two days there was considerable violence, with the destruction of property amounting to about $10,000, for which the city will have to pay. A limited number of cars are now running under police protection. The prospects of the strikers gaining their ends are good, provided no more violence is used, principally through the sympathy of the public, which has an intense antipathy to the Union Traction Company on account of its recent policy of abolishing free transfers.

An Electrical Exhibition.—A Company has been organised to hold an electrical exhibition in New York City during the month of May, and is endeavouring to obtain the co-operation of the several national electrical professional organisations to the extent of holding their meetings in the same building in that month. The National Electric Light Association has met the wishes of the Company in this respect, and overtures are being made to the American Institute of Engineers. While the main purpose of the exhibition is purely commercial, it is intended to include a number of interesting features, such as working polyphase systems, spectacular effects, &c.

Cast Welded Rail Joints.—A contract has been given by the street railway companies of Boston and Providence for rejointing the rails of their lines by a new process. The process consists in casting a slug of iron around the joints, which

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have been previously prepared by cleaning and the insertion of short wrought-iron plugs in the bolt holes of the rails made for the tie plates thus displaced. Expansion and contraction need not be allowed for, as experience has shown that the elasticity of the rails is sufficient for this purpose. and any poor joint is at once detected through being thereby drawn apart. This process is much cheaper than the electric welding one, and that it promises reliability is evident from the above large and conservative companies adopting it.

CORRESPONDENCE.

TELEGRAPHY IN LONDON: 1847-1896.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue I read with much interest the letter from my dear old friend Mr. J. W. Wilkins in connection with telegraphy in London in the early days.

I quite remember the fact of the Seymour-street office being the first public telegraph office in London, but he is in error in saying that that office was abandoned for that at Founders'-court, because the central telegraph office, as well as the general offices of the old Electric Company, were situated at 345, Strand (at which office I was in charge), in 1846.

Mr. Wilkins' letter is most interesting as a reminiscence of the remote past, and I wish he could be induced to give us more of his interesting reminiscences, as we have very little or no record existing of the early days of telegraphy, prior to the incorporation of the Electric Telegraph Company in March, 1846. He could, if he will, tell us a great deal, and I trust he will allow himself to be drawn out of his shell, and put on record facts which even I have a very hazy recollection of after a lapse of half a century.

I agree with you that the house in Seymour-street might be immortalised with a tablet recording the fact of its being the first public telegraph office not only in England, but in the world.—Yours, &c., W. T. ANSELL.

London, December 27, 1895.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir:—If I rightly understand the feeling of the large section of the Institution who, with its best interests at heart, are of opinion that the time has now arrived when some changes should be carried into effect, their desires may be comprised under two principal heads.

They are anxious, firstly, that the constitution and the manner of election of the Council should be so altered as to render the Council more truly representative of those who are actually doing the electrical work of the present day, more in touch with their requirements, more conscious of their desires and aspirations, more amenable to their wishes. Secondly, that the standard of qualification required for full membership of the Institution should be raised, so that such membership should be a real, and not as at present, a practically nominal distinction.

With a view to arriving at a satisfactory solution of these problems I beg to submit for consideration the following suggestions, which are, of course, only in outline, and are capable in some cases of considerable modification in detail.

1. Some curtailment of the growing preponderance of power at present vested in the permanent members of the Council as distinguished from the elective members.

2. An increase in the number of elective members of Council, so that all branches of the profession shall be more adequately represented.

3. A larger number of members of the Council to retire annually, so as to allow of the introduction of more fresh blood every year.

4. Greater facilities to be given for country members serving on the Council, it being understood that such country members of Council need not give such constant attendance at the Council meetings as is expected of members resident in London.

5. A much longer interval of time to elapse between the publication of the Council's nominations for new members of the Council and the date on which the ballot is held.

6. The list of nominations to be published at least one month before the issue of the ballot papers.

7. The ordinary members to be given an opportunity of adding names to the Council's nomination list, and names so added by ordinary members to be printed on the official ballot papers in such a manner as to be indistinguishable from those nominated by the Council.

8. The evening devoted to the annual general meeting to be reserved entirely for the necessary formal business and for discussion on any matters pertinent to the general affairs and welfare of the Institution.

9. Some alterations to be made in the constitution of the Institution, whereby for the future no one shall be qualified for election as a full member who is not actively engaged as a practicing electrical engineer or electrician, a new class being created, as in the case of the Institution of Civil Engineers, for those who desire to belong to the Institution, and whose association with the Institution may be of advantage to the latter, but who are not qualified for full membership.

None of the above suggestions can be said to be in any way revolutionary, one and all of them being taken from the regulations in force in other engineering societies older and more experienced than our own.

I believe that some changes in the direction indicated could not fail to be salutary, and would greatly increase the prestige, usefulness and harmony of the Institution as a whole.—Yours, &c., A. A. C. SWINTON.

December 31, 1895.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would not the following, which is a modification of Mr. Addenbrooke's proposal, put the matter in form?

Increase the number of members of the Council, say, to 24, and allot a certain number and one vice-president to each branch. Let each branch act as a committee, presided over by its vice-president, reporting to the whole Council for approval. This is practically the arrangement that rules in municipal councils, aldermen, or older members of the Council, acting as chairmen of committees. Each committee has its own work, and exercises certain powers within it own domain, reporting to the whole Council periodically. In the case of the Institution the arrangement should work even better than it does with municipalities. The presidential chair would be filled by a leading member from each branch in turn, so that there need be no room for jealousy between the different branches. As other departments of electrical industry are created, further batches of six, or whatever number may be arranged, could be added to the Council, just as additional members are added to a town council as its area and population expand.

May I suggest also that country members might receive more consideration than they now do? At present a country member obtains no advantage beyond a casual visitor. He pays his subscription for the benefit of his London *confrère*. I believe there is a very strong feeling among country members on this point, and that the formation of the Northern Society of Electrical Engineers is an expression of this fact.

With regard to the immediate cause of the present outbreak, I am strongly of opinion that the Council have done wrong in not recommending Sir David Salomons for the presidency, and that the members who have taken the action which has led to the recommendation of Dr. Hopkinson have also done wrong. The time for action, if any was necessary, was allowed to pass years since. Sir David is allowed to mount, step by step, till his foot is on the rung of the presidential chair, and is then thrust rudely back. He stands in the peculiar position, that while he has been judged worthy to fill the chair in the President's absence—perhaps a more difficult task than that involved in the presidential office itself—he is judged unworthy to preside in his own name. The members who have taken action this year could as easily have taken

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action prior to one of the elections when Sir David qualified as Vice-president. Why did they not do so?

There is also another side to this question. Electricity is such a fascinating study that it has enlisted the services of a large army of wealthy amateurs, many of whom could hold their own with eminent practising electrical engineers. Should they not be represented? And should an eminent scientist be disqualified for a post of honour because the work is to him one of love and not of necessity?—Yours, &c.,

SYDNEY F. WALKER.

Cardiff Electrical Works, Severn-road, Cardiff.

THE PAST YEAR'S WORK.

MESSRS. JOHNSON AND PHILLIPS report that during the past year all the departments have been uniformly busy. The manufacture of alternators, dynamos, transformers and central station accessories has surpassed that of previous years. The firm have been very busy on several large contracts, which include transmission of power plants for South Africa, alternators for the St. Helens' Corporation, and the station plant for the Cape Town Electric Lighting Company. Orders for transformers continue to pour in, and the firm claim to have more transformers of their manufacture on circuit in this country than any other manufacturers. Several of 100 kilowatts are now being constructed and the sizes on order vary from this to half a kilowatt. The cable machinery department has been very busy on stranding, cable-making, and wire-covering machines both for this country and abroad, and have also had in hand the picking-up and paying-out machinery, accessories and stores forming the complete equipment for the Japanese Government's cable steamer. The arc lamp department has been kept exceptionally full of orders, especially during the latter part of the year, and nearly all the Corporation contracts of the year have been secured, including Portsmouth, Brighton, Taunton, South Shields and Edinburgh, also for the lighting of Johannesburg. The total orders are much in excess of the previous year. The new type of Brockie-Pell lamp introduced at the beginning of last year is rapidly gaining favour, the pattern being considered the best yet devised. The trade in carbons has also been exceptionally heavy. The cable department has been chiefly occupied during the year with the manufacture of vulcanised rubber cables for wiring purposes and underground use. High-tension concentric mains have been completed in connection with the lighting of London, Walsall and Malta, as well as a large quantity of single mains for various towns at home and abroad. The Brooks oil-insulated cables have been supplied for the wiring of the Glasgow Harbour Tunnels, the wires being insulated with oil right up to the incandescent lamp holder. The use of this system for this special class of work has been a great success. In the meter department every effort has been necessary to meet the steadily increasing demand, and standard designs for all sizes, from 5 to 1,000 amperes, have been prepared, in addition to those in use at the beginning of the year. From these designs instruments of all sizes have been stocked and sold. Very extensive additions to the instrument shops have been made for rapidly and accurately testing these instruments. The plant put down early in the year has been kept fully occupied and should the sales continue to increase at the same rate further additions will very shortly be needed. Messrs. Johnson and Phillips write in a very optimistic tone, and congratulate themselves on the work they have secured and executed during the year, regarding the outlook for 1896 as extremely hopeful.

Amongst the leading electrical firms who issue satisfactory reports for 1895 may be mentioned the ELECTRIC CONSTRUCTION COMPANY (LIMITED), who have had an unprecedented amount of work during the year and inquiries and orders for all classes of machinery. Generating plant of a special type has been manufactured and erected for the authorities of Wolverhampton, Stafford, Manchester, Halifax, St. Pancras (London), and for the electric supply companies of Liverpool, Birmingham, Chelsea, Oxford, Crystal Palace, Clerkenwell (London), &c., &c. In traction work the Company have successfully completed the contract for the Madras tramways. A large influx of orders for general electrical engineering work has necessitated the preparation of new catalogues, which have been issued during the year. Considerable progress has been made in the design and efficiency of the Company's dynamos, motors, continuous-current transformers, alternators and converters, arc lamps, switches and other apparatus. The number of employés has steadily increased, and important additions to the works premises and machinery are necessitated by the satisfactory increase of business. The work in hand includes a 500 H.P. dynamo for the War Office, a 300-kilowatt steam alternator for Halifax, motor equipment for the Liverpool Overhead Railway extension (some particulars of which were given in our issue for December 13th), and for the electrical equipment of the Hartlepool Tramways. These and other important orders in hand represent about six months' work.

Another branch of what may now fairly be termed the electrical industry which has shown considerable extension during the past year is that represented by Messrs. DOULTON AND CO.'s stoneware conduits. During 1895 this conduit has been used both for high and low-pressure electric supply schemes, amongst the districts supplied being Bedford, Portsmouth, Sunderland, Edinburgh, Chelmsford, Preston, Stafford, Oswestry, &c., and several of the London supply companies have adopted the conduit. Of course, several types of conduit and accessories have had to be devised to meet the varied requirements of electrical supply, and Messrs. Doulton have therefore wisely prepared a new catalogue for this branch of their business. Bare copper mains are not everywhere regarded with favour, but Messrs. Doulton inform us that there has been scarcely any diminution in the demand for the insulators which they have supplied for some years past for these mains. Both the London and Staffordshire works of the firm have been busy during the year with large orders for insulators for telegraph, telephone and electric traction purposes, as well as for battery jars, porous cells, plumbago crucibles and the many other Doulton manufactures used in various branches of the electrical industries. A distinct branch of Messrs. Doulton and Co.'s business is the manufacture of plant for the softening and purification of water for boilers and manufacturing purposes, amongst the contracts executed during the year being one for a complete water-softening plant for the new St. Pancras electric supply station at King's-road.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is in active preparation, and will be ready at the end of January. Orders for Advertisements and Subscriptions (6s. 9d. post free, abroad 6s. 6d.) should now be sent in. Full particulars post free on application.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES can be obtained of the Booksellers or direct from the Publishing Offices:—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

'THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

TENDERS INVITED.—The St. Pancras Vestry invite tenders for wiring and other work in connection with the electric lighting of the Vestry Hall and Offices in Pancras-road. Specification, &c., can be obtained at the Electricity Department Offices, 57, Pratt-street, N.W., and tenders must be sent in to Mr. A. E. Pycraft, at the Pratt-street Offices, by 12 noon of the 16th inst. Some further particulars are given in our advertisement columns.

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TENDERS INVITED.—The Posen Direction of the Prussian State Railways require tenders for the supply of 90,000 arc-lamp carbons. Tenders to the Königliche Eisenbahn Direction, 40, St. Martin Strasse, Posen, by the 10th instant.

——— The Hanover Direction of the Prussian State Railways invite tenders for the supply of 1,100 telegraph poles. Tenders to the Königliche Eisenbahn Direction, Hanover, by the 16th inst.

——— The Municipal Authorities of Brünn (Austria) invite tenders for the establishment of an electricity generating station in the town for supplying electrical energy for lighting and power purposes, including the supply of current for an electric tramway. Tenders to the Burgmeisteramt Brünn, by March 1st.

TENDERS ACCEPTED.—The Gas and Electric Lighting Committee of the Aberdeen Town Council have accepted the following tenders for stores for the ensuing year :—

J. Abernethy and Co., for ironwork	£374	14	0
Glegg and Thomson, for malleable iron and steel	149	6	8
J. Blaikie and Sons, for brasswork and lead and tin work	264	13	8
Stewart and Co., for tubing	417	13	4
G. Walker, for engine and exhauster	584	0	0
J. Wallace, for iron girders	388	17	0

BUSINESS FOR DISPOSAL.—Our advertisement columns contain brief particulars of a well-established electrical manufacturing and contracting business for disposal in London, with a present turnover of about £11,000 per annum.

NEW WORKS.—The site for the new works of the Castner-Kellner Chemical Company has been fixed at Western Point, Runcorn, where it is anticipated the new factory will provide employment for many hands. It is proposed to erect an electrical plant, equal when finished to 4,000 H.P., at an estimated outlay of £130,000.

ADDITIONAL PLANT.—The Newcastle-upon-Tyne Electric Lighting Company have ordered from the Brush Company a 300-kilowatt Mordey alternator, this making the sixth machine of this type in the station, and brings the total capacity of the station up to 900 kilowatts.

CHANGE OF ADDRESS.—Messrs. F. Wiggins and Sons, mica merchants, owing to increase of business necessitating additional warehouse room, have purchased 103, Minories, and during the demolition and rebuilding of this and their old premises adjoining, have taken temporary premises at 62 and 63, Minories, where (or to their other establishment, 10, Tower-hill, London) for the next twelve months all communications should be addressed.

——— Messrs. W. F. Dennis & Co. have now taken possession of their larger premises at 23, Billiter-street, London, E.C., *vice* No. 11, in the same street.

APPOINTMENT.—Mr. Thomas Bell has been appointed representative by Messrs. Heaton and Co., electrical engineers.

DISSOLUTIONS OF PARTNERSHIP. — The partnership firm of McKinley, King Smith and Co., iron merchants and electrical engineers, of Upper Thames-street, E.C., has been dissolved; as has also the firm of Baker, Hill and Co., electrical engineers, decorators, &c., of Oxford.

LIQUIDATIONS.—A meeting will be held on the 25th instant, at 12 o'clock, at 401 and 402, Mansion House-chambers, Queen Victoria-street, E.C., to receive an account of the winding-up of the Electric Lighting and General Development Syndicate (Limited).

——— In the Chancery Division of the High Court of Justice, Mr. Justice Vaughan Williams on December 4th made an order that the voluntary winding-up of the Herculite and Electrical Manufacturing Company (Limited) be continued, but subject to the supervision of the Court.

——— Mr. W. Izard, 52, Gracechurch-street, E.C., has been appointed trustee in the bankruptcy of Smeaton and Page, electrical and general engineers, 135, Minories, London, E.

——— Notice is given of the release of the trustee (Mr. J. Bowling) in the bankruptcy of Harry Austin and James Myers, lately trading as electrical engineers under the style of Austin and Myers, at Armley, near Leeds.

DISCHARGE.—An application is to be made at the Bankruptcy Court on the 16th inst., at 11:30 a.m., for the discharge of Walter Andreae, lately trading as an electrical engineer at 132, Hurlingham-road, Fulham, and 62, Vauxhall Bridge-road, S.W.

WIRE CONTRACT.—The contract for gutta-percha wire for use by the National Telephone Company for the year 1896 has, we understand, been secured by the United Gutta Percha and Rubber Company (Limited), of Craig Park Works, Townmill-road, Glasgow.

BELTING TABLE.—A useful, and, as far as we have tested it, reliable belting table is issued by Messrs. J. W. Cable and Co., of Clerkenwell-road, E.C. Measurements of belting required to transmit any given horse-power from pulleys of 8in. to 60in. diameter and 90 to 200 revolutions are given, with examples for the use of the table, which are simple.

DIARIES.—Not the least useful annual publication which reaches us is Messrs McCorquodale and Co's "Railway Diary and Official Directory" for 1896, which, besides being a useful size, gives a large quantity of valuable information to those having dealings with the railway companies and their officials in this country. The information is given in a compact form, and there must be many electrical firms to whom it would be useful. The published price is 1s.

CALENDARS, &C.—We have received from the Eastern Telegraph Company copies of their Paper Knife and Calendar for 1896. On the paper knife, as usual, is legibly printed in colours a map showing the routes of the submarine cables of the world.

——— Messrs. Street & Co., the well-known advertising contractors, of Cornhill, E.C., and Serle-street, W.C., send a handsome framed Calendar worked in colours.

——— From the Commercial Cable Company a neatly-printed hanging Calendar is to hand, which, in addition to serving the useful purpose of a day-to-day indicator, contains a quantity of information concerning the Company's offices, &c.

——— From the Direct Spanish Telegraph Company we have received a highly-coloured calendar, of Spanish origin, with a date calendar of the bold and fearless type. Those of our readers interested in flag lore or in heraldry will be especially interested in this calendar.

THE "ENGINEERING MAGAZINE."—The January number of this magazine is now ready, and fully maintains its high standard of excellence, both in the variety of the subjects dealt with and the excellence of its illustrations. The articles in the current issue include :—"Representative Money and Gold Exportations," by Horace White ; "Cripple Creek Gold Mines and the Stock Boom," by T. A. Rickard ; "Future of the American Iron Trade," by J. M. Swank ; "Are American Railway Rates too High?" by H. T. Newcomb ; "An Engineer's Life in the Tropics," by C. P. Yeatman ; "Are we Educating too many Electricians," by H. Floy ; "The Location and Construction of Dams," by J. B. Johnson ; "The Value of Good Architecture in Cities," by Barr Ferree ; "A Piece-Rate System and Shop Management," by F. W. Taylor; and "The Law of Water and Irrigation," by R. J. Hinton. The usual exhaustive review of the World's Press is also given. This number, as well as all the back numbers, may be obtained at the offices of the European edition, 1, 2, and 3, Salisbury-court, Fleet-street, London, E.C. A complete index to the main articles in the magazine from the commencement in April, 1891, is now ready, and will be forwarded post free on request.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—It is important that all entries for the 1896 edition of the well-known Blue Book should be sent in at once to the publisher, 1, 2 and 3, Salisbury-court, London. The book will be published about January 31st, and will contain many new features of interest to the electrical and allied trades, as well as the old features brought up to date. The business changes in January, which will apparently be exceptionally heavy this year, will be fully recorded. This is an important matter, and makes the book of special value. Orders for subscriptions and advertisements should be sent in at once.

ABERDEEN.—The sub-committee recently appointed to consider the question of electric motors have presented their report, and it has been decided to invite some of the principal makers to forward motors of various designs for exhibition in the Corporation's shop in Union-street.

BILSTON.—The new public baths and waterworks are lighted electrically. The installation has been carried out by the Universal Electric Light and Power Company. The electroliers are of a special design, and were manufactured by the Edison-Swan Company.

BRADFORD.—In view of the extension of the Corporation electricity works, the members of the Electricity Sub-Committee are visiting some of the neighbouring electricity supply stations before making any definite recommendation as to the nature and scope of the extensions.

BRADWELL (YORKS.).—Mr. John Hall, a machine smith, has recently installed the electric light in his business premises at Bradwell. He rents from the District Council an overflow from the waterworks reservoir, which gives him sufficient power to work a dynamo of his own construction, from which he derives current for lighting his two shops in Bridge-street.

CANADIAN IMPORT DUTIES ON ELECTRIC BELLS.—The Canadian Comptroller of Customs recently decided that the duty on electric bells imported into the country should be 25 per cent. *ad valorem*.

CANADIAN MICA TRADE.—At a recent meeting of the representatives of the mica-producing firms in the province of Quebec, it was decided to form an association for the purpose of regulating prices. The association purpose also that the selling price of all mica exported be based on the value of mica in Canada governed by grades.

CHURCH LIGHTING.—The Catholic church of St. Joseph's, Banbridge, Ireland, is now lighted electrically, the work having been

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carried out gratuitously by Mr. E. Geoghegan, proprietor and manager of the Banbridge Foundry Company.

COLCHESTER.—At the meeting of the Town Council on Wednesday the special report by the Lighting Committee on the electric lighting question was discussed. The report stated that an important communication had been received from the officer commanding the Royal Engineers in the Eastern District in reference to the lighting of certain military premises. In view of the contents of this letter, the Lighting Committee recommended that steps be taken to put the Colchester Provisional Electric Lighting Order in operation, that they be empowered to instruct their consulting electrical engineer (Mr. W. H. Massey) to prepare plans and specifications for the establishment of electricity works in the town, to make application to the Local Government Board for sanction to borrow the necessary money for the carrying out of the scheme, and also to make provisional arrangements with the War Department for the supply of electric current. A long discussion took place, and the further consideration of the matter was deferred till the 16th instant.

CORK.—It having been stated that a recent fire at the Munster Arcade, Cork, had been caused by the fusing of electric light wires, Messrs. Handley and Shanks, in a letter to the *Cork Constitution*, go into particulars on the subject. The writers point out that owing to the fire inquiries have been made as to the liability to similar outbreak through electric lighting installations, and after pointing out that representatives of fire insurance companies have rules to guide them, which insure almost complete immunity from risk, Messrs. Handley and Shanks give an extract from the table issued officially by the Metropolitan Fire Brigade of the number of fires within the metropolitan area and the causes thereof for the three years 1892-1894, as follows:—Candles 567, gas 833, oil lamps 1,305, electric 9.——The Cork Chamber of Commerce and Shipping have approached the postal authorities with a view to their erecting a trunk line between Cork and Dublin, thus putting the former city in telephonic communication with London. No definite reply to the request has as yet been given, but the Postmaster-General has caused inquiries to be made as to the probable revenue from the suggested line.

COVENTRY.—A circular issued by Mr. G. S. Ram, of the Coventry Municipal Electricity Works, calls special attention to the opportunity which the introduction of the electric light into Coventry offers the owners of factories and workshops to overcome the penalty clauses of the Factory Act so far as they refer to the provision of extra air space during overtime hours. The circular is as follows:—

"The Factory Act, which comes into operation January 1, 1896, prescribes the minimum air space to be allotted to each person employed in a factory or workshop. The Home Secretary may raise this minimum for any period during which artificial light other than electric light is employed for illuminating purposes. The use of the electric light in a factory or workshop thus excludes the operation of any order made by the Home Secretary under the above provision, and enables the same number of persons to be employed during the period of artificial illumination as by daylight."

This is a most important matter for owners who have only limited workshop space, and should lead to many orders for wiring for the electric light where current is readily obtainable. In certain industries (such as the printing trade), in which much overtime is worked at certain seasons, this point will be fully appreciated.

EALING.—The Electric Lighting Committee have just presented a very favourable report on the progress of their electric light undertaking. Applications for 6,436 8 c.p. lamps have been received, and 5,353 have already been connected. Additional machinery, capable of supplying current to 3,000 lamps, is being put down, and the popularity of the installation had been so great that it is difficult to keep pace with the demand.

EDINBURGH.—The Electric Lighting Committee have decided to recommend that the following streets be lighted electrically:—South Clerk-street (at Literary Institute) to Salisbury-place, Waterloo-place to Abbeyhill, Lauriston to Tollcross, Dalry-road from Haymarket to Ardmillan-terrace, Fountainbridge from Freer-street to Viewforth, Greenside to Pilrig, Frederick-street to Comely Bank, Hanover-street to Cannonmills, and Cowgate (from Grassmarket) to St. Mary-street, at a cost of about £2,630.——The National Telephone Company recently suggested that the Corporation should lay underground tubes for telephonic purposes at the Company's expense; but the Sub-Committee to whom the matter was referred recommend that the proposal be not entertained.

ELECTRICITY IN MINING.—An electric lighting installation has recently been carried out in the Brilliant Gold Mine, Queensland, by the Australian branch of the Brush Company.

FACTORY LIGHTING.—Recent contracts carried out by the Banbridge (co. Down) Foundry Company include the premises of the Damolly Linen Weaving Company, the Boyne Weaving Company (Drogheda) and the Hazelbank Weaving Factory (Lawrence Town). For the former installation water power is utilised, and at the Boyne Factory the installation consists of over 1,000 lamps, being one of the largest in Ireland. The Foundry Company are described as manufacturers of their own electrical apparatus.

GLASGOW.—The Glasgow Corporation gas and electric lighting treasurer (Mr. James Fleming) reported to the Sub-Committee on finance on December 26th that the electric lighting rents collected for the year commencing on June 1st, 1895, amounted to £5,389. 8s. 5d., compared with £5,221. 18s. 5d. for the corresponding portion of the financial year 1894-95, an increase of £167. 10s. An interesting series of articles on Glasgow and its tramway system is appearing in the *Glasgow Herald*.

HANLEY.—The parish church at Shelton is being fitted throughout with an installation of incandescent lighting by Mr. Wm. Hodgkinson, of Hanley. The installation will also comprise an electric motor for blowing the organ.——The extensions at the Corporation electricity works are being pushed forward with the utmost rapidity, the engineers hoping to be able to supply double the number of lamps at the end of the present month.

HIGH WYCOMBE.—Some time back the Electric Lighting Committee received certain proposals from Messrs. Pritchetts and Gold for the transfer to them (or to a company to be formed by them) of the High Wycombe Provisional Electric Lighting Order. The suggested terms of transfer were as follows: (*a*) A contract for ten years to be entered into for the lighting of all the present street additional lamps that may be required at the price of £3 per annum per 16 c.p. lamp. Hours of lighting and other conditions to be similar to those in the present contract with the gas company. (*b*) Electric current to be supplied to private customers at the rate of 8d. per unit. The Corporation to undertake to take current at this rate for all municipal buildings and offices. (*c*) The Corporation to have the option of purchasing the undertaking at the expiry of seven years from the date of commencing public lighting on paying a sum equal to the amount expended plus a profit of 15 per cent. If the Council failed to exercise their right of purchase at the end of seven years they would have the further option of purchasing at the expiry of 14 years on similar terms, but with the addition of 10 per cent. profit, and in this case one year's notice of intention to purchase to be given by the Corporation. (*d*) The Council to give an engagement that the machinery and undertaking should be exempt from rating. (*e*) Finally, the Council would have to stipulate that no other company or firm should supply electric current during the continuance of the Provisional Order. The Committee were willing to accept these terms, subject to an approved agreement being entered into and to the following modifications:—(1) The licence to exercise the powers under the Order to be for a term not exceeding 21 years; (2) the stipulation as to rating of machinery to be withdrawn; (3) the contract for public lighting to be for seven instead of ten years, and the price per lamp to include repairs; (4) the firm to defray the cost (£246) of obtaining the Order; and (5) any election to purchase the works by the Corporation to be by six months' notice at any time upon the terms mentioned in the tender. Messrs. Pritchetts and Gold, however, declined to accept these stipulations, but were willing that the Council should have purchasing powers at any time after 14 years on six months' notice, and to accept other modifications by which the contract for public lighting is to be for 14 years, and the cost of obtaining the Order to be refunded by the Corporation in the event of their exercising their purchasing rights. The entire question was discussed at considerable length at the last meeting of the Council, and it was finally decided to refer the further consideration of the matter back to the Committee, with power to arrange the details of the contract.

ISLINGTON.—The Lord Mayor of London will perform the opening ceremony at the electric lighting station in Eden-grove.

LECTURES.—Before what is described as "a fairly good attendance" at the Royal Institution, Hull, on Tuesday, Prof. V. B. Lewis, Professor of Chemistry at the Royal Naval College, lectured on "Flame." The British Gas Light Company had very kindly fitted up the lecture hall with incandescent burners "with all the latest improvements," and Prof. Lewes was good enough to describe "the bright incandescent gas light" as the light of the immediate future. Many of the lecturer's remarks were of a similar harmless and instructive character. A local journal, in its account of the lecture, states that the incandescent gas light is "pronounced by oculists as the best light for the eye, being the nearest approach to daylight." This will probably surprise the Hull folks, who have had some years' experience of the electric light.

NEWCASTLE.—The British Thomson-Houston, Limited, have laid before the City Council an offer to equip and work the Newcastle Tramways electrically, for a sum not exceeding £86,000, or about two-thirds of the estimated cost of the cable system. The scheme will be discussed by the Council at its next meeting. The Company ask the Council to seriously consider the subject before embarking upon a large outlay for cable traction in view of the fact that cable lines in the United States are being in a number of cases replaced by electric systems.——Discussing the rival systems of haulage, Mr. Phillips Dawson delivered a lecture before the Tyneside Geographical Society on Monday, at which Captain

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Noble presided, and a large audience assembled, including many of the town councillors and leading merchants of the town. After an interesting discourse, in which Mr. Dawson pointed out the advantages of electric traction, the lecturer answered a number of questions to the general satisfaction of those present. Figures showing the great advances made by electric over other systems of haulage were also given. A cordial vote of thanks to the lecturer was unanimously agreed to.——In their estimates for 1895-6 the City Lighting Committee have made provision for 24 additional arc lamps for lighting some of the new streets in the Byker and Heaton districts.

NEWMARKET.—The District Council have decided to oppose the application of the Newmarket Electric Light Company's for a Provisional Order.

NEW YEAR'S HONOURS.—Amongst the list of New Year's honours appears the name of Major J. S. Goldie Taubman, Speaker of the House of Keys and Chairman of the Douglas Southern Electric Tramways (Limited), who has been created a knight.

OGWEN (NORTH WALES).—At the last meeting of the District Council it was decided to authorise the Bangor Town Council to include the district in any application they might make to the Board of Trade for a Provisional Electric Lighting Order.

OLDHAM.—In accordance with Prof. Kennedy's recommendations, the Electric Light Committee of the Town Council have instructed their electrical engineer to prepare plans and particulars of extensions to the plant at their electricity station.

PRETORIA (SOUTH AFRICA).—A Reuter's telegram of the 28th ult. states that the Boer Government contract for the establishment of electric lighting in the town which is just issued forbids the use of English-made plant, and provides that only that made on the Continent shall be adopted. In reference to this matter the following letter appeared in the *Standard* of Wednesday over the signature of "One Who Knows":—

"Appearing as it does at the present juncture the statement that the Government of Pretoria has interdicted the use of English plant in its electric lighting might be interpreted as an unfriendly act to England, but in reality it is not so. The electric lighting of Pretoria, under Government management, has been in full operation for more than two years; but the original plant, which was sent from England, proved to be of very inferior quality, and is already worn out. It is natural, therefore, that the Government of Pretoria should get their new plant from some other country."

This statement received prompt denial from the English firm who constructed and erected the plant, who replied as under:—

"The statements are not only incorrect, but very misleading. The plant is in perfect repair and eminently satisfactory, the engineer in charge of the lighting station having recently stated to one of our engineers, who has lately returned from South Africa, that no plant could run more satisfactorily than that under his charge. As regards the underground cables, which have caused some trouble, no blame can be attached to the makers, the only mistake being that a class of cable was chosen unsuited to the peculiar nature of the soil. We do not, therefore, see how the performance of the present plant, which has been running nearly four years, can be said to have given rise to the decision referred to. We do not suggest that any unfriendly act is meant by interdicting English plant, but only suppose that, as in other cases, influence has been brought to bear by some Continental firm in favour of their own plant to the exclusion of others."

It is somewhat surprising that a leading English paper should allow a direct charge of this kind to appear over a *nom de plume*. To be effective such charges should be made with the full measure of responsibility attaching to them.

REDUCTION IN TELEGRAPH RATES.—The Commercial Cable Company announce that, as from the 1st instant, the rates to the following places will be reduced to 1s. 3d. per word:—Burlington, Clinton, Cedar Rapids, Davenport, Dubuque, Fort-Madison, Keokuk, and Muscatine (State of Iowa), Hastings, Redwing, Stillwater, and Wabash (State of Minnesota), Hannibal and Louisiana (State of Missouri).

REDUCTION IN TELEPHONE TRUNK LINE RATES.—The Treasury have sanctioned a reduction in the scale of charges for trunk telephone communication. The new scale, which comes into operation on January 1st, is as under: For 25 miles, 3d.; for 50 miles, 6d.; for 75 miles, 9d.; for 100 miles, 1s. For every additional 40 miles or fraction thereof, 6d.

ROCHDALE.—The Library Committee have decided to recommend the Town Council to light the Free Library by electricity, and to apply to the Local Government Board for sanction to borrow £500 to defray the cost of the installation.

ROTHERHAM.—At the last meeting of the Electric Light and Tramways Committee it was decided to recommend the Town Council to oppose the application of the Sheffield District and Rotherham Tramways Company's Bill for the construction of electric tramways in the district.

SOUTH AFRICA.—An application was recently made to the Town Council of Kingwilliamstown for a ten years' concession to light the town by electricity. The concession was not granted.

SOUTH STAFFORDSHIRE TRAMWAYS.—A further extension, until March 25th next, has been granted by the Board of Trade to the South Staffordshire Tramways Company for working the steam sections of their tramway system. The extension was opposed by the local authorities through whose districts the trams run, and the matter aroused a considerable amount of local interest.

STAPLETON (BRISTOL).—At the meeting of the District Council on Wednesday last it was decided to oppose the application of the Great Western Electric Light and Power Company for a Provisional Order for the district. At the same meeting a letter was read from Mr. D. Travers Burgess, on behalf of the Bristol Electric Lighting Committee, stating that, as the Corporation were proprietors of electricity works within the district, his committee had requested him to inquire whether the Council intended to oppose the application of the Great Western Company, and, if so, as to the nature of such objection. It was decided to reply that the matter was under consideration.

SWANSEA.—The Town Council again discussed the proposed electric lighting, dust destructor and tramway schemes on Monday last. The meeting was called for the purpose of formally empowering the Council to proceed with its Bill in the next session of Parliament. At the commencement of the proceedings a deputation waited upon the Council to urge the postponement of the schemes for at least twelve months. Mr. R. Martin (Chairman of the Tramways Committee) then moved that the Council be empowered to proceed with the Bill, and said that under the scheme the Corporation would in 24 years' time become possessed of its tramways without paying a penny for them. He referred to the Bristol Tramway Company, whose receipts had in short a time increased from £200 to £800 or £1,000 a week as a result of the introduction of electric traction. The tram lines of the town were at present in a sad state, but under the proposed arrangement they would be renewed, and the Company enabled to work them at a profit. By getting the Company as customers for their "day load" they would be enabled to sell electric current for lighting purposes at 3d., and even at this figure the Corporation would still make a profit. Even assuming that they could not obtain sufficient power from refuse destruction, and that they had to burn coal in order to obtain the necessary power, the total cost (including sinking fund) would be only £5,879 a year. 275,000 units at 3d. per unit would amount to £7,503. 16s. 8d., leaving a profit of £1,695 per annum, while with a production of 1,533,000 units per annum they could sell electrical energy profitably at 1d. per unit. Mr. Martin dealt very fully with the arguments in favour of the scheme, and gave it as his opinion that the street lighting would be effected free of cost to the ratepayers and surplus power could be disposed of at 3d. per unit. They had not finally made up their minds as to the dust-destructor scheme. It was absolutely necessary that a new method of disposing of the town refuse should be adopted. This scheme was the best means of destroying the refuse, and whatever power could be obtained from it should be applied to the relief of the rates. The motion was carried by 30 votes to 7.

TELEGRAPHIC COMMUNICATION WITH BUENOS AYRES.—We have received the following communication:—

"Our attention has been called to a pamphlet lately circulated amongst merchants, purporting to give, from certain examples, selected from 26 days out of a whole year, a statement of the average time of transit of cable messages exchanged between London and the city of Buenos Ayres. The time is stated to be—

By the direct route, *via* Lisbon, Madeira and Brazil (about 7,280 miles) ... ... 108 minutes.
By the Galveston route, *via* United States, Mexico, Central America, Peru, Chili and Argentina (about 11,960 miles) ... ... 80 minutes.

The undersigned have had the whole of the messages for all the dates in 1895 given by the pamphlet carefully examined, and find that the average time occupied by the messages sent over the Lisbon-Madeira route was 75min. only, and not 108min., as incorrectly stated by the pamphlet. One statement being found so exceedingly inaccurate, you can form your own opinion as to what reliance can be placed upon the other, which is put forward for purposes that are manifest.

"For the Western and Brazilian Telegraph Company (Limited),
"R. M. CUNNINGHAM, Secretary.

"For the Brazilian Submarine Telegraph Company (Limited),
"RICHARD COLLETT, Secretary."

THEATRE LIGHTING.—The New Grand Opera House, Belfast, is lighted throughout electrically.

THEFT—A driller named Morrison was charged at Bradford with stealing tools, the property of Messrs. Roslin and Matthews. He had been in the prosecutor's employ, but was discharged. Remanded.

TORQUAY.—A meeting of the Electric Lighting Committee was held on Tuesday last for the purpose of selecting a site for an electricity generating station. Several sites were proposed, but the Committee adjourned without coming to a decision. When a site has been selected, the consulting engineer (Mr. W. H. Trentham) is to submit an amended report and estimate of the cost of the Council's suggested electric lighting scheme.

TUNBRIDGE WELLS.—At the last meeting of the Town Council, Councillor Strange, in discussing the Lighting Committee's report, complained of the neglect to light the side streets at night. The electrical engineer (Mr. H. L. P. Boot) explained that the new machinery would soon be ready to meet extensions and the promise

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of a contiuuous supply of current. Sir David Salomons said they must do everything possible to meet local convenience and retain the confidence of the public in the success and advantages of the electric light, and the Committee undertook to remedy defects in the lighting of the side streets as far as possible.

WALSALL.—The local papers express their satisfaction at the success of the electric lighting installation in the town. Full advantage was taken of the Electric Lighting Committee's permission for those connected to use the current one week free of charge, but this generosity will probably prove remunerative in the long run.

WARMLEY.—The District Council have decided to oppose the application of the Great Western Electric Light and Power Company for a Provisional Order for the district.

WHITECHAPEL (LONDON).—The Board of Works recently had a proposal from the Commissioners of Sewers for the erection of four arc lamps on the east side of Middlesex-street (which is within the Whitechapel district), and for supplying current to the same upon condition that the Board pay the cost thereof. The Committee to which this matter was referred recommended that the proposal be not accepted, and this recommendation was agreed to at the last meeting of the Board.

WIDDRINGTON.—The Widdrington Mechanics' Institute is now lighted electrically. Eight 95 c.p. lamps are employed for illuminating the billiard room.

WIMBLEDON.—At the last meeting of the District Council a letter was read from the Local Government Board with reference to the Council's recent application to borrow £32,000 for electric lighting purposes. The letter stated that, in view of the early expiration of the electric lighting licence of 1889, the Board would not sanction the loan for any period longer than the unexpired term of the licence. If, however, the Council were anxious to carry out the scheme by means of borrowed money, the matter would have to stand over until the Council could show that they had obtained new powers. The Chairman and Clerk were appointed to wait upon the Secretary of the Board in reference to the matter.

ANNUAL DINNER.—The employés of Mr. R. W. Paul, of Hatton Garden, E.C., were entertained at the Holborn Restaurant on New Year's Eve, the occasion being the first annual dinner.

NEW COMPANIES, STATUTORY RETURNS, &c.

KAMM'S ZEROGRAPH SYNDICATE (LIMITED).—This Company was registered on December 27th, with a capital of £12,000, in £10 shares, to enter into an agreement with Leo Kamm, inventor and electrician, of Hornsey-rise, London, N., to acquire or take licences for the user of any patents, rights, or privileges for the use, sale or manufacture of any telegraphic apparatus, or any instrument or appliance for the transmission of messages; to carry on any business connected with telegraphy or type writing, and to establish and carry out any system of telegraphy. The first subscribers, with one share each, are: Leo Kamm, inventor and electrician; H. F. Hoveler, S. Reuschel, F.W. von Limburg, C. Hess, H. Hempel, and J. W. T. Cutlan. The first Directors are Leo Kamm and S. Reuschel.

LIGHTNING EXPRESS RAILWAY SYNDICATE (LIMITED).—This Company was registered on December 23rd, with a capital of £100,000, divided into 25,000 £10 per cent. Preference and 75,000 Ordinary shares of £1, to acquire the inventions of Fritz B. Behr, civil engineer, in connection with lightning express or high-speed railways, and in connection with improvements in carriages and electric locomotives for such railways, and the sole and exclusive licence to use the inventions belonging to the Lartigue Railway Construction Company (Limited), for the purpose of building, equipping and working lightning expresses or high-speed railways, and to carry on the business of constructors of railways and tramways of all kinds, and particularly of those with a single rail, on the Lartigue system of construction; railway, mechanical and electrical engineers, and the business of a telegraph, telephone and electric light company in all its branches. The first subscribers are: Leonard Clow, stockbroker; Cecil G. Lindo, solicitor; Lieut.-Col. Sydney F. Foster; Benjamin G. Lake, solicitor; Fritz B. Behr, civil engineer; Arthur J. Sanderson, financier; and Norman S. Russell, civil engineer.

MADEIRA ELECTRIC LIGHTING COMPANY (LIMITED).—This Company was registered on December 23rd with a capital of £20,000, in £1 shares, to carry into effect an agreement between Harris Ullathorne and Arnold Hartley, electrical engineers, of Bradford, and the Company, for the acquisition by the Company of a concession granting the right to supply electric light to the City of Funchal, Madeira, with electricity for lighting, power and other purposes, and to carry on the business of electricians, engineers and contractors, suppliers of electricity, and manufacturers of and dealers in electrical plant, apparatus and materials.

OTIS STEEL COMPANY (LIMITED).—This Company was registered on December 20th with a capital of £450,000, divided into 33,000 Preference shares of £10 each, and 30,000 Ordinary shares of £4 each, to carry into effect an agreement with the Otis Steel Company (Limited), and Alexander Young, its liquidator, to acquire the shares, stock, debentures, debenture stock and other securities of the Otis Steel Company, of Cleveland, Ohio, U.S.A., or any other American company, and to carry on the business of metal manufacturers, workers, founders, forgers and refiners, smelters, &c. The first Directors are: Jeremiah Head, civil engineer, Josiah T. Smith, and J. E. Touch, consulting engineer.

ROAD MOTOR ASSOCIATION (LIMITED).—A Company was registered on December 20th, with a capital of £15,000, in £1 shares, to, amongst other things, carry on business as electricians, mechanical engineers, wire drawers, tube makers, metallurgists, &c.

RAILWAY AUTOMATIC ELECTRIC LIGHT SYNDICATE (LIMITED).—The annual return to October 3rd has only just been filed. The capital is £25,000, in 400 Ordinary and 600 Preference shares of £25 each; 396 of the former and 586 of the latter have been taken up, 200 Ordinary have been issued as fully paid, and the full amount has been called on the remainder.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30½d. per oz. (Jan. 2nd). Consols (2¾ per cent.) 106¼–106⅜ for money, 105⅞–106⅛ for account; 2½ per cent. 102¾–103¼ (Jan. 2nd). Stock Exchange Settling Days: Consols, Jan. 3rd; Stocks and Shares Continuation Day, Jan. 14th; Ticket Day, Jan. 15th; Pay Day, Jan. 16th.

SIR W. G. ARMSTRONG, MITCHELL AND CO. (LIMITED).—At a special meeting of the shareholders of this Company, on Tuesday last, it was unanimously decided to adopt the reconstruction scheme referred to in our last issue, and at the same time to increase the ordinary capital of the Company to £3,000,000. A statutory meeting for the confirmation of this decision will be held on the 15th instant.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended December 29th were £890, against £858 in the corresponding week of 1894, an increase of £32. The total receipts for the half-year amounted to £23,443, against £23,305 for the corresponding period of 1894, an increase of £138.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The warrants for the interest due on this Company's £300,000 5 per cent Debenture stock have been posted.

ELMORE'S WIRE MANUFACTURING COMPANY (LIMITED).—The annual meeting of this Company took place at Leeds on Tuesday last, Mr. J. J. Atkinson presiding. The Chairman explained an arrangement whereby the Company would be enabled to start the new year unencumbered by any old losses. He said the Company's sales had steadily improved since the beginning of the past year, when the sales of copper sheets were only a few tons monthly. Further progress was only stopped by lack of capital; but he stated that in a short time a scheme would be submitted for greatly increasing the Company's resources to meet the demand for high-class and higher-priced articles. It has been decided to issue £7,000 worth of Six per Cent. Debentures, and more than half have been already applied for.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 29th inst. amounted to £941. The amount for the corresponding week last year was £837; increase, £104.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have received telegraphic advice stating that the necessary authorisation for the purchase of the Company's line has been continued by the Brazilian Chamber of Deputies and the Senate, and is again included in the Budget for the coming year. This Company's traffic receipts for the week ended December 27th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,329.

WESTERN UNION TELEGRAPH COMPANY.—This Company have issued their report for the quarter ended December 31, 1895:—The following statement, dated December 11th, exhibits the condition of the Company at the close of the quarter ended September 30, 1895:—

Surplus July 1st, as per last quarterly report.....		$7,447,476 35
Net revenues, quarter ended June 30, 1895.....		1,842,648 96
		$9,290,125 31
From which deducting for—		
Dividend of 1¼ per cent. paid October 15	$1,191,945 00	
Interest on bonded debt	223,557 32	
Sinking funds	20,000 00	
	$1,435,502 32	
Left a surplus October 1st, ...		$7,854,622 99
The net revenues of the quarter ended December 31st, based upon nearly completed returns for October, partial returns for November, and estimating the business for September, would be about.....		1,700,000 00
		$9,554,622 99
From which appropriating for—		
Interest on bonds	$223,550 00	
Sinking funds	20,000 00	
		243,500 00
		$9,311,072 99
It requires for a dividend of 1¼ per cent. on capital stock issued, about		1,191,945 00
Deducting which leaves a surplus, after paying dividend, of		$8,119,127 99

In view of the preceding statements, the Committee recommend that a dividend of 1¼ per cent. on the capital stock of this Company be declared payable on and after the 15th instant.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Dec. 28.	Price Tuesday, Dec 31.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Dec. 28. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	10/0	Anglo-American	42 44	41 43	5 4 8	Jan., Apr., July, Oct.	41	..
£2,993,560	Stock	20/0	Do. Preferred	79 81	79 81	5 11 1	" "	81½	79½
£2,993,560	Stock	5/0	Do. Deferred	5⅞ 6⅛	6 6⅛	.. ..	.. ..	..	..
£178,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	101 105	101 105	3 17 8	January and July	..	..
180,000	£10	3/0	Brazilian Submarine	12⅝ 13⅛	13⅛ 13⅜	5 9 1	Mar., June, Oct., Dec.	13⅛	11⅞
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906) ..xd	111 115	110 114	4 7 9	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	160 170	160 170	4 2 4	Jan., Apr., July, Oct.	..	..
16,000	10	3/0	Cuba Submarine	13 14	13 14	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 13 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	3⅝ 4⅛	3½ 4⅛	4 8 11	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each ..xd	104⅞ 107⅞	102⅞ 105⅞	4 5 9	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	7⅞ 8⅛	8 8⅛	4 14 2	Jan., Apr., July, Oct.	8⅛	..
400,000	10	2/6	Eastern	16 16⅛	16 16⅛	3 18 9	" "	16⅜	16⅛
70,000	10	6%	Do. 6 per Cent. Preference	17⅛ 18	17⅛ 18	3 6 8	" "	17⅛	17⅛
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	125 128	125 128	3 2 11	May and November	..	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 13 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17 17⅛	17 17⅛	4 0 0	Jan., Apr., July, Oct.	17⅛	17⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	127 130	127 30	3 10 1	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	102 106	102 106	4 16 7	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	102 106	102 106	4 16 7	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	108 111	108 111	3 13 3	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 115%	3 10 0	May and November	..	..
180,227	10	1/8	Globe Telegraph and Trust	9½ 10	9½ 10	4 5 0	Jan., Apr., July, Oct.	9⅝	9½
180,042	10	6%	Do. 6 per Cent. Preference	16½ 17	16½ 17	3 10 7	" "	16⅝	16½
150,000	10	5/0	Great Northern	21⅝ 22½	21⅝ 22½	3 16 5	Jan., April, and July	22½	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1888 issue	104 107	104 107	4 14 7	March & September	..	..
17,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	..	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	.. ..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 110	106 110	5 11 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	109 112	108 111	3 12 1	.. ..	..	..
11,839	8	4/0	Reuter's	4 5	4 5	.. ..	April and October	..	..
3,381	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	127 132	127 132	4 10 11	" "	..	..
15,609	10	2/0	West African Telegraph	5⅛ 6⅛	5⅛ 6⅛	.. ..	January and July	..	..
£238,300	100	5%	* Do. 5 per Cent. Debentures (red.)	102 105	102 105	4 16 10	March & September	..	..
80,000	10	2/0	West Coast of America	1 2	1 2	.. ..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902 ..xd	98 103	94 99	8 1 7	June and December	..	..
88,321	10	1/8	West India and Panama	⅜ 1⅛	⅜ 1⅛	.. ..	..	1	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10⅛	10⅛ 10⅜	5 11 7	May and November	10 1/16	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8⅛ 9⅛	8⅛ 9⅛	6 6 4	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.) ..xd	111 114	103 112	4 9 3	June and December	..	..
64,242	15	3/9	Western and Brazilian	9 9⅜	9 9⅛	5 2 9	May and November	..	..
33,129	7½	3/9	Do. 5 per Cent. Cumulative Preferred	6½ 6⅝	6½ 6⅝	.. ..	..	..	..
33,129	7½	1/6	Do. 5 per Cent. Deferred	2⅜ 3⅛	2⅜ 3⅛	.. ..	..	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 14 10	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	108 107	103 107	5 14 10	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	113 118	113 118	5 13 8	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100 103	100 103	5 18 10	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	8½ 8⅝	8½ 8⅝	.. ..	..	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16 1/16	1/16 1/16	.. ..	May and November	..	..
171,504	£1	8·415	Oriental Telephone and Electric (fully paid)	1/16 1/16	1/16 1/16	.. ..	Yearly	..	..
484,597	5	2/6	National	5¼ 6⅛	5¼ 6⅛	4 1 8	June and December	6⅛	5⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	17⅛	15 1/16
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15⅛ 16⅛	15⅛ 16⅛	3 12 9	" "	..	..
119,284	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅛ 6⅛	6⅛ 6⅛	3 16 11	..	6⅛	..
1,100,000	Stock	8½%	* Do. Debenture Stock, 4½% (red.) xd	106 108	105 107	8 5 5	January and July	..	..
58,000	5	3/0	United River Plate	2⅛ 3	2⅛ 3	.. ..	" "	..	..
£146,783	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.) ..xd	92 97	90 95	5 5 3	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12⅜ 13⅛	12⅛ 13⅛	1 17 9	..	13⅛	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15¼ 16	15⅛ 16	3 15 0	..	15 1/16	..
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.) xd	132 136	131 135	3 14 1	June and December	135	..
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	.. ..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5⅛ 5⅜	5⅛ 5⅜	.. ..	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	.. ..	..	..	..
8,322	£5	..	House-to-House Electric	.. ..	.. ..	.. ..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	.. ..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	.. ..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅜ 8⅛	7⅜ 8⅛	.. ..	..	..	..
111,000	5	..	London Electric Supply	.. ..	.. ..	.. ..	..	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	10 11	10 11	2 0 11	..	..	..
150,000	Stock	4½%	* Do. 4½% Debs. xd	117 120	115 118	3 16 3	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9	8½ 9	.. ..	..	..	..
..	..	..	Rand Electric	.. ..	½ ½ prem	.. ..	..	..	..
19,980	£5	2/0	St. James and Pall Mall	8⅛ 8⅜	8⅛ 8⅜	.. ..	..	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	9 9⅛	9 9⅛	3 13 8	..	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8⅛ 8⅜	8⅛ 8⅜	3 2 10	..	8⅜	8 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1⅛ 1⅜	1⅛ 1⅜	10 17 4	..	..	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅞ 2⅛	1⅞ 2⅛	5 12 11	..	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 19 4	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2 2½	2 2½	.. ..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1⅞ 2⅛	1⅞ 2	.. ..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock xd	104 107	104 107	4 4 1	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	.. ..	..	..	..
110,000	2	..	Electric Construction	⅝ ¾	⅝ ¾	.. ..	..	..	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 11 0	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	¾ ⅞	¾ ⅞	.. ..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¾ ⅞	¾ ⅞	.. ..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	18 19	18 19	3 18 11	February & August	18	..
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101 103	101 103	4 8 8	March & September	..	..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	.. ..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	.. ..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	.. ⅜	.. ⅜	.. ..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	39 41	41 43	4 3 9	March and July	40½	..
£150,000	100	5%	* Do. 5 per Cent. Bonds	104 107	104 107	4 15 8	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	.. ..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	.. ..	..	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	13½ 14½	13½ 14½	4 2 9	..	..	..
£30,000	10	7/0	Do. 7 per Cent. Preference	15½ 16½	15½ 16½	4 4 0	..	16⅝	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108 111	108 111	4 2 2	..	111	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway	40 43	40 42	2 16 6	May and November	..	..
7,650	10	5%	Do. 5% Perpetual Preference	14½ 15½	14⅜ 15¼	3 5 7	..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130 132	128 130	3 1 11	May and November	..	..
37,500	£10	2½%	Liverpool Overhead Railway	11½ 11¾	11½ 11¾	1 18 4	..	..	..
10,000	10	5%	Do. 5% Preference	15½ 15⅝	15⅜ 15⅝	3 3 6	..	..	..
145,000	Stock	4%	Do. 4% Debenture	112 114	114 116	3 9 0	January and July	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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NOTES.

THE concise compendium of the law relating to the auditing of companies' accounts, which Mr. SYDNEY MORSE has been good enough to throw into the form of a circular-letter to the electrical Press, is an illustration of the complicated tangle into which the law on a very simple matter is allowed to drift in this country. Instead of dealing once and for all with the important subject of auditing in a single clause in a general Act, the law of audit has to be dug out of half-a-dozen different Acts passed in as many different years. It will be news to most of our readers that an audit is not made obligatory by Act of Parliament in the case of ordinary limited liability concerns; and equally surprising are the wide powers given to auditors under the Metropolis Water Act of 1871. There can be no doubt, after the recent pronouncement by the Board of Trade and Mr. MORSE's clear statement, that the Board of Trade audit has a different object in view to the assumed object of the shareholders' audit. That is in itself, however, no reason why, under a sensible dispensation, a company carrying on such a comparatively simple business as electricity supply should be saddled with the expense and trouble of a double audit.

THE invention of a new name is most meritorious when the new-born name covers an area of thought which can only otherwise be expressed by a cumbersome phrase, and the meritoriousness of the deed is the greater the more frequently the expression has to be used. In any case it is a purer and more dignified process, provided the laws of philology are not violated, than the contraction of the phrase itself into a series of initials, such as E.M.F. or R.M.S. Prof. FLEMING's article this week, on "The Form Factor of Alternating Current Curves," affords instances of both methods. In the term "form factor" which he uses, we have a convenient expression for a ratio, the importance of which in matters relating to alternating current machinery is on the increase. Arising out of a dispute in regard to the value of a sine wave of electromotive force or current in an alternator, there has recently been conducted in all parts of the world a large amount of research on the advantages and disadvantages of different wave forms, and it will be found convenient to have a name such a "form factor," by which an important characteristic of the wave shape may be specified. Dr. FLEMING is inclined to think that the hysteresis loss in a transformer will be constant for different waves having identical "form factors." It is not quite evident that this would be the case. We should have thought that the superposition of one or more rapid harmonics upon the main wave, for example, might considerably affect the hysteresis without causing any change in the ratio of the root-mean-square value to the true-mean value.

IN his article on "Electric Tramways and Telephonic Disturbances" in the current issue, Dr. DU RICHE PRELLER sums up strongly in favour of the "bar" or "shoe" contact for electric traction purposes. It must be admitted that Dr. PRELLER's experience has been such as to lead any impartially-minded individual to condemn the "trolley" wherever telephonic disturbances are to be feared. From the æsthetic point of view the demerits of the "bar" and "trolley" methods are about equal, the former involves the uglier car, the latter the uglier overhead construction.

A SENSATIONALLY-WORDED story has come to hand from Vienna, *viâ* the columns of last Wednesday's *Standard*. It seems that Prof. RÖNTGEN, of Würzburg University, while experimenting with some cloth-screened vacuum tubes in a dark room, in which some sensitised paper happened to be lying about, found that the paper became acted upon by electromagnetic waves. Further investigation enabled Prof. RÖNTGEN to obtain a "photograph of a human hand, showing only the bones and the rings on the fingers," the hand being laid upon a wooden case containing photographic paper, so as to intercept the passage of the rays. The whole phenomenon seems likely to admit of ready explanation, when the conditions of the experiments are more fully published. We cannot, however, agree with the newspapers in regarding this discovery as "a revolution in photography"; there are very few persons who would care to sit for a portrait which would show "only the bones and the rings on the fingers."

A FATAL boiler explosion some time ago, at a station of the Philadelphia Edison Electric Light Company, has led to an inquiry which throws an interesting light upon the boiler practice at that station. The particular steam generator which blew off one of its headers, fracturing the bolts without the least contraction at the fracture, was of the Root type, a well-known form of water-tube boiler. The absence of the

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usual stretching and contraction of section of the bolts before the explosion led to a suspicion of crystalline structure; but this charge on the part of the electric light company was rebutted by the manufacturers, who showed that the fragments of the bolts were normally malleable and free from brittleness due to crystallisation. How, then, to account for the extraordinary mode of fracture was the problem; but the manufacturers were successful in solving it, and in doing so they turned the tables upon their adversaries. The explosion was due to nothing else than "water hammer," brought about by forcing the boilers beyond their rated capacity some 100 per cent. The manufacturers regarded this practice as "unreasonable handling," showed that "the employés had instructions to keep steam up to the required pressure, irrespective of any demands that might be made on the boilers," and acoused the electric light company of using a forced draught of three or four inches of water when forcing the boilers, as alleged.

PROBABLY most electrical engineers will disagree with the manufacturers of this Root boiler, in believing it to be a sin to keep up the pressure whatever the load. Surely it is a greater error to instal a boiler plant of such a character that to keep up the pressure under a heavy load is either impossible or dangerous. What, too, is to be thought of the design and rating of a boiler plant, in which a draught of four inches is required to force the boiler only 100 per cent.? Lancashire and similar boilers are much more readily forced to this extent, and will work satisfactorily at this rate for a considerable time and without any risk of explosion from "water hammer." It is indeed one of the defects of certain water-tube boilers that they cannot be forced to any considerable extent without the continuity of the circulation breaking down, the tubes becoming filled with steam, often with disastrous results.

WE are often reproached by our implacable friends across the Atlantic for the painfully slow way in which we English are admitting the trolley within our borders. An article on "Track and Overhead Department Economics," in a recent issue of the *Street Railway Review* of Chicago, affords, however, some much-needed consolation to us. Says the author in his opening flourish:—"The alleged 'mistakes of Moses' were few compared to those which have been made in track and overhead construction during the brief period which has elapsed since the advent of the trolley; and the alleged 'wealth of Crœsus' dwindles into insignificance when compared to the vast sums which have been expended in trying to rectify those mistakes." Well, we in England cannot afford to make the "alleged mistakes of Moses," nor do we care to dissipate the "alleged wealth of Crœsus," so long as it is our own wealth; perhaps if it were mostly borrowed from American capitalists we should not mind so very much.

Ayr.—The Ayr central station was formally opened by Lord Kelvin on Wednesday.

Electric Lighting in Government Workshops.—Orders have been given for lighting the workshops in Portsmouth Dockyard throughout by electricity.

Exhibition in Turin in 1898.—A large exhibition is to be held at Turin in 1898, and the Committee of the Electrical Section has just decided that that section shall partake of an international character.

Electric Supply Station Map.—We publish this week a coloured map showing the towns in the United Kingdom possessing the boon of the electric light, and the system and and ownership of each central station.

Cable Interruptions and Repairs:—

	Date of Interruptions.	Date of Repairs.
Aden—Zanzibar	December 24, 1895 ...	January 4, 1896
Puerto Plata—Martinique ...	December 19, 1895 ...	—
Perim—Obock	January 2, 1896 ...	—

House-to-House Oil Mains.—A company is being formed in Lincoln, U.S.A., for the purpose of supplying kerosene through pipes for domestic lighting and other uses. The *Electrical Engineer* of New York calls this "the new process which will render explosions or fires cheap and easy."

Interurban Electric Traction in Germany.—The construction of an electric tramway between Halle and Leipzig (21 miles) is contemplated. Work is about to be commenced on the construction of an electric tramway between Eisenach and Marienthal, the necessary permission having been secured.

A Big Gas Engine and Dynamo Set.—The largest gas engine in Germany, direct-coupled to a dynamo, is now being used in the Lübeck Exhibition for, as the *Gas World* puts it with unconscious humour, "the production of the necessary electric current" for lighting purposes. The engine is rated at 200 H.P., and it is of the Körting type.

A Wide-reaching Patent.—Mr. J. Swinburne, says *l'Electricien*, has just applied for a patent with the following comprehensive ambit: "Improvements connected with electric telegraphs, organs, condensers, deposition of nickel and cobalt, and with packing eggs and other fragile articles, and coating eyelets and such objects, and making bleaching powder."

Appointment.—Mr. Alfred Hay, B Sc., recently demonstrator in electrical engineering at University College, Nottingham, has been appointed as lecturer on electrotechnics at University College, Liverpool, *vice* Mr. F. G. Baily, who has gone to Heriot-Watt College, Edinburgh, as successor to Dr. Mullineux Walmsley. Mr. Hay was in the Faraday Electrical Works (Glasgow) for three years and studied physics under Prof. Tait with distinction, taking first prize in advanced class.

An Electrical Disturbance at Huddersfield.—"There was a rather alarming display of electrical energy at the bottom of Cloth Hall-street, New-street, Huddersfield, on Saturday morning," says the *Bradford Observer*. "Horses passing over the crossing were visibly affected by electric shocks owing to an escape of electricity from the Corporation mains. The charged spot was fenced round, and men were set to work to stop the leakage. Nobody was hurt."

Death from Electric Shock.—At the Eichdorf-Grünberg power transmission plant in Silesia a workman, while trying to do some repairs to a pole carrying the bare conductors, touched one of them with his head and received a 10,000-volt shock. He fell to the ground and died immediately. He had taken up his position on an insulator of the telephone circuit immediately below the power circuit, and was in the act of tying himself to the post. There were burns on his neck and feet marking the entrance and exit of the current.

Electric Traction in America.—About the middle of last month a new Sprague Electric Railway Company was incorporated in the United States, with a capital of £200,000, for the purpose of taking up the problem of electric traction as applied to such systems as the New York Elevated Railways. The new Company is, we believe, under the management of Mr. F. J. Sprague. Interest is being expressed in electrical circles in America in this new venture, and speculation is being made in regard to the type of railway system which Mr. Sprague will adopt. The *Electrical Engineer* of New York, in a leading article on the subject, observes that in the past Mr. Sprague has favoured "the unit motor car as opposed to the train locomotive."

Military Telegraphy.—A *Times* correspondent, in the course of an account of the organisation of the Hungarian cavalry,

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states that each regiment has a telegraph patrol, consisting of two non-commissioned officers who have undergone a six months' special course of training and of two privates as artificers, forming part of its staff. They carry wire for some eight miles of telegraph and telephone communication, as well as various appliances for re-establishing or for destroying telegraphs and for tapping existing wires. Besides these, each cavalry division would be accompanied on active service by a telegraph detachment, with six four-horse waggons, supplying materials and wire for 20 miles of telegraph and telephone.

English Apathy towards the Polyphase System.—So far as power transmission is concerned, says the *Electrical Engineer* of New York, "the dearth of water powers in England may, perhaps, largely account for the neglect of the polyphase current, at least in its relation to long distance transmission, but aside from this we notice an unmistakable tendency among English electrical engineers to the stretching of the continuous current to its ultimate limit for distribution. Perhaps Lord Kelvin's undisguised antipathy for the alternating current may also have its influence here. But that the polyphase current has come to stay and to grow in usefulness no one who follows the signs of the times will, we think, be prepared to deny, even in England."

Ventilation for Telephone Exchanges.—*Nature* states that an ingenious system of purifying atmosphere and regulating temperature is in operation for the switchboard room of the Chicago Telephone Company, where dust formerly interfered seriously with the connections on the switchboard. The air for the room is forced through a chamber, where it is thoroughly sprayed, then passed through rapidly-rotating spiral coils, which strip it of superfluous moisture, and afterwards through a chamber kept at nearly uniform temperature by the use of ice or heating apparatus, as may be required. Access to the switchboard room is through an ante-chamber, and the temperature of the room itself shows a variation of not more than 2deg. in a month.

The Laval Steam Turbine in America.—It is stated that in a few weeks the Edison Electric Illuminating Company of New York will have in operation at one of their stations two 300 H.P. De Laval steam turbines with attached dynamos. These turbines were built by the Maison Breguet, Paris, and are now on their way to America. They were ordered under guarantee to comply with the following specifications: Each 300 H.P. turbine is to drive two Desroziers dynamos, each of 133 H.P. capacity. The turbine shaft is to run at 13,000 revolutions, driving at a speed of 1,300 revolutions, by means of helical gearing, two dynamo shafts situated on either side of the turbine shaft. Each dynamo is to be capable of generating continuously without undue heating 770 amperes at 130 volts, or 625 amperes at 160 volts.

Electric Tramway for the Berlin Exhibition 1896.—The details of this tramway are now settled, and the line is to be on the circular system, about 2·5 miles long, and will connect all the principal points of the Exhibition. There will be 10 stations. The line will be standard gauge, and overhead conductors will be employed. There will be always on the line 18 trains of two cars each, running at a speed of nine miles an hour, with an interval of 1½ minutes. The fare will be uniform at 1½d. any distance. The cars will be partly of the open and partly of the closed type, and similar to street cars, but more comfortably fitted. Each train of two cars can carry 90 passengers. The line will run along the footpath of the Exhibition, but will be fenced off for the safety of the public. At crossings the line will be bridged over. Naglo Bros., of Berlin, are the contractors.

Electrically Operated Gatling Gun in America.—The Naval Rapid Fire Gun Board has submitted to the chief of the Bureau of Ordnance a report on the trial of an improved Gatling gun. A novel electrical attachment is used with the gun, which permits of about 1,800 shots a minute being fired. The motor is attached to the breech of the gun-casing by an interrupted screw. The electric current is regulated by a switch, and the connection with the firing mechanism made and broken by a push-button held in the gunner's hand. The weight of the motor and casing is 106lb; the length, 21⅜in. The additional length of the gun when the motor is attached is 20in. The projection of the central shaft from the breech when the motor is unshipped is $2\frac{7}{16}$in. The Board says, according to the *Western Electrician* of Chicago, that several hundred shots were fired, the only interruption being due to temporary jams in the gun or feed strips, and that the action of the motor was smooth and regular throughout.

Accumulator Cars at Hanover.—Frequent mention has been made of late of these cars in connection with accumulator traction, but the fact of the matter is that the cars are really worked on a combination system—that is to say, they run on the overhead trolley system while outside Hanover, during which time the accumulators are charged *in situ* on the car, and run by accumulators only when in the centre of the town. The length of trolley line is about ten miles and of ordinary line for accumulator traction about five miles. So far, 32 cars have been equipped with accumulators, but this figure will have increased to 62 by the spring. The accumulators of each car weigh 2½ tons, and the car complete, but without passengers, 7½ tons. The cells are of the Hagen Company's type, the positive plates of which are not pasted. The Tramway Company, so far, has not taken any risk with regard to the cells, but is paying £80 per car per year to the Hagen Accumulator Company for working and maintenance.

Proposed New Anglo-German Cable.—Owing to increased traffic the existing telegraph lines between England and Germany have proved insufficient for some time past, and especially so during certain hours of the day. Experiments have been made on the circuit between London and Emden and on the circuit between London and Hamburg with the Hughes duplex, which has already been tried on shorter cables in this country, with the view of ascertaining whether this system would meet requirements. The first results on the London-Emden circuit were very encouraging, but later on it was found impossible to obtain satisfactory working even though the most skilled operators were employed. Further experiments gave the same results, and the failure was put down to the varying electrical conditions of the Anglo-German circuits which they are subject to, since they are connected to considerable lengths of iron overhead line. It is therefore intended, says the *Elektrotechnische Zeitschrift*, to meet the increased traffic by laying a new cable and erecting copper wires.

Farewell Dinner to Mr. A. P. Trotter.—On Monday evening last Mr. Trotter was entertained at a farewell dinner at the Whitehall Club, and was presented with a gold watch as a small memento of his many electrical friends in the Mother Country. Dr. John Hopkinson was in the chair, and amongst those present were Mr. Preece, Mr. Crompton, Prof. Hughes, Prof. Forbes, Mr. F. H. Webb, Mr. R. P. Sellon, Mr. Garcke, Prof. Grylls Adams, Mr. Mordey, Mr. Swinburne, Mr. Beaumont, Mr. A. E. Mavor, Mr. L. W. Holmes, Mr. H. E. Harrison, Mr. Rawortb, Mr. Bertram Blount, Mr. Henry Edmunds, Mr. Campbell-Swinton, Mr. R. S. Erskine, Mr. G. L. Addenbrooke, and Mr. A. H. Preece. Expressions of regret at inability to attend were also received from Sir Thomas Blomefield, Sir Frederick Bramwell, Lord Kelvin, Prof. Ayrton, Prof. Kennedy, Major Cardew, Major-General Webber and Sir David Salomons and some twenty other gentlemen. "Success to Mr. Trotter" was proposed by the Chairman, and "Electrical Engineering in South Africa" by Mr. Crompton. Other toasts and speeches followed. Mr. Trotter sails for the Cape tomorrow in the Union liner s.s. "Gaul."

Calcium Carbide.—At the annual meeting of the German Electro-Chemical Society, says the *Engineer*, Dr. Borchers exhibited an apparatus by which he not only succeeded, nearly ten years ago, in preparing calcium carbide, but also showed that all the oxides which were regarded as irreducible could easily be reduced by the action of carbon. It consists of a small chamber or furnace of fire-brick, through the walls of which pass thick carbon rods 40mm. in diameter. Inside the chamber these are connected by a thinner carbon rod, 4mm. in diameter and 40mm. long. The furnace is fed with a mixture of lime and carbon. The action is not electrolytic, the effect of the current being simply to heat the lime to a temperature at which it is reduced by the carbon. An electromotive force

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of 12 volts and a current of 90 amperes is used. The current may be either direct or alternating, and by diminishing the length of the thinner rod calcium carbide can be produced with an electromotive force of only 1 volt, so that electrolysis is out of the question. It was at first thought that alcohol and potassium cyanide might be manufactured cheaply from calcium carbide, but at present there seems little likelihood of these expectations being realised.

"Terrestrial Magnetism."—A new periodical, entitled *Terrestrial Magnetism*, will appear in America this month. It is an international quarterly journal, to be published under the auspices of the Ryerson Physical Laboratory, University of Chicago, and edited by Dr. L. A. Bauer, with the co-operation of numerous workers in terrestrial physics in many parts of the world. The journal, says *Nature*, will be devoted exclusively to terrestrial magnetism and its allied subjects, such as earth currents, auroras, atmospheric electricity, &c. The magnetic needle has become such a promising instrument of research, not only in terrestrial but also in cosmical physics, that the journal which is to be devoted to phenomena connected with it will appeal to a large class of investigators. To quote from the circular heralding the new publication: "No other mechanical means is so surely and so completely recording the physical history of terrestrial and cosmical changes as the self-registering magnetographs of our magnetic observatories, whereby the fitful tremors of the delicately-suspended magnetic needle are being indelibly fixed on the sensitised sheet. On that paper, as Maxwell eloquently expressed it, the never-resting heart of the earth is now tracing in telegraphic symbols, which will one day be interpreted, a record of its pulsations and its flutterings, as well as of that slow but mighty working [the secular variation] which warns us that we must not suppose that the inner history of our planet is ended."

An Electrically Driven Shear.—Ordinarily speaking, the work of driving a ponderous shear is least adapted to the electric motor, as, from the nature of things, the forces which must be applied are not such as can economically be developed directly by the motor. By the aid of a heavy fly wheel and intermediate gearing, however, the difficulty may be overcome. As an example, we may cite the large shear just built for an American steel works in Illinois, where, since all the other plants are electrically driven, it became necessary to drive the shears in similar manner. The motor, according to the *Iron Age*, is a slow speed, steel frame, constant speed machine. The armature makes but 500 revolutions per minute, and is controlled by an extra heavy rheostat that will admit of starting the motor very slowly. This is a very important feature, because the inertia of the flywheel, gear wheel and lever of the shear require great power to start them. The shear itself is the heaviest of its kind, weighing, with the motor, over 90,000 pounds, and is calculated to exert a pressure of 900 tons at the centre of the knives. It has capacity to cut 4½in. square soft steel billets, and as large a section of rounds as is now used in railroad axles. The knives are 18in. long and may be extended to 24in.; are 7in. deep and 2½in. thick. The bed is massive and intended to absorb the great shocks due to heavy cutting. It alone weighs 44,000lb. The cutting edge of the knives is exactly central between the housings, thus throwing an equal strain on both housings. The lever is 14in. through the knife seat, to insure great strength sideways, to resist the cross strain when the knives are dull.

Electric Fuse-Train.—"To Edwin Gomez, of New York," says *Electricity* of New York, "belongs the credit of being the first inventor to enter the electrical field with death-dealing devices, which may be used in sinking English ironclads or in the more peaceful art of blasting rocks. The invention of Mr. Gomez is called the "Electric Fuse Train," and its object "is to effectually retain the force of exploding gunpowder, so that none of it is lost, but simply directing its force to any desired point." The circular announcing this discovery to a war-talking world does not give a detailed description of the invention, but states that the Electric Fuse Train "burns with a sudden and an irresistible flash, the flame and explosion travelling with so great a velocity that it can never be put out by the pressure of water when submerged; and when the flame reaches the torpedo, shell, mine, &c., the coil of fuse train, flashing off, fills the powder-chamber instantly with an intensely hot, confined flame that penetrates the powder and causes every grain to explode at the same instant." By employing this apparatus in igniting gunpowder or other explosives, "an entire revolution may be produced" and "results never before attained may be accomplished, because all the grains of powder are fired at the same time, in consequence of the fuse train being coiled all through the powder, and producing a sufficient flash to penetrate and fill the spaces between the grains of powder in every portion of the powder-chamber. This fuse train is perfectly reliable and excels every other means of communicating fire to one or more charges of powder, torpedoes, shells, mines, blasts, &c., either near together or distant from each other—one line of the fuse train only being required for any number of explosions."

The Leeds Electric Traction Proposals.—At the last meeting of the Leeds Tramways Committee, the members were informed that the report of Dr. Hopkinson upon the experiment in electric traction proposed to be tried in the city had arrived. It will be remembered that at a meeting of the last Highways Committee on October 31st it was resolved "that the necessary steps be taken for the extension of the Roundhay tramway to the Canal Gardens at the Park; that the overhead electric traction system be continued from the junction of the Roundhay tramway at Sheepscar along North-street and Briggate; that in Boar-lane, from Briggate to the Yorkshire Banking Company's premises, an installation of the conduit system be laid; that the overhead system be then continued along Wellington-street and Kirkstall-road to Kirkstall Abbey, and that central poles be used wherever practicable." They also decided to engage Dr. John Hopkinson to advise them as to how best this experiment could be carried out. Dr. Hopkinson informs the Committee that the experiment they suggest is quite practicable, and that if a conduit system is desired in Boar-lane, it could be worked in conjunction with the overhead electric wires in Briggate and Wellington-street. He points out, however, that the cars would have to stop at the junction of the overhead system with the electric conduit in order to alter connections. He suggests to the Committee that this could be avoided if they were to adopt, in place of the electrical conduit system, a system similar to the Westinghouse Electric Company's working model tramway at Westminster. As to a question submitted to him as to whether the refuse destructors might be utilised with advantage for generating the electricity required, Dr. Hopkinson advises not, and recommends that all the power required should be obtained from a central electrical generating station. The Committee decided to visit Westminster for the purpose of inspecting the working of the Westinghouse system. The Committee expect to be able to lay a definite scheme before the Council at its next meeting early in February.

Contemporary Electrical Science.—In the *Acta* of Lund University, Nils Grane described a novel method to determine the temperature at which iron becomes non-magnetic. An iron wire is held by an electro-magnet and heated by a current traversing it until it falls off. The temperature is then found by catching it in a calorimeter. He found, naturally, that under the conditions of the test the temperature at which the change takes place is not constant. It increases with the strength of the magnet, varying between 735°C. and 831°C. For nickel the figures are 368°C. and 481°C.—Another interesting Paper, abstracted, like the last, in *Wiedemann's Beiblätter*, No. 11, is due to F. Sauter, of Ulm, and deals with globular lightning. After considering a large number of authenticated cases of this rare form of lightning, he comes to the conclusion that these globes are masses of incandescent gas, which move slowly and often exist for several minutes. They sometimes disappear silently, sometimes with strong detonation and mechanical destruction, accompanied by electric shocks. The reproduction of such phenomena in the laboratory has not up to the present been successfully accomplished, although Planté and von Lepel managed to obtain small globules conveying the discharge between two plates covered with moist tissue paper.

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REVIEWS.

Traité Theoretique et Pratique des Moteurs à Gaz et à Pétrole. Tome II. Par Dr. Aimé Witz. (Paris: E. Bernard et Cie. 1895).

The increasing importance which is being attached to the gas engine by electrical engineers should bring into prominence before the electrical profession the able and valuable researches of Dr. Aimé Witz, whose work on subjects connected with the efficiency and economy of gas motors has done much to throw light upon the complex and recondite aspect of these matters. It is to Dr. Witz that we owe, among other things, much of our information regarding the influence of piston speed on the rate of explosion of the gaseous charge in a gas engine; and, upon the extensive and careful series of experiments in this direction which he undertook, he has founded an ingenious—if debatable—theory of the influence of the cylinder walls in delaying the point of maximum pressure, and in modifying the subsequent conditions of pressure throughout the stroke.

But the work before us is something more than an account of Dr. Witz's researches; it is a comprehensive treatise upon the theoretical and practical aspects of gas motors at the present time. With not quite unmixed feelings of pleasure we have to confess that it is far less of a catalogue and far more of a scientific treatise than any corresponding work in the English language. Perhaps we ought to have stated at the outset that this is an extension of the author's original work "Traité des Moteurs à Gaz," which, after the publication of the third edition in 1892, was found not to cover a rapidly-extending subject. Hence the publication of the present work, which embodies the former one and includes much more besides. In addition to the ordinary text, of which there are some 414 pages in nine chapters, one of which is exclusively devoted to petroleum engines, there are four large folding plates, upon which are depicted scale drawings of some modern types of engine. These, together with the numerous illustrations in the text, are usefully selected and well executed.

The chapter on gaseous fuels deals amply with its subject, but suffers—from an international point of view—from the use of H in place of H_2 in the chemical discussions. It is regrettable that some international code of chemical symbols, with their quantitative significances, cannot be agreed upon and be adhered to by every author. This chapter is divided into four sections. The first treats of ordinary town gas, or lighting gas. It would be well if makers and users of gas engines, and those who advertise their performances, were always to take into account Dr. Witz's warning, that town gas not only varies from works to works, but at the same works from day to day—aye, and from hour to hour sometimes. A close comparison between two rival engines would often be invalidated if the facts as to the relative values of the gas they consumed could be known. We are well aware that scientific trials, such as those made in 1888 by the Society of Arts Commission, are accompanied by gas analyses; but the number of commercial trials which are not is well-nigh legion. The remaining three sections of the chapter on gaseous fuels deal with "poor gas," gas producers and petroleum respectively. A table, covering nearly three pages, which states the chief places where Dowson gas producers are in use, seems to us useless padding.

It is in Chapter V., on the "Théorie Expérimentale des Moteurs à Gaz," that Dr. Witz is at his best, and here the reader will probably find the greatest interest. Dr. Witz makes no hesitation about the matter, but plunges at once into the great contention—upon which, as we have already said, he has thrown so much light—as to the cause of the departure of the diagram of pressures, during the working stroke, from that which mathematical theory would dictate; and the consequent phenomenon of after-burning. "Tresca, Schoettler, Steward and Brooks, . . . Ayrton and Perry, . . . Donkin," &c., have advanced contending views; some have thrown the blame on dissociation, some on change of specific heat in the gases, some on the walls of the cylinder. "Lequel avait raison?" asks Dr. Witz. The answer, which he puts into the mouth of Mr. Dugald Clerk, reminds one of the Greeks playing games below the walls of Troy: "Toute le monde et personne"—all have won and all shall have prizes: all the alleged causes intervene in the phenomenon in question.

Dr. Witz, however, seems somewhat disinclined to admit the finality of this answer; and, no doubt, even if Mr. Clerk is right qualitatively, there is still the relative importance of these several influences to be determined. Naturally, Dr. Witz is disposed to attach the greatest importance to the action of the cylinder walls. This has been his special line of research, and by its aid he has obtained light which, apparently, other lines of research in this question have failed to yield so clearly. Yet, as he emphatically states, the theory is even now far from complete; and it is requisite that numerous and systematic trials and tests should be made by various methods under various conditions, and that these should be "discussed, compared, reconciled," before we can expect to see the time when they will establish "la théorie expérimentale sur des bases de granit: c'est une question de temps et de travail." Happily there are many workers in this field.

We have not space to enlarge upon the remaining contents of Dr. Witz's treatise; but what we have said should serve to show that it is a work which ought to be in the hands of everyone who is desirous of studying the modern developments of the gas engine in practice and in theory.

Annuaire pour l'An 1896. Edited by the Bureau des Longitudes. (Gauthier-Villars et Fils.)

The 1896 edition of this compendium of physical, electrical, chemical, astronomical and ethnological tables contains a brief historical summary of the action-at-a-distance and undulatory theories, and a lengthy account of the optical researches of Fresnel, both by M. Cornu; also M. Janssen's account of his third ascent of Mont Blanc, and an interesting biographical notice of the late Rear-Admiral Fleuriais by Captain Bernardières, of the French Navy, who also contributes a short account of the magnetic cartographic work now being carried out under the auspices of the French Government. As the Annuaire contains, in addition to purely scientific data, a mass of information with regard to calendars (Gregorian, Julian, Mohammedan, Jewish and Chinese), tables of foreign money equivalents, compound interest and sinking fund tables, &c., it would be difficult to say who could purchase it without finding something useful therein.

Submarine Telegraphy. James Bell, A.I.E.E., and S. Wilson. (London: "Electricity.")

This purports to be mainly a handbook on submarine telegraphy, and is styled by the authors "A Practical Book for Practical Men." In no wise do its contents justify its title. Barely 11 pages are devoted to submarine telegraphy, and moreover, of these nearly five are taken up with descriptions of an improved siphon recorder and two automatic transmitters, not the best known, perhaps, of their kind. Everywhere in the superficial and scanty information given on submarine cables we find errors and crude statements, manifesting on the part of the authors but slender acquaintance with the subject on which they have set themselves to treat. Of these errors it will suffice to notice one or two. Nearly a page is sacrificed in describing the theory of reflection as applied to the mirror galvanometer, while the "Minotto" cell, we learn, is used to work cables, further space being wasted in describing this bygone means of producing electrical energy on a small scale. The authors also inform us that a current flowing through a siphon recorder coil causes it to vibrate (*sic*). Again, we are told that the Commercial Company's cable system gives a working speed of 60 words a minute by means of the automatic system, which is an impossibility having regard to the length of the cable and its weights of copper and G.P. The method of duplex working shown in Fig. 9 is cumbersome, ineffective, and now obsolete for long cables, by reason, as is well known, of the retardation it introduces in the bridge arms R and R_1. The teredo we find referred to as having only recently been safeguarded against by means of brass tape, though the first brass-taped cable dates several years back, and since then

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cables innumerable have been similarly protected against the ravages of that genus.

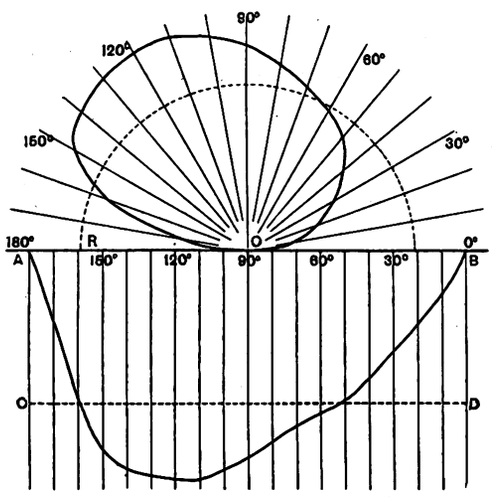
In the three small paragraphs headed "Test for Faults," and amounting in all to 18 lines, the authors surpass even themselves. We quote the first paragraph only—the italics are our own: "When a *disconnection* occurs in a cable, *both offices work with copper currents*, the copper having the effect of sealing up *a fault* by depositing chloride of copper on the *broken ends*, whereas a zinc current would *clean the ends and stop communication*. The copper current, however, gradually eats away the *ends of the conductor* and eventually breaks down communication."

But enough. Should the authors attempt any further "practical book for practical men," let us hope they will first take the trouble to study their subject, and that they will give any such book a less misleading title than their present effort so unfortunately bears.

THE FORM FACTOR OF ALTERNATING-CURRENT CURVES.

BY J. A. FLEMING, D.SC., F.R.S.

In the design of alternators, as well as in the discussion of some transformer problems, we have frequently to consider the relation between the true mean (T.M.) value and the square root of mean-square (R.M.S.) value of the equispaced ordinates of a single-valued curve representing a periodic current or electro-motive force. It is convenient to have a simple term to express this ratio. I venture to suggest the term *form factor* for it. This quantity has been already recognised and symbolised in various alternating-current investigations by Mr. Kapp, Dr. Roessler and others, who have pointed out its significance. If f stands for the form factor of any periodic curve, then $f = \frac{\text{R.M.S. value}}{\text{T.M. value}}$ of the ordinates of a semi-wave taken at equidistant intervals along the time axis. If y is the ordinate of the curve and x is the half-wave length, then $f = \frac{\frac{1}{x}\int_0^x y^2\,dx}{\frac{1}{x}\int_0^x y\,dx}$. Geometrically it can be obtained as follows: On any horizontal line draw a wave diagram to represent the half-wave of a periodic curve of electromotive



force or current, and with any point on this line as a polar centre draw a polar diagram to represent the same curve. With the planimeter find the areas of each of these curves and find the rectangle equal in area to the wave curve and the semicircle equal in area to the polar curve. Then the ratio of radius O R of the semicircle to the altitude B D of the rectangle is the form factor for the curve considered. For it has been shown that the radius of the semicircle represents the R.M.S. value of the ordinates of the curve, and the altitude of the rectangle represents the T.M. value of the same.

The form factors for certain curves are given below:—

Curve.	T.M. value of ordinate as fraction of max. ordinate.	R.M.S. value of ordinate as fraction of max. ordinate.	Formfactor f.
Sine	0·637	0·707	1·1
Semicircle.....	0·7854	0·835	1·063
Triangle	0·5	0·58	1·16
Rectangle.....	1·0	1·0	1·0
Semi-ellipse.....	0·785	0·816	1·039
Parabola with axis vertical.....	0·666	0·730	1·096
Two semi-parabolas meeting at a cusp..	0·33	0·447	1·35

The more peaked the curve the larger the form factor. If one dared to disregard proprieties of language, the form factor might otherwise be called the "coefficient of peakiness" of the curve.

It is now well understood that the core loss in a transformer depends upon the form factor of the curve of primary electromotive force, and that an increase of form factor causes a diminution of core loss due to hysteresis. It has not yet been entirely demonstrated that curves of electromotive force of different shape but equal form factor will give equal hysteresis loss, but it is very probable such would be the case. Under these circumstances a specification for transformers is incomplete unless it is stated that the test of core loss shall be made on an alternator with a curve of electromotive force having a given form factor. The form factor of the curve of electromotive force of an alternator may change considerably as the character of the load whether inductive or non-inductive is altered, if the alternator is one having a large armature reaction.

ELECTRIC TRAMWAYS AND TELEPHONIC DISTURBANCES.

BY C. S. DU RICHE PRELLER.

Introduction.—In the course of last summer the writer took the opportunity of investigating the effects of the working of certain electric tramways on telephones in Switzerland, Alsace, and France, more especially with the view of determining (1) which of the different overhead contact systems is most liable to cause telephonic disturbances, and (2) whether the disturbances, if any, are due to induction, leakage, or to other causes.

It is, of course, not the purpose of this Note to enter into a detailed description of the various electric tramways examined; suffice it, therefore, to briefly state the features which bear strictly on the subject under notice, in reference more especially to the tramways of Zurich, Geneva, Bâle, Mulhouse, Havre and Marseilles.*

Contact Systems.—The three (now four) electric tramways so far constructed in Zurich all radiate from one central point near the lake, and connect various suburbs on the hills flanking the town, the aggregate length being about six miles, worked on the trolley system. At Geneva, where the entire system of horse tramways is now being converted to electric traction, the first section, connecting one of the suburbs with the centre of the town, is about four miles in length, and is worked with a slide contact shoe, which system will also be used on the extensions. The tramway at Bâle, traversing the town from one end to the other, and crossing the Rhine about midway, is three miles in length, and is worked on Siemens and Halske's contact-arm, or, as it may not improperly be termed, "cross-bow" system. This contact will also be used on the other lines to be constructed further on. Precisely the same remarks apply to the tramways of the neighbouring town of Mulhouse (Alsace), where steam traction is being replaced by the system just

* A detailed account of the Marseilles and St. Louis Tramway by the writer was published in *Engineering*, 1893.

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mentioned, and the lines so far converted measure about five miles in length. The Havre network of electric tramways, comprising at present 12 miles of chiefly double line, is worked on the trolley system, which is also in operation on the Marseilles and St. Louis tramroad, three miles in length. It may be added that on all the lines mentioned the steepest gradient is 5 per cent., at Zurich and Marseilles 6·5 per cent. (1 in 20 and 1 in 15 respectively), and the minimum radius of curvature is in all cases 20 metres, or 66 feet.

Insulation.—The means of ensuring the continuity of the return circuit through the permanent way are, in all the cases referred to, substantially those now commonly adopted, that is, the girder rails are bonded at the joints by 8mm. to 10mm. copper wires fastened through, and soldered to the web, the wires being connected at equal distances, varying from 30 to 100 metres (100ft. to 330ft.), to an uninsulated copper conductor of the same diameter, which is laid between the rails throughout the whole length of the line. The only exception is the line at Marseilles, where the conductor is a lead-covered galvanised iron wire.

The means of insulating the contact wire, too, are very similar in all cases—that is, where span wires and iron posts are used, threefold insulation is provided (*a*) between the contact wire and the span wire at the point of suspension, (*b*) between the span wire and the collar resting on the cap of the post, and (*c*) between the cap and the post.

Telephones.—On examining the arrangement of the telephone lines in relation to the electric tramways referred to, the writer found that at Zurich the telephone wires are, along one section of tramway, laid underground in iron pipes, whilst along the remaining sections, which form by far the greater part of the entire length, the wires are carried overhead, and that, although at certain points they cross the contact wire of the trolley lines more or less at right angles, there are various sections up to 200 metres (660ft.) in length each, where from 40 to 80 telephone wires, not provided with metallic return, run parallel, or nearly so, to the tramways at a vertical or horizontal distance varying from 1 to 5 metres (3·3ft. to about 16ft.). Similarly, at Geneva, the telephone wires are, to a small extent, laid underground, but for considerable distances along the tramway, and in sections up to 600 metres (660 yards), they are carried overhead, the distance from the tramway line being in some cases 5, in others only 1 to 2 metres (about 16ft., 6ft., and 3ft.), and the telephone having earth return. Again, at Bâle, and also at Mulhouse, overhead telephone wires with earth return run for long distances parallel to the tramway, and are from 12 to 15 metres (40ft. to 50ft.) apart from the latter. At Havre, and likewise at Marseilles, the telephone wires running parallel to the tramways are placed at a distance of 15 metres (50ft.) from the latter, and are provided with metallic return.

Disturbances.—The tests made by the writer of the telephones at Zurich showed that in all the districts traversed by the electric tramways there are serious disturbances, the starting and stopping of the cars, their passage through curves, the action of the motors, and notably the "singing" of the armatures, being so distinctly audible as to materially interfere with telephonic communication. In a minor degree these disturbances extend all over the town, the writer himself having traced them to within about two miles from the nearest tramway line. The inconvenience thus caused in the more immediate neighbourhood of the tramways is so great that the overhead telephone wires most affected are now being laid underground. At Geneva, as well as at Bâle and Mulhouse, the writer found, in striking contrast to Zurich, that even at the public or private telephone stations in close proximity to the tramways, the disturbances are so insignificant as to be practically *nil*, an observation which is, moreover, confirmed by the fact that in neither of these towns has the working of the electric tramways given rise to any complaint, and consequently no remedial measures, such as those at Zurich, have been necessary. On the other hand, at Marseilles, as the writer pointed out at the time (1893), considerable trouble was at first experienced in connection with the telephones, the disturbances being very similar to those observed at Zurich, and the public or private telephone stations more especially affected being those situated in houses to which span wires of the tramway line were attached, at a distance, in some cases, of only about 3ft. from the telephone wires. An experimental remedy to protect the telephones by means of induction coils and condensers proved of little or no avail, and telephonic communication continued so unsatisfactory that the telephone wires most affected were in the end removed to a distance of 15 metres (50ft.) from the tramway, and provided with metallic return. Again, at Havre, the writer found that the electric tramways, after being opened for traffic, gave rise to complaints, albeit in a much less degree than at Marseilles and Zurich, the telephonic disturbance being restricted almost entirely to the sound produced by the starting of the cars. Here, too, however, the telephone wires, placed at a distance of 15 metres (50ft.) from the nearest tramway line, had, by order of the authorities, to be doubled, the metallic return being extended to the entire telephone system of the town.

Causes.—The broad and striking result of the investigations thus made by the writer is that the electric tramways of Zurich, Marseilles, and Havre, worked on the overhead trolley system, have given rise to more or less serious telephonic disturbances, which necessitated remedial measures, whilst the tramways of Geneva, Bâle, and Mulhouse, worked with an overhead slide contact, have produced no such disturbances. The phenomenon is at first sight puzzling, and it will be interesting to briefly examine its causes.

To some extent electromagnetic and electric induction must, of course, always take place between two sets of parallel overhead conductors, such as tramway contact wires and telephone wires, the principal cause being the extreme sensitiveness of the latter, in which consequently even very slight inductive effects of the higher tension current* are reproduced. In the cases under notice, where the two sets of conductors are carried on, or suspended from, separate supports, the magnitude of the disturbances depends, in the main, on the magnitude and suddenness of the changes of the inducing current and its pressure, on the length over which the two sets of conductors run parallel, and on the distance between them, the inductive effect being, however, by no means in a simple ratio to that distance. Both at Zurich and Geneva the safeguards against excessive induction are practically the same—viz., the two sets of conductors cross each other at certain intervals, and the tramway working current, being the higher tension current of the two, has a separate return by means of the conductor between the rails, while, on empirical grounds, the large number of telephone wires tends *per se* to lessen the effects of induction. Notwithstanding this equality of conditions—those at Geneva being, indeed, more unfavourable owing to the greater parallel lengths, and consequently the considerably higher coefficient of induction†—there are serious telephonic disturbances at Zurich, whilst at Geneva the disturbances are inappreciable or *nil*; hence it is reasonable to conclude that the phenomenon in the former town is not primarily, and certainly not entirely, due to induction.

It has already been shown that the ordinary means adopted for minimising leakage are practically the same in all the cases referred to. It might be argued that the morainic soil of Zurich is more conducive to earth currents than the gravel soil of such towns as Geneva and Bâle; but this argument would possess some value only in the case of clay or other soil which, being impervious, retains moisture.

The primary cause of the telephonic disturbances must, in the writer's opinion, be sought in the trolley system itself. There is, in the first place, between the two systems of trolley and slide contact a marked difference in the mode of suspension; for while the trolley contact wire requires a large number of points of suspension, especially in curves, so as to conform to the axis of the tramway, the conductor for slide contact bars or cross-bars can be laid out in long polygonal sides with very few points of suspension, and at crossings the contact wires are

* It is hardly necessary to state that the pressure of the working current is in all cases 500 to 600 volts.

† The coefficient of reciprocal electromagnetic induction is $= \frac{2l}{10^9}$ (log nat $\frac{2l}{d} - 1$), l being the parallel length and d the distance apart, in centimetres.

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simply soldered together, thus ensuring continuity of contact. In the trolley system, on the other hand, every point of suspension, whether it be an ear clamping the contact wire or a frog at crossings and bifurcations, involves a jump of the trolley wheel over the obstruction in the former and over the gap in the latter case, and this necessarily causes sparking, which *e.g.*, at Zurich is particularly violent, and occurs at almost every point of suspension. Consequently, leakage takes place through defective contact, and it is this latter which, in the writer's opinion, constitutes the primary cause of the telephonic disturbances. This view is confirmed by a trial which the writer witnessed on one of the lines at Zurich, when the Geneva slide contact was temporarily substituted for the trolley wheel, with the result that the sparking and the effect on the telephones were practically the same, thus showing that the fault lies not so much in the trolley wheel *per se* as in the overhead system which the trolley wheel involves.

Another cause which tends to intensify the telephonic disturbances referred to must be sought in the construction of the motors as well as of the contact pieces. In this respect the noiseless running and inappreciable wear of the motors and of the chain motion used at Bâle and Mulhouse contrasts strikingly with the howling of the motors and the rattling of the spur gearing on the Zurich lines after little more than 12 months' running, albeit the steep grades and sharp curves in the latter town account, to some extent, for the more rapid wear. No less striking is the contrast between the smooth, silent gliding of the aluminium cross-bow slide in the former towns, and the grating, more especially in curves, of the trolley wheel against the contact wire.* All this "concord of sweet sounds" finds its echo in the telephones as the effect of induction, while the starting of the motors, involving a sudden increase of current, affects the telephones more especially owing to the sudden rise of the difference of potential between earth connections as the effect of defective contact and the inadequacy of the ordinary means of insulation.

Conclusion.—It has been shown that a good slide contact system, in conjunction with well-constructed and smooth-running motors, is much less liable to affect telephones having earth return than the trolley system, which, in the various cases enumerated, has necessitated remedial measures, consisting either in the burying or the doubling of the telephone wires in the vicinity of the electric tramways.* The cost of the former operation was, at Zurich, about £1,600 per mile (25,000fr. per kilometre), of which the tramway companies have so far contributed about half; while at Marseilles the cost of removing to a distance of 15 metres (50ft.), and doubling the telephone wires most affected, was entirely defrayed by the Company, and amounted to £1,000 per mile (about 16,000fr. per kilometre) of tramway; and at Havre, the company had to contribute for the same purpose the sum of £5,000, being at the rate of about £600 per mile of tramway. The average cost is therefore about £1,000 per mile, and this has been entirely saved in the three other cases where the slide contact system has been adopted.

The writer is very far from wishing to disparage the overhead trolley system, which, in its rough and ready fashion, has rendered immense service in the United States, and is well adapted also for suburban and country districts in Europe. But as regards the peculiar conditions of many towns in Europe, and more especially in this country, it may fairly be averred that, if overhead wires are tolerated at all, the slide contact system as already in operation in various Continental cities, *e.g.*, at Dresden, Hanover, Barmen, on the suburban lines of Buda-Pesth, and elsewhere, and in a somewhat different form in the Isle of Man, is free from many of the disadvantages inherent to the trolley system, and therefore marks a conspicuous advance on the latter. More especially is this the case in towns and districts where the risk and responsibility of telegraphic or telephonic disturbances, and not only the considerable cost, but the local difficulties of remedial measures, have to be reckoned with; and it is with the view of drawing attention to this important point that the writer deemed it opportune to give publicity to his impartial investigations in the interest of electric traction.

* This defect has recently been mitigated by substituting for the American trolley wheels with narrow groove, other wheels of better material, and having a groove 4·6cm. (1·8in.) in width, which allows more lateral play. It is not infrequently contended that a contact slide wears the contact wire. This is, however, a fallacy, and, according to the writer's experience, the reverse is the case, viz., the slide contact piece being invariably made of softer material than the contact wire, it is the latter which wears the former. In the aluminium cross-bow used, *e.g.*, at Bâle, the wear is reduced to a minimum, the more so as both the contact surfaces are well greased, the oblong and curvilinear contact frame, 1·5m. (about 5ft.) in length, being self-lubricating. It is, moreover, self-reversing.

* As another case in point may be mentioned the Douglas and Laxey (Isle of Man) tramway, where, as Dr. E. Hopkinson informs the writer, no trouble whatever has been experienced from telephonic disturbances, although the Company's telephone wires are fixed upon the posts of the Government telegraphs at a distance of not more than 25ft. from the tramway conductor, and run parallel with the latter for nearly two miles. The telephone wires have, it is true, metallic return; but, as is well known, even this by no means affords absolute protection against inductive effects such as might be produced within a short distance from the line if the latter were worked on the trolley instead of the slide contact bar system. A further case is that of the Mont Salève electric mountain railway near Geneva (*vide* the writer's account in *Engineering*, 1894). On this line, worked with a slide contact and an outside conductor rail, simple electrical bonding at the rail joints without a separate return conductor sufficed to stop the telephonic and telegraphic disturbances at first experienced, and the doubling of the wires could be dispensed with.

THE "SAFETY" SYSTEM OF CONCENTRIC WIRING.

At a time when the discussion on two Papers on concentric wiring is pending at the Institution of Electrical Engineers, some particulars of the "Safety" system may be of interest. This system of wiring, which has been developed during the last five years under the "Andrews" patents, is designed principally to provide a fire-proof and safe system of interior electric wiring on lines which somewhat resemble those of ordinary gas fitting. The system is concentric, with the outer conductor bare and well earthed; and the conductors and other fittings attaching to it are the manufactures of Messrs. Sharp and Kent. The chief features of the system may be summarised as follows: (1) No wood casing is used; (2) every joint is hermetically sealed, and is thus damp-proof; (3) every connection is made with a screwed coupling similar to a gas fitting; (4) all switches and fuses are enclosed in metallic cases; (5) the external conductor or sheathing and the cases of all the fittings, &c., form a continuous conducting earthed-return circuit.

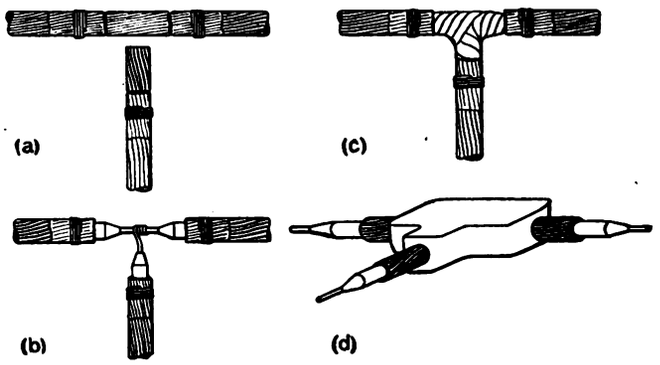

FIG. 1.—Method of making a T joint.

The cable used on the "Safety" system consists of ordinary copper conductor, insulated with vulcanised india-rubber, and surrounded with an armouring of copper or iron wires, this armouring forming the return conductor. The manner of making a joint is interesting, and, in the case of a T joint, is as follows: In Fig. 1, let (*a*) represent the two pieces of concentric cable to be jointed. First the outer sheathings are bound round with thin copper wire, as shown at (*a*), and then tinned. The armouring is now cut away, leaving the insulation projecting, and the inner wires are cleaned and jointed, as shown at (*b*). This inner joint made, it will be insulated with pure rubber, then with a layer of white rubber, followed by vulcanised strip, and finally silesia strip, as shown at (*c*). A copper sheath is now placed over the insulated inner joint, and the ends of the outer

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sheathing are joined. When this has been done the T must be placed in a mould, shown in Fig, 2, and molten fusible metal must be poured over and around the copper sheathing, the heat of which operation will perfect the vulcanisation of the joint. When this fusible metal is cooled a firm, strong, water-tight and well-insulated joint will have been made, the general appearance of which is seen at (*d*) in Fig. 1. Such a joint as this is usually made, in factory and cheaper classes of work, where a pendent is to be attached to the main conductor; but in better class of work the attachment will be by means of a screw ferrule, as shown in Fig. 3. It may be remarked that the lamps themselves are provided with screw threads which

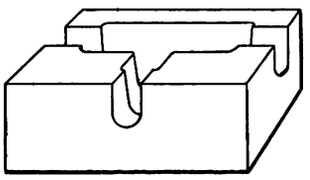

Fig. 2.—Mould for T joint.

will fit the sockets into which the fittings are usually screwed, so that a cheap and expeditious plan is to attach the lamps directly to the sockets without any intermediate fittings.

The "Safety" system of concentric wiring, though mainly designed for interior conductors, is not essentially restricted to this purpose, but can readily be adapted to the requirements of low-pressure street mains and feeders on the two or three-wire system. Indeed, we understand that Messrs. Sharp and Kent have the contract for laying the mains of the three-wire system at Guildford, and will adopt the "Safety" system of conductors in that contract, with only such slight modifica-

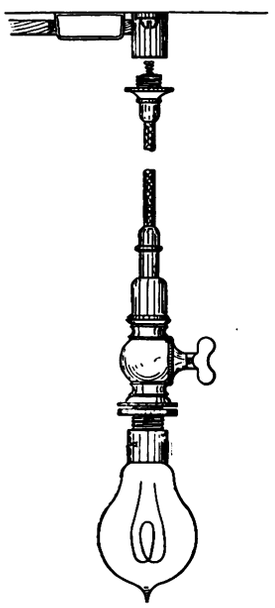

Fig. 3.—Pendant with Screw Ferrule.

tions as are necessary on account of the difference in the conditions. Both for interior and exterior wiring, therefore, the "Safety" system appears to answer its purpose; and in the former class of work it has, we understand, received the approval of the officials of several leading insurance offices.

A STEEL-CASED MOTOR.

The accompanying illustrations show a new design of enclosed type motor constructed by Messrs. Mavor and Coulson under the Sayers patents. The general features of the motor are similar to the enclosed type of machines which this firm have manufactured for some three years past. The enclosing casing is of low carbon steel of high magnetic permeability, and forms a magnetic shell from two opposite points of the inner surface of which the field poles project. Thus, in addition to the enormous protective strength of the steel shell, these machines are practically devoid of external magnetic field, and on this account are well adapted to ship work, the effect on the most delicate compass being, it is said, imperceptible at quite a short distance. Great improvements have recently been made in the general design of these machines.

In regard to the general performance, the following are particulars of test runs of a machine designed to give 12 B.H.P. at 770 revolutions:—

Efficiency Test.—12*in. by* 7½*in. Motor driving Generator by Belt.*

Mean of Three Readings.

Motor.			*Generator.*		
Speed.	Volts.	Current.	Speed.	Volts.	Current.
775 ...	122 ...	104	885 ...	100·8 ...	100·4

Motor input = 122 × 104 = 12,600 watts.
Generator output = 100·8 × 100·4 = 10,170 watts.

$\frac{10,170}{12,630}$ = 80 per cent. efficiency, double conversion.

The motor was run as a generator with a view to ascertaining the rise of temperature for continuous running, as under:—

12*in. by* 7½*in. Motor run as Generator.*

Direction of Rotation—Counter-clockwise.

Time.	Speed.	E.M.F.	Current.	Remarks.
2:30	766	110	89	
2:55	756	111	89	Stopped 10 minutes to repair belt.
3:10	795	110	92	
3:20	790	110	90	
4:0	785	110	88	Brushes sparkless throughout.
4:20	794	110	90	
4:45	780	110	88	
5:0	784	110	90	
5:15	784	110	88	
5:30	784	110	88	

Maximum Temperatures.

Magnet coils.....	111°F.	..... Rise.....	53°F.
Armature	120°F.	..... „	62°F.
Air	58°F.	.....	

The machine was next run for 6 hours as a generator at 40 per cent. over rated load.

Time.	Speed.	E.M.F.	Current.	Remarks.
10:30	800	110	126	Sparkless.
11:0	800	110	122	„
11:30	810	110	124	„
12:0	830	110	120	„
12:30	840	110	120	„
1:0	840	110	118	„
1:30	845	110	126	„
2:0	850	110	123	„
2:30	855	110	120	„
3:0	860	110	124	„
3:30	865	110	123	„
4:0	865	110	123	„
4:30	860	108	122	„

At end of six-hours run at 40 per cent. over load the following maximum temperatures were observed:—

Armature	144°F.	..... Rise.....	90°F.
Magnets.....	128°F.	..... „	74°F.
Air temperature	54°F.	.....	

A test was made to see what load could be carried without sparking at the brushes, with the following results:—

Time.	Speed.	Volts.	Current.	Remarks.
11:0	Not taken.	100	175	Run for 15min. without any sign of sparking.

A subsequent test showed that slight signs of sparking appear with a load of 185 amperes.

When running as a dynamo the machine was loaded up to 120 amperes; the load was then suddenly reduced to 80

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amperes, when, without change of position, the brushes remained absolutely sparkless; on reducing the load to 40 amperes only slightest traces of sparking were visible. The rocker was then moved to sparkless position with 40 amperes, and then all load switched off, when the machine remained absolutely sparkless, running light. Copper gauze brushes were used.

The following particulars of this size of machine may be of interest: Weight of machine complete, 16¾cwt.; resistance between brushes at 120°F., 0·0435 ohm; resistance of shunt at 120°F, 53 ohms. A portion of the top part of magnet shell at commutator end is hinged to the main portion, and when opened, as shown in Fig. 2, allows of ready inspection and adjustment of brushes, &c. The top part of shell lifts off vertically, after

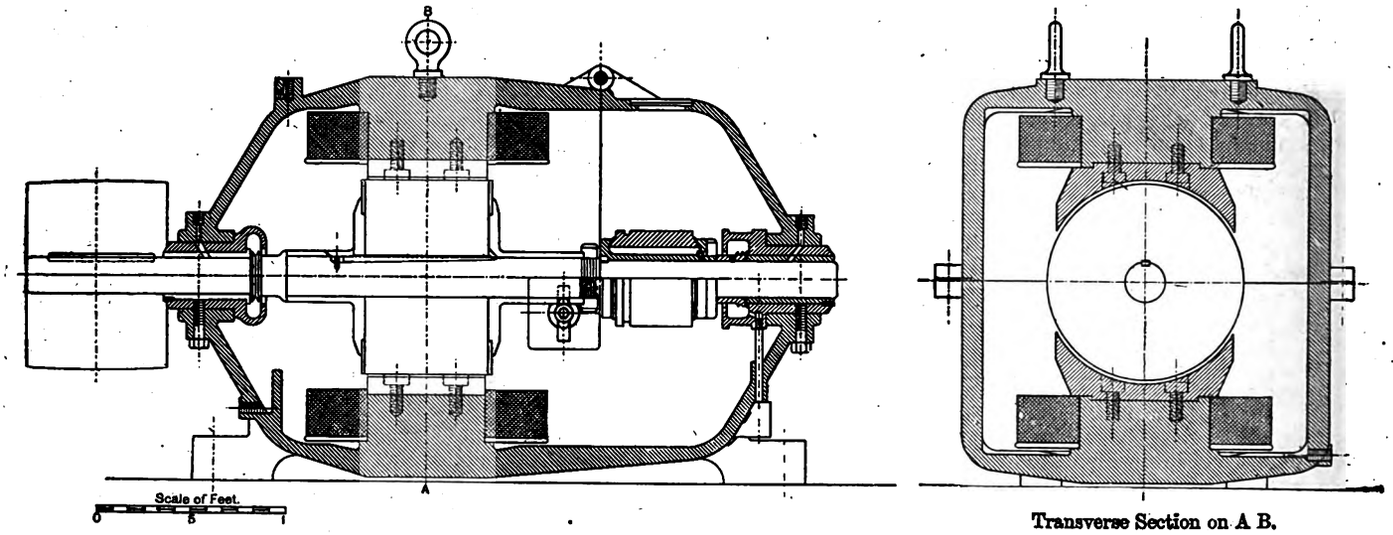

FIG. 1.—Sayers' Steel-Cased Motor. Longitudinal and Transverse Sections.

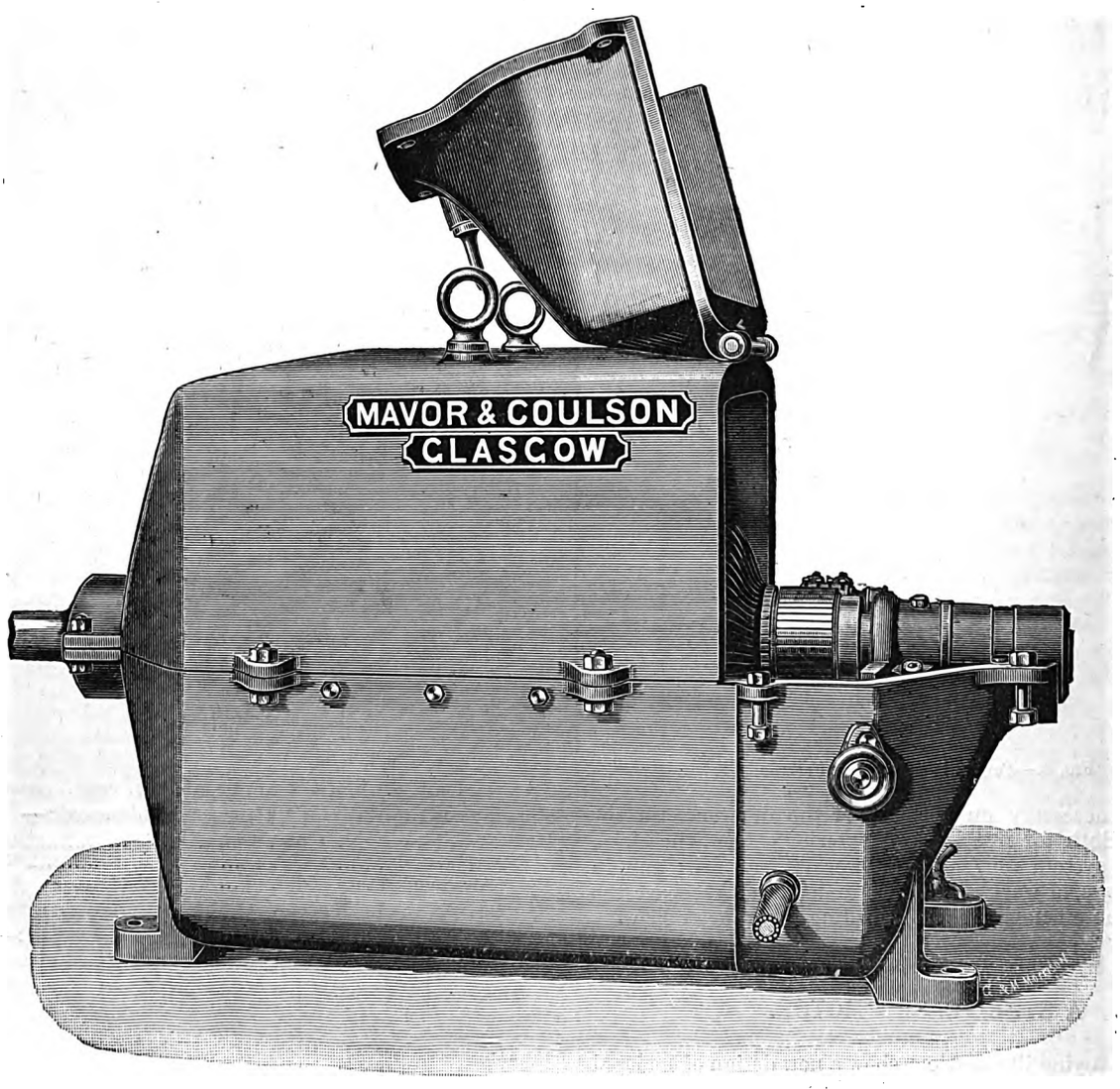

FIG. 2.—Sayers' Steel-Cased Motor.

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ELECTRIC SUPPLY STATIONS OF THE UNITED KINGDOM.

[COPYRIGHT.

[Data relating to these Stations will be found in the Electric Supply Station Table, published with this Edition.]

"Electrician" Series.

Extra copies of this Map can be supplied, Price One Shilling.

1, 2 & 3 Salisbury Court, Fleet Street, London.

Blue = Continuous Current.
Red = Alternating Current.

□ = Municipality.
○ = Company.

△ = In Progress.

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which the armature can also be lifted vertically, while by removing the pole piece the magnet bobbin can be slipped off.

Below we give a facsimile of Messrs. Mavor and Coulson's design sheet for the machine from which the above tests were taken. The characteristic of the machine is level up to the normal load :—

ENCLOSED TYPE MOTOR.

Design No. 80. Size, 12½in. by 7½in. N=4,925,000. Constant M=12·6

Magnetic Circuit.

—	Area in sq. cm.	B.	Length cms.	H per cm.	Total.
Air space	634	7,770	0·76	7,770	5,900
Armature core ...	384	12,800	30	10	300
Teeth max. (roots)	285	17,200	4·75	100	475
Teeth, min.	...	...	...	...	...
Field magnets ...	398	13,600	24	12	288
Core limbs.....	425	11,600	90	8	720
					7,683 × 10/4π = 6,100 +10% = 6,700 amp. turns

Windings.

Main Winding.*

Resistance.	Turns.	Size.	Length.	Weight.
0·0385 bet. commutator coils at 120°F.	Two turns per section in adjacent slot, *i.e.*, 2 wires per slot.	0·22in. by 0·1in. sc. and bd.	382ft.	32½lb.

* The wires forming any armature section lie in slots which are two less than diametrically opposite.

42 Commutator Coils embracing 7 teeth.

Resistance.	Turns.	Size.	Length.	Weight.
0·00406 ohm per coil at 120°F.	Two turns per coil, *i.e*, 2 wires per slot.	0·1in. by 0·1in. sc. and bd.	195ft.	7½lb.

Magnet Shunt-Wound.

Res.	Limbs.	Layers.	Turns per layer.	Total turns.	Size.	Current.	Weight.
53 ohms at 130deg.	2	1	Total turns, 3,350.	1,850 turns of No. 18, 1,500 turns of No. 17.	No. 18 (0·049in.) B.W.G., No. 17 (0·058in.) B.W.G.	2 amperes.	44½lb. No. 18 (No. 18 wound on first)., 62lb. No. 17.

ILLUMINATION versus GLARE.*

BY ALBERT SCHEIBLE.

One of the most notable events of the past year was the advent of a practical illuminometer. It was noteworthy not so much because it is more needed to-day than a photometer, but more particularly because it emphasizes illumination as the one thing to be attained by electric lighting. We have learnt to produce light at any desired spot and in any desired unit, and we can now do this at a very low cost considering the methods used. Hence it is high time that we should turn our efforts towards using this light to produce the desired effect. In doing so we must remember that it is not the lamps themselves which we want to show; they are merely accessories—necessary evils, perhaps—and as such we gladly tolerate them as means towards our end. That end is illumination. It may be the illumination of a show window, a store, a parlour, a workshop or a street. In each case there is something other than the lamps which we want to exhibit; the lamps themselves can be quite inconspicuous while still supplying the light for the store display, the reception room or the avenue. I say they can be inconspicuous, though as yet we rarely find them to be so.

Not many years ago, when electric lighting first came into use, the public clamoured for it as something new, something that should not only be used but readily seen as well. It was not enough then for the townspeople to know that so intense a light could be produced in so small a space; they wanted to have this intensity kept prominent—wanted to be dazzled by the penetrating rays even if they were thereby kept from seeing what was supposed to be lit up by the lamps. But that era has now gone by. We need no exhibit of arc or incandescent lights in our stores or streets; what we do need is the light itself. To use this in the most effective manner we need to get rid of that exhibition glare which custom has handed down to us as a dazzler and incidentally as an illuminant. Are we doing so to-day? Just look at a few pert examples.

1. *The Show Window.*—Everybody knows that this is the one place above all others where the dealer wants the public to see his wares. Time and expense are seldom spared in causing these windows to serve their proper object. Models are devised to show the proper use of the goods, and artists are set to work arranging them so that the eye will long to rest upon them; the result is a feast for the passer-by. At least it is so in the daytime, but rarely so at night, and why? Is it for lack of light? Certainly not, for hundreds of candle-power are cast on the window in excess of what it received at noonday. Perhaps there is an arc lamp right in front of the window, or there may be a border of incandescents around the edge. In either case it is the lamps and not the goods that catch and hold your eye. You stop and say to yourself: "Oh! how pretty those lights are!" And you go on, forgetting that there were goods in those show windows, and that the real purpose of the lights lay not in their being pretty themselves, but in showing up a pretty something else. The true beauty of the light—that of its meek utility—had been entirely missed.

Yet things can be otherwise. There are some stores already where the light in or near the windows is concentrated on the goods and shielded from the observer's eye, where the electric light readily produces the desired illumination without reducing the effectiveness of it by the offensive glare. Perhaps we are too strongly prejudiced in favour of the electric lights; then let us look at gas jets or Welsbach burners in similar locations and with all charity for the latter ask ourselves if even the right light in the wrong place (the glaring, self-conspicuous place) is what we want.

2. *In the Home.*—When we place lights of any kind in the rooms of our house we generally look upon them as mere substitutes for the daylight during the hours when this is not available, and we are justified in calling that method of lighting the best which most nearly approaches the diffused daylight in its effect. We need not pretend to imitate the dazzling sunlight, for we carefully exclude its glare by shutters or moderate it by tinted shades. Thanks to these shutters and shades we get a mellow and diffused light, inoffensive to the eyes but ample for giving thorough illumination to the room. When evening comes it would be only natural for us to reproduce this illumination as best we can, and surely the incandescent lamp is the best medium yet devised for producing a close approach to the daylight effect. But where is the residence which can boast of this mellow lighting by night as well as by day? Surely the grouping of a few incandescent lamps where they can glare right into one's eyes cannot give the desired effect any more than we would get it during the day by admitting the bright sunlight through three or four peep-holes. Custom told us to place our incandescents just where we were used to seeing our oil or gas lamps. But these had to be within easy reach as they needed frequent adjustment, and they also had to be kept at a respectful distance from the wall or ceiling to avoid fires. Fortunately the incandescent lamp is not subject to these same ailments, and as the most modern of the lot it surely should not be handicapped by the faults of its predecessors. If we must have the lamp right before our eyes we can frost its bulb and perhaps enclose it in a much larger opalescent globe, so that we will see not a dazzling white horseshoe-shaped filament but a dimly glowing ball of light. I for one like to see the light dimmed and diffused in this way, and I prefer even then to place the lamps close to the ceiling, where they will be least noticed by sensitive eyes. If you can have a number of such glowing globes scattered along the ceiling each with a lamp of rather low candle-power, the result will be so much the better, since it more nearly reproduces the diffused daylight effect.

Perhaps you will ask as to the economy of such a plan: "Will it pay to cut off a third of the light by the tinted globe?" I think it will, for it is not so much the candle-power output of our lights that counts, but rather the illuminating effect produced by them. When we put a 16 c.p. incandescent in place of a 10 c.p. double gas burner or 8 c.p. of oil lamps, we spend more candle-power of light on the room, but do we necessarily get a more effective illumination? Is it not a fact that we strive during the day to keep down the candle-power of light which comes into our rooms, in order that we may have just the amount needed for a proper illumination? Any light in excess of this is injurious to our eyes and detracts from the effect of all the objects when we look at them for any length of time.

If we want to exhibit the lamps themselves we can find many ways of doing this by using the miniature forms now on the

* From the *Electrical Engineer* of New York.

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market. But for effective and artistic lighting I trust that the time will come when the incandescent lamp will be merely the power behind the globe, from whence it can shed a truly diffused light on our room without being seen of itself.

3. *Street Lighting.*—When we come to the lighting of streets and alleys the question of candle-power is apt to be misleading unless it is kept subsidiary. The fact that lighting contracts, when not made on a midnight or an all-night basis, are usually taken on a moonlight schedule, shows that the illumination due to the moon in its second or half-moon phase is considered ample for lighting the streets at night. Many small towns have tried to reproduce the moonlight effect by using tower lights, but the shadows from two or three-story houses or from trees of almost any size have spoilt the result in most cases. The more common method of using arc lights at every street crossing is certainly far from giving a moonlight effect. It invariably gives an intense illumination to a spot fifty or a hundred feet in diameter, but when you go beyond this area the intense shadows and the dazzling rays detract from the effectiveness of the illumination, thus leaving the street rather poorly lighted for either riding, driving or walking. It is not a lack of light in this case, but a lack of its proper distribution. In the case of incandescent street lighting there are usually three or four lamps to a block, and while the absolute candle-power per block is much lower, the illumination produced may still be much more satisfactory. The light is more evenly distributed in this case, the lamps are near enough to avoid any deep shadows, and the glare of the lights themselves is almost insignificant as compared with that of the arc lamps. This point is noted alike by pedestrians, teamsters, horseback riders or cyclists—in fact by everybody for whose benefit the street is illuminated. The more uniform distribution of the light, together with the absence of the glare and of the intense shadows, all help to bring the incandescent "many-lamps-to-a-block" method much nearer to producing a moonlight or diffused daylight illumination than the usual plan of having arc lights at every corner or at alternate ones. It would, therefore, seem worthy of a great deal more attention than it has heretofore received, and while it may not be universally adaptable, still for most places a street hood incandescent method should give the most desirable and effective illumination.

I have mentioned just three instances—the show window, the residence and the street. There are many other places where a little thought will show that we are squandering a good deal of energy in order to produce an offensive glare while the incidental illumination could be much more agreeably produced by scattered lights of lower candle-power. In the case of the show window we can cover the lights so as to hide them from view altogether. There are some cases of store or room lighting where we could do the same to advantage; but for street lighting it is entirely out of the question. However, we can always use opal, ground glass or tinted shades over the lamps so as to dim the glare, and we can reduce the candle-power of our units so as to still further cut down the dazzling. Then when we increase the number of the lights and scatter them more widely we can get the one effect which we are seeking in each case: not an exhibition of intense and glaring lights whose dazzling power is enhanced by the deep shadows which they produce, but an illumination really worthy of the name.

THE RELATION BETWEEN THE ATOM AND THE CHARGE OF ELECTRICITY CARRIED BY IT.*

BY J. J. THOMSON, M.A., F.R.S.

(Concluded from page 325.)

Thus, on this view the chemical combination consists in the formation of an aggregate of a large number of H and Cl molecules, then the interchange of the charges on some of the atoms, then the formation of an aggregate of HCl molecules, and finally the breaking up of this aggregate into a number of separate molecules of HCl. It will be noticed that there are no atoms set "free" during the whole of the process. The presence of free-charged atoms during the progress of chemical combination between gases could be detected by experiments made on the electric conductivity of the mixture whilst the combination is proceeding. If free-charged atoms are present they will move under electromotive forces, and will cause the mixture of gases to act as a conductor of electricity. A method of testing the conductivity of gases and the results of experiments made with it are given in a Paper by the author (*Proc.* Camb. Phil. Soc., Vol. VIII., p. 258). These experiments showed that when a mixture of H and Cl was combining it did not possess any conductivity, thus proving that in these cases no charged atoms were set free during the combination. Some other cases of chemical combination gave the same result; on the other hand, there was a class of cases in which the mixture of gases acted as a conductor whilst chemical combination was going on. The experiments thus proved that in many cases of chemical combination no charged atoms are set free.

I also investigated this point by another method. Let us assume for a moment that free charged atoms are liberated during chemical action. To fix our ideas, let us take the case of a piece of zinc attacked by chlorine; suppose now that we electrify the zinc: if chemical action liberated free ions, or, supposing that an aggregation of atoms is necessary, if the algebraical sum of the charges on the atoms forming this aggregate were not zero, then when the electrified zinc atom enters into chemical combination an atom of chlorine must be set free carrying a charge of electricity of the same sign as that on the electrified zinc atom. Thus, in this case the charge would leak from the metal into the gas and the latter would cease to insulate. If, on the other hand, chemical combination went on between an aggregate of atoms, the algebraical sum of whose charges was zero, then, however much the zinc was attacked, there would be no liberation of charged atoms, and no transference of electricity from the metal to the gas.

I made an extensive series of experiments to find out whether an electrified metal plate when immersed in a gas by which it was chemically attacked did or did not lose its charge. I was never able to trace any leakage of electricity to this cause, even though two metal plates charged to a great difference of potential, either by a Wimshurst machine or by a battery of 2,000 small storage cells, were placed close together in the gas. The electrified surfaces were zinc, mercury and electrolytic solutions, the gases chlorine and nitrosyl chloride; but though the conditions of the surfaces showed that active chemical action had taken place, there was no escape of electricity through the gas, whether the surfaces were positively or negatively electrified. In these cases the chemical combination went on at the temperature of the room when there was no chance of the gas being dissociated. In the case of combination at very high temperatures when the gas may be dissociated we shall see later that there are cases where chemical combination does promote the discharge of electricity.

The aggregation of molecules, as described in the preceding sections, is one method by which the attractions between the oppositely electrified atoms in the molecule might be weakened sufficiently to allow chemical action to proceed. Another method by which the same end might be accomplished would be for the molecules to be immersed in, or to be close to the surface of, a conductor or substance of large specific inductive capacity. The effect of this, as explained in the *Philosophical Magazine*, Vol. XXXVI. p. 320, would be to diminish the attraction between atoms and allow them to be easily separated. The substance which acts as the bridge for the interchange of the charges on the atoms might be the substance which when collected into lumps served by its electrostatic action to diminish the attraction between the atoms. This method of producing chemical change closely resembles the preceding—in each of them the presence of a third substance is necessary, and in each of them the formation of molecular aggregates, but whereas on the first view the aggregates are those of the substances which are combining chemically, on the second they are formed by the third substance.

The hypotheses to which we are led by the preceding considerations may be summed up as follows:—

The forces between charged atoms placed very near together are modified by the electro-chemical properties of the atoms. In consequence of this, an electro-negative atom, if positively charged, cannot, in the absence of a strong external electric field, interchange its charge with the negative charge on an electro-positive atom, unless the two are connected by an external conducting circuit.

Chemical action does not, in general, take place between a single pair of molecules alone in the field, but requires the formation of aggregates either of the inter-acting molecules or of some third substance which is either a conductor of electricity or has a large specific inductive capacity.

In the preceding statement an element is called electro-positive or electro-negative, according as its Volta coefficient is negative or positive.

Thus, on these hypotheses, chemical combination between two elements involves in general two processes: (1) a process by which all the electro-positive atoms, half of which were originally positively and half negatively charged, all become positively charged, while the electro-negative atoms become all negatively charged; (2) the combination of these properly charged atoms to form a molecule of the compound.

In some cases the process of chemical combination seems only to reach the first stage, that of the interchange of charges between the atoms of the elements. If the process stops at this stage, the electro-positive substance will be charged with positive electricity, the electro-negative substance with negative electricity. If one of the substances, say the electro-positive, is a solid or a liquid, while the other is a gas, then at the surface of the solid or liquid there will be two layers, one of positive electricity on the solid or liquid,

* Abstract from the *Phil. Mag.*, Vol. XL., December 1895.

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the other of negative in the gas. This double layer of electrification will make the electric potential discontinuous at the surface separating the two substances, the potential in the solid just inside the surface of separation exceeding that in the gas just outside the surface by a finite amount. The electrification produced by the splashing of drops is evidence of the existence of this double layer of electrification: when a drop of water or of mercury falls through air and splashes on a plate, the drop itself is positively electrified, while there is negative electrification in the surrounding air. On the view just given, this is an example of incomplete chemical combination: in the case of the water, the electrical interchanges preliminary to the formation of H_2O_2, the oxygen in the air getting the negative charge, have taken place; the second stage, however, does not go on, or at any rate is not completed during the falling of the drop. Thus the positively and negatively electrified atoms are not bound together so firmly as they are in a chemical compound, and get separated in the great extension of surface produced by the splashing. In the case of mercury the first stage of oxidation, that is the assumption of the negative charge by the oxygen and of the positive by the mercury, occurs, while the second either does not occur or is not completed during the fall of the drop. It would seem from the phenomena of drops that examples of this incomplete chemical action are very frequent, for the splashing of drops of the most widely different substances gives rise to electrification. In fact it seems possible that the existence of this double coat, and on our hypothesis of incomplete chemical action, is almost universal at ordinary temperatures, and that the electrification produced by the friction of heterogeneous substances is due to the partial rubbing off of this coating from one or both of the substances.

We shall now proceed to consider in the light of this hypothesis as to chemical action several simple chemical and electrical phenomena. We shall begin with the case of oxidation. Let us suppose that we have a zinc rod immersed in oxygen, and in order to take a case where the chances of combination are greatest, let us suppose that the oxygen molecules are dissociated by some external agent into atoms. Suppose that the combination begins, $\overset{+}{Z}n\overset{-}{O}$ being formed. Since a positive charge is withdrawn from the zinc and a negative one from the oxygen, the zinc and oxygen, which were originally electrically neutral, will now be charged negatively and positively, so that at the surface of contact of the zinc and the oxygen a charged condenser will be formed with its negative charge carried by the zinc atoms, its positive charge by the oxygen atoms. According to our hypothesis, zinc and oxygen atoms in these electric states do not combine unless connected by conducting circuits, so that, unless such circuits are present, for each molecule of ZnO formed there will be an increase in the charge on the condenser, and consequently an increase in its potential energy. The charge on the condenser is proportional to the number of molecules of ZnO formed, so that the electrostatic potential energy will be proportional to the square of the number of molecules; the diminution in the chemical potential energy due to the formation of ZnO is only proportional to the number of molecules of this substance. Thus the increase of the potential energy increases faster with the number of molecules of ZnO formed than the diminution in the energy; so that after a certain amount of chemical combination has occurred, any further combination will be attended by an increase in the total potential energy. When this point has been reached chemical combination will stop; so that under these circumstances only a limited amount of chemical combination will occur. Suppose now, however, that in addition to the zinc and oxygen other substances are present which can form conducting circuits between the negative zinc and the positive oxygen atoms, and thus enable these atoms to interchange their charges, so that the zinc becomes positively, the oxygen negatively electrified. In this state they can combine so that the condenser at the surface of the zinc will be discharged. As this condenser is constantly being discharged, there will be no increase in the potential energy due to it, and thus the progress of the chemical action will be accompanied by a diminution in the potential energy, and will therefore proceed until one or other of the substances is exhausted.

Similar considerations will show why but little chemical action goes on if zinc is immersed in acid, while the action proceeds freely when the zinc is connected to the acid by an external conducting circuit.

Observation seems to prove that a difference in the sign of the contact potential difference between two substances does take place when the circumstances are altered in such a way that we might expect great changes in the relative importance of these effects to occur. Thus there are cases where, when the substances are cold, when we should expect the chemical action to be sluggish, the electro-positive substance is at a higher potential than the electro-negative one, while when the temperature is that of red heat or higher, when chemical action is presumably more vigorous, the sign of the potential difference is reversed. Thus, for example, when a drop breaks off from a column of mercury and falls through oxygen, the mercury is positively, the oxygen negatively, electrified; again, when ultra-violet light falls upon a clean metal plate the metal is positively, the surrounding air negatively, electrified. In this case the sign of the potential difference indicates that the effect due to the interchange of charges overpowers that due to the chemical combination. If, however, we have a piece of metal above a red heat surrounded by air, the air will acquire a positive charge, the metal a negative one, so that in this case the effect of chemical combination overpowers any effect that may be due to the interchange of atoms.

The contact of the zinc with the solution in the preceding example thus gives rise to the formation of two layers of atoms, one layer being positively, the other layer negatively electrified. When the solution is very weak, this double layer which is interposed between the zinc and the solution consists of a layer of partly dissociated zinc molecules, the positive atoms being next the solution, the negative atoms next the zinc plate. If the solution is strong, the transition between the zinc and the solution is made by a layer of partly dissociated molecules of the salt, the positive layer, consisting of zinc atoms, being next the zinc, the negative layer, consisting of atoms of the electro-negative constituent of the salt, being next the solution. In the case of the contact of a metal and the electrolyte, the work required to produce the double electrical layer which gives rise to the potential difference is in the preceding investigation supposed to be done by the osmotic pressure. There is, however, another source of energy quite adequate to produce potential differences at the surfaces of contact of different substances, and which is available in the case of solids as well as liquids. This source is surface-tension. Every unit of area of the surface of separation of two substances, A and B, contributes an amount of potential energy equal to the surface-tension between A and B. Now Lord Rayleigh has shown (*Phil. Mag.*, October, 1883, p. 315) that, if the transition from A to B, instead of being abrupt, takes place through a thin layer (whose thickness need only be commensurable with molecular distance) whose properties are intermediate between A and B, the potential energy due to surface-tension will be diminished. This diminution in the potential energy will produce a tendency for such a transitional layer to be formed, even though the formation of the layer is accompanied by a double layer of electrification. The energy rendered available by a sensible diminution in the surface tension will be more than sufficient to charge the double layer of electrification up to a potential difference amounting to a large fraction of a volt. For if the distance between the electrified layers is 10^{-8}cm., and their potential difference 1 volt, the energy per unit area of the condenser formed by the double layer will be equal to $10^{16}/8\pi \times 10^{-8} \times 9 \times 10^{20}$, or about 44 ergs. If the surface tension were the same as that of water, the energy due to it would be 78 ergs per square centimetre, so that if any sensible diminution in this took place the energy rendered available would suffice to charge up the layer to a potential difference comparable with a volt. Even if the formation of this layer required as a preliminary chemical decomposition to liberate the charged atoms forming the layer, and this decomposition required a supply of energy, there would still be plenty available for this purpose. The thickness of the layer is comparable with the range of molecular forces; thus the quantity of matter in it, and therefore the amount of chemical decomposition, will be exceedingly small, so small as to be quite imperceptible by chemical means, but small as it is it may, in consequence of the enormous electric charges carried by the atoms, be sufficient to produce a finite potential difference between the coats of the double layer.

The amount of energy which would be liberated by a diminution in the abruptness of transition, and the effects which this might be expected to produce, are, I think, much greater than is generally suspected. Thus we should, for instance, expect that the abruptness of transition between, say, a metal like mercury and a gas like oxygen, would be diminished if between the mercury and the gas there was a film of the compound of the two: the tendency to form this compound would be very great, for if the film of oxide only diminished the surface tension by one per cent., enough energy would be liberated to suffice to raise the temperature of a film of oxygen 10^{-5}cm. thick several hundred degrees Centigrade. With this amount of energy available, it is difficult to avoid the conclusion that even the least oxidisable metals must, when exposed to air, be coated with a thin film of oxide, and though this film is too thin to be detected, either by chemical or optical means, it may yet, as we have seen, produce appreciable electrical effects. The same effects, too, might be expected to take place between solids: thus, if copper and zinc were brought into intimate contact, there would be a tendency for a layer of brass to form between them. It does not seem impossible that, under favourable circumstances, the zinc and copper might be cemented together by this film of brass.

This consideration, too, must have an important application to the electrification due to the splashing of drops; this phenomenon requires the existence of a double coating of electricity over the

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surface of the drop; to provide the atoms which carry the charges on these coatings chemical decomposition may have to take place. The energy for this may come from the lowering of the surface tension produced by the formation of an intermediate layer, so that at the surface of the drop chemical changes may take place, of which we have, at ordinary temperatures, no experience from experiments made with large masses of the substances.

Contact Difference of Potential between a Metal and a Coating of Oxide.

If we have a metal plate covered with a film of oxide or other compound of the metal, the transition from the metal to the air will be more gradual if the molecules of the compound in the part of the film near the plate are arranged so that the metal atoms are next the plate, and the oxygen atoms on the far side. In the molecules of the oxide, the metal atoms carry the charge of positive electricity, while the oxygen atoms carry the negative charge: there will thus at the surface of the plate be a double coating of electricity, the positive side of this layer being next the plate; the potential, therefore, will fall as we pass from the metal to the layer of oxide—that is, the oxide will be negative to the metal. This agrees with the results obtained by those who have experimented on contact electricity, and it further appears, as a possible interpretation of their experiments, that the potential difference between a metal and its oxide may amount to a considerable fraction of a volt.

Communication of Electricity from the Electrified Atoms of a Gas to a Conductor.

This is only another aspect of the preceding question. For suppose we have a number of electrified atoms of a gas in contact with a metal, and that the metal is electro-positive to the gas, the electricity can go from the gas to the metal in the following ways: (1) If the atoms of the gas are negatively electrified, they may combine with positive atoms of the metal to form a neutral compound, leaving an excess of the atoms of the metal negatively electrified. Or, if the atoms of the gas are positively electrified, then, if any substance is present which can form conducting chains between the atoms of the gas and those of the metal, the atoms will interchange their charges, the positive charge going to the electro-positive substance and the negative to the electro-negative. Those atoms of the gas which were positively charged might unite with those negatively charged to form molecules, so that the gas itself would emerge electrically neutral after contact with the metal.

It will be seen that each of these methods requires something more than mere contact of the gas and metal; this seems borne out by the phenomena exhibited by electrified gases. It was shown by Giese that electrified gases from a flame could pass through wire gauze connected with the earth, and yet retain their charges: this fact is exemplified in a very striking way by Lord Kelvin's electric strainers, as he finds that electrified gases still retain an appreciable fraction of their charges after passing through these strainers, which consist of many layers of wire gauze placed one behind the other. In an experiment I described in the B.A. Report for 1894 ("The Connection between Chemical Combination and the Discharge of Electricity through Gases"), an electrified gas retained its charge though enclosed in a vessel with a large pool of mercury connected to the earth. I have also found that such gases retain a large proportion of their charge after bubbling through a mixture of sulphuric acid and water. In a Paper "On the Passage of Electricity through Hot Gases" (*Phil., Mag.*, [5] XXIX., p. 444), I showed that when a current is flowing through a hot gas a piece of cold metal interposed between the electrodes completely stops the current, though when the metal gets red hot the current passes through it with ease. In all these cases the charged atoms would be striking against conductors, so that they furnish very strong evidence that this process alone is not sufficient to rob the atoms of their charges.

The first of the processes alluded to above would tend to make a gas lose a negative charge or the metal a positive one, while the second process would make the gas lose a positive charge, the metal a negative one. This is on the assumption that the metal is electro-positive to the gas; if it were electro-negative, the words positive and negative must be interchanged in the preceding statement.

The first process involves chemical combination, thus anything tending to promote combination, such as a high temperature of the gas or metal, would increase this effect; we should therefore expect to find evidence of this effect in the case of hot bodies. A very good instance of this effect is the fact, discovered by Guthrie, that a hot ball of iron could retain a negative charge when it could not retain a positive one. The experiments of Elster and Geitel also illustrate this point. Again I found (see *Proc.* Roy. Inst., April 13, 1894), that if in a vessel containing hydrogen (and probably a little air) at a low pressure, we split up some of the molecules of the gas so as to get a supply of positively and negatively electrified atoms, a red-hot clean copper rod connected with the earth would discharge the negative electricity and leave the positive behind. The negative electricity escapes from the gas, since the negatively electrified gaseous atoms combine chemically with the positive atoms of the metal. If, however, a red-hot copper rod thickly coated with oxide is placed in the gas, the *positive* electricity escapes from the gas through the rod to the earth. This is in accordance with the theory; the chemical process which now goes on is the reduction of the oxide: and this is effected by the positive hydrogen atoms combining with the negative oxygen atoms; thus the process affords a means of escape to the positive electricity in the gas, but not to the negative.

The second process by which we have explained the escape of electricity from a gas is that of the interchange of charges between oppositely-charged atoms. As the tendency for this process to take place arises from the Volta effect, it will be great when we have a number of strongly electro-positive atoms charged with negative electricity near a number of electro-negative ones charged with positive electricity. Thus we should expect the effect to be great when one of the substances is an electro-positive metal, as when this is in an electrically neutral state half the strongly electro-positive atoms are charged with negative electricity, and on account of the Volta effect there is a great tendency for them to lose their charges. When, however, we have an electrolyte instead of the metal we should expect the effect to be much smaller, as in an electrolyte the electro-positive element has the positive charge, the electro-negative one the negative; it might, however, still exist to some extent if, for example, the electrified gas in contact with the electrolyte were more electro-negative than the negative element of the electrolyte, and if the gas carried a positive charge.

This difference between metals and electrolytes may perhaps be the explanation of the fact that, whereas a sheet of metal when illuminated by ultra-violet light rapidly loses a negative charge while it can retain a positive one, this effect being most pronounced the more electro-positive the metal, an electrolyte, on the other hand, when exposed to ultra-violet light does not lose its charge, whether this be positive or negative.

Another example of the discharge of electricity by the second process is that in the glow discharge from a metal where the temperature is low the negative discharge occurs more easily than the positive—*i.e.*, the potential difference between the point from which the electricity escapes and the nearest large conductor is less when the point is negatively electrified than when it is positively. It would be interesting to see whether this difference would still persist if the point from which the discharge takes place were made of an electrolyte and not of metal. On the hypothesis we have just been describing we should expect the difference to be much reduced by the substitution of an electrolyte for the metal. Some recent experiments by Prof. S. P. Thompson show that the conditions of discharge are modified when lead peroxide is substituted for metal.

When a glow discharge takes place from a metal point connected directly with a Ruhmkorff coil or a Wimshurst electrical machine the surrounding gas gets negatively electrified. This, however, is not always the case if we connect the point from which the discharge takes place to an instrument producing potential differences greatly exceeding those given by a Ruhmkorff coil. A very convenient form of such an instrument is the one described by Prof. Elihu Thomson, which is a transformer whose primary is a coil connecting the outside coatings of two Leyden jars, while the secondary is a coil with a large number of turns carefully insulated from the primary. When the oscillating current produced by discharging the jars passes through the primary, the electromotive force induced in the secondary is able to induce sparks of great length. Using a transformer of this kind instead of the Ruhmkorff coil, Harvey and Hird (*Phil. Mag.*, Vol. XXXVI., p. 45) and Himstedt (*Wied. Ann.*, LII., p. 473) found that when the point discharged in oxygen, the gas was *positively* electrified, while when it discharged in hydrogen, the hydrogen was negatively electrified, just as when the Ruhmkorff is used. The very intense field produced by the transformer would split up the molecules of the gas and promote direct combination between the metal and the gas; this, as we have seen, would cause the gas to be positively, the metal negatively, electrified, and this, as we have seen, is what happens in the case of oxygen, though not in that of hydrogen. In the case of the electrification of the air in a vessel into which a point is discharging, we have to consider not only the communication of electricity from the point to the gas, but also the diffusion of the electrified atoms of the gas from the neighbourhood of the point through the vessel. Any difference in the rate of diffusion would, even though the communications of + and − electricity from the point to the jar were made with equal ease, give rise to an electrification of the gas. Imagine, for example, that negatively electrified atoms diffuse through the gas more quickly than positively electrified ones; then, if the rates of emission of + and − electricity were the same, the negatively electrified atoms would get further from the point than the positive, so that the outlying regions would get a charge of negative electricity; the region round the point would be charged with positive

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electricity, part of this would leak back into the point, leaving the gas as a whole negatively charged. Several phenomena, which I shall now proceed to describe, have led me to the conclusion that the effects due to the communication of the electricity from the metal to the gas are masked in many cases by the difference in the rates at which the electrified atoms diffuse, the negative atoms in all my experiments diffusing more rapidly than the positive ones. In the case of oxygen, where the gas gets a positive charge, the strong tendency for the oxygen to combine with the metal is sufficient to overcome the more rapid diffusion, whereas with such gases as hydrogen and carbonic acid, where the tendency to combine is weaker, diffusion gets the upper hand.

I made several experiments with chlorine, using different materials for the discharging point. The first substance I tried was silver chloride which had been fused into a solid mass; when this point was connected to one of the terminals of the high-tension transformer, the chlorine was negatively electrified. I then used a zinc point, protecting the zinc before the experiment began by covering it with a glass tube, through which it was pushed just before the discharge began; in this case, again, the chlorine was negatively electrified to a slight extent. I then replaced the zinc point by a sodium one, protecting this in the same way as the zinc by a glass tube; when the discharge passed from the sodium point, the chlorine was *positively* electrified. Thus by using a substance such as sodium, which has a very great affinity for chlorine, we are able to overcome the effect of diffusion, and get a positive charge in the gas, just as when the discharge passes from a copper point into oxygen.

The following experiments seem to show that a negatively electrified hydrogen or oxygen atom moves more quickly under equal electric intensities than a positively electrified one.

The outside coatings of two Leyden jars, A, B (Fig. 6), were connected by a wire wound into a coil C. In this coil an exhausted bulb was placed and a platinum wire fused into the bulb; this wire was connected with an electrometer. The inside coatings of the jar were connected with the terminals of an induction coil through the primary of which the alternating current used for lighting the

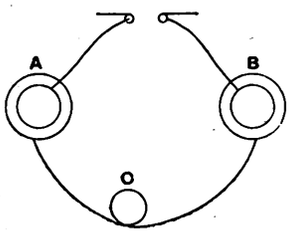

FIG. 6.

laboratory passed. This caused an arc discharge to pass between the terminals of the induction coil, and produced a potential difference between the insides of the jars. This potential difference can be very greatly increased by directing a blast of air on the space between the terminals of the induction coil, and so blowing out the arc. If we now examine the electrical state of the platinum wire in the bulb, we shall find that when the blast is on the wire acquires a positive charge when placed near the equator of the bulb (by the equator of the bulb we mean the region inside the bulb adjacent to the coil which encircles it), and a negative charge when placed near the pole. If, however, after the blast has been on for some time, it is suddenly stopped and the arc allowed to pass between the terminals of the induction coil, the sign of the electrification is reversed, the platinum wire now acquiring a positive charge when placed at the pole of the bulb and a negative charge when placed at the equator. Both these results are, I think, explicable if we suppose that the negative atoms diffuse more rapidly than the positive ones. For, take the case when the arc is blown out. Here there is a great potential difference between the electrodes, and the coil surrounding the bulb is raised to a high potential. This causes a brush discharge to start from the glass into the rarefied gas in the bulb, the discharge starting from the part of the glass nearest the coil, *i.e.*, from the equator. If, now, the negative atoms travel faster through the bulb than the positive, then, even though the same number of the two kinds of atoms start from the glass, the negative atoms will be in excess in the region remote from the origin of the discharge, while near this origin the positive atoms will be in excess: thus we shall have positive electrification at the equator, negative electrification at the poles. Let this go on until a number of positive and negative atoms are dispersed through the bulb. Then stop the blast. This at once greatly diminishes the potential difference between the terminals of the induction coil, and lowers the potential of the coil surrounding the bulb to such an extent that the brush discharge no longer takes place from the glass: the electric intensity in the bulb is lowered, so that no further decomposition of the gas takes place, and the bulb now does not show any luminosity. The charged atoms produced by the previous discharge linger for some time in the bulb before recombining, and move under the electric intensity due to the oscillating currents in the coil; the lines of electric intensity arising from the induction due to these currents are circles, with the line joining the poles of the bulb for their axis. Under these forces the atoms will tend to describe these circles; and since the negative ones move more quickly than the positive ones, the negative atoms will be revolving round the axis of the bulb with greater rapidity than the positive ones; hence, on account of centrifugal force, there will be an excess of negative atoms at the equator, and consequently an excess of positive ones at the pole: thus the equator will be negatively, the poles positively electrified. This electrification is, however, only transient, as the opposite charged atoms soon recombine.

If the negative atoms move more quickly than the positive ones, then in a discharge tube in a steady state the pressure at the positive electrode must be higher than that at the negative. For at any part of such a tube where there is no excess of positive electrification, the number of negative atoms which in unit time cross a section of the tube is greater than the number of positive ones. There will thus be a stream of *atoms* towards the positive electrode: to keep the pressure in the tube constant, we must compensate this by a stream of *molecules* from the positive to the negative electrode.

The potential gradient will vary inversely as the pressure of the gas, and the ratio of the pressure at the positive electrode to that at the negative will depend upon the square of the reciprocal of the pressure.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

SATURDAY, January 11th.

ASSOCIATION FOR THE IMPROVEMENT OF GEOMETRICAL TEACHING

11 a.m and 2 p.m. Meeting at University College, Gower-street.

TUESDAY, January 14th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "The Sanitary Works of Buenos Ayres: Sewage, Drainage and Water Supply," by the Hon. R. C. Parsons.

WEDNESDAY, January 15th.

ROYAL METEOROLOGICAL SOCIETY.

7:45 p.m. Annual General Meeting at the Institution of Civil Engineers, 25, Great George-street, S.W.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Annual Meeting at 20, Hanover-square. Presidential Address by A. D. Michael.

THURSDAY, January 16th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Presentation of Premiums, Inaugural Address of the President, Dr. John Hopkinson. M.A., F.R.S.

FRIDAY, January 17th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Students' Meeting. Paper to be read: "Iron Tunnels," by W. O. Leitch, Jun.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "More about Argon," by the Right Hon. Lord Rayleigh, F.R.S.

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NOTICE.

With the current number of "The Electrician" is issued as a Supplement (Gratis) a Coloured Sketch Map of Provincial Electric Supply Stations. Complaints of non-receipt should be at once sent to the publisher.

OVERPRODUCTION.

An exceedingly sanguine man is Mr. HENRY FLOY, of America. Having discovered by a partial application of the statistical method that, contemporaneously with an unlimited faith in the future of electricity, there exists in the United States, as elsewhere, a decidedly limited demand for electrical engineers, and that, as a consequence, "the opinions and lives of many individuals are erroneously shaped," Mr. FLOY concludes it is "time for those who realise the situation to set about correcting the existing misconceptions." As if anything short of actual contact with hard facts had ever dissipated a pleasant popular fallacy. However, whether it is agreed or no that Mr. FLOY's attempt to stem the flowing tide with a magazine article is an attempt to perform the impossible, the results of his inquiries are of some interest. Struck by the alarmingly small ratio which the apparent supply of suitable positions bears to the undoubted demand for them by the twelve hundred ambitious young men annually graduating as electrical engineers, Mr. FLOY, like a true American, proceeded to send out some 260 personal letters to the present-year graduates in electrical, mechanical and civil engineering from Cornell and Lehigh Universities and the Massachusetts Institute of Technology, and—strange to relate—received no less than 122 "most interesting, courteous and complete" replies. We shudder at the thought of the replies, which would probably have been received in this country had anyone ventured to interrogate English engineering graduates in an equally inquisitorial fashion. The replies would assuredly have proved interesting, but possibly neither courteous nor complete. One probable point of similarity is, however, mentioned by Mr. FLOY: "the letters written by the graduates of one college were particularly noticeable as indicating their authors' lack of training in the use of good English."

Turning now to the statistical data gleaned by Mr. FLOY, and presented this month to the readers of the *Engineering Magazine*, in an article entitled "Are we Educating too many

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Electricians?" let us see what they reveal, bearing in mind the author's modest estimate of them as "strong indications of probabilities," not proofs. To would-be electrical engineers he sent out 108 circulars, and received 52 replies. These *tend* to show that while a greater percentage (78·8 per cent.) of electrical engineering graduates secured employment, as compared with civil and mechanical engineering graduates, they only did so in virtue of the fact that they had taken up positions in which their electrical training was so much pure waste, and because they were content to accept considerably lower pay. It is also worthy of notice that almost twice as many electrical men secured employment through the influence of relatives than was the case with the mechanical or civil men. This is really too disheartening. We have frequently been asked for advice by potential engineers as to the best branch to specialise in, and our invariable counsel has been: Exercise great care in choosing your father, and then join *his* branch. We have always flattered ourselves, however, that this well-known dictum did not apply to electrical engineering. But if Mr. FLOY's statistics indicate "strong probabilities," nepotism is more flourishing in the profession of electrical engineering —at any rate in America—than it is in the more ancient engineering professions.

Is there not good reason to believe that we in England are also educating too many electrical engineers? The same idea prevails, it is true, about every profession in this overcrowded little island; but whilst it is sombrely acquiesced in by harassed fathers as regards, say, the legal or the medical profession, it is in the case of electrical engineering only prevalent amongst the initiated. Hence the stream of youth impinges upon electrical engineering with tremendous force, which nothing but the irresistible logic of facts will diminish. Meanwhile, it may be asked whether there would not at least be greater contentment among young electrical engineers if they were less elaborately prepared for posts they are destined never to occupy. Assuming, for the sake of argument, that the average college electrical engineering course is all that could be wished as a mental equipment, does it not tend to foster an intense dislike, if not a positive disability, for the dull routine work which forms so large a part of the general engineering work of the world? No doubt the training now fashionable is an excellent machine for turning out demonstrators, professors, and engineering investigators, but is it to be compared with that received through the medium of the shops, drawing office, works test-room, evening class and miscellaneous outside experience so far as the filling of the more numerous and less exalted posts with contented, competent men is concerned? The man whose mind is enriched with sound scientific knowledge has intellectual resources and interests unknown to his less elaborately trained competitor; but is he as a rule likely to regard his college education merely as a means of enlivening the drudgery of his mechanical day-stint? Will he not rather come to look upon his two or three years' college course as a long lane leading nowhere, unless it leads to congenial employment, and a remuneration more commensurate with his many accomplishments? In short, will the "techniker" be as contented with his lot as the man who lacks "the burden of lean and wasteful learning." The *tendency* of the supply is, of course, to accommodate itself to the demand; but the process is sometimes long, and, in matters of this kind, always painful. It may be perfectly true, economically speaking, that there is no such thing as over production, but merely "ill-assorted" production; but when the ill-assorted product is a human being the distinction becomes indistinguishable.

ELECTROMAGNETIC THEORY.—LXXXI.*

BY OLIVER HEAVISIDE.

(*Continued from page 278.*)

§ 322. The following way of regarding the matter is useful in combinations. It has the advantage of compactness. Imagine any combination to be disturbed by the impression of a current upon it. Let the current be h, and its point of entry be denoted by y. Then

$$h = Y_y V_y, \quad \text{or} \quad V_y = \frac{h}{Y_y}, \tag{76}$$

is the connection between h and V_y, the resulting potential at y, if Y_y is the conductance operator there, or the sum of the conductance operators of the paths open to the impressed current. The path of entry is not counted.

If Y_y is known, (76) may be algebrised as it stands. But to represent an initial state of charge or electrification, let $h = pQ$, where Q is constant. Then

$$V_y = \frac{pQ}{Y_y} \tag{77}$$

expresses the potential at y due to the impulsive entry of the charge Q; and its expansion is

$$V_y = \Sigma \frac{Q\epsilon^p}{Y_y'} + \text{steady term}, \tag{78}$$

ranging over the roots of $Y = 0$, the accent meaning differentiation to p. There is a steady term if p/Y_y is finite when $p = 0$. This is exceptional.

Now to find V_x, the potential at some other point x in the combination, we require to multiply V_y by the operator V_x/V_y; as in

$$V_x = \frac{pQ}{(V_y/V_x)Y_y}. \tag{79}$$

But in a normal state, such as the general term of the expansion refers to, we must multiply by u_x/u_y, if u is the normal function. This makes

$$V_x = \Sigma \frac{Qu_y u_x}{u_y^2 Y_y'} \epsilon^{pt} = \Sigma A u_x \epsilon^{pt}. \tag{80}$$

Now, the coefficients A are subject to the conjugate property, and determined by (62). The numerator Qu_y agrees. So the denominator is U − T. Or

$$V_x = \Sigma \frac{Qu_y u_x}{U - T} \epsilon^{pt}. \tag{81}$$

But U − T represents an integration extended over the whole system. It is fixed when u is fixed at any point, and has nothing to do with the value of y, the position of Q. Therefore the alternative form of U − T shown in (80) must be independent of the position of y, so that

$$V_x = \Sigma \frac{Qu_y u_x}{u_z^2 Y_z'} \epsilon^{pt}, \tag{82}$$

where z is any point, and Y_z the conductance operator there. (But do not choose a place where u vanishes, as that will require a compensating infinity.) Lastly, if there are only two paths meeting at z, we have the equivalent form

$$V_x = \Sigma \frac{Qu_y u_x}{-c_z^2 Z_z'} \epsilon^{pt}, \tag{83}$$

by (66), (68), where c_z is the normal current at z, corresponding to u_z, and Z_z the resistance operator there. This form is perhaps more generally useful.

An integration over the whole combination will determine the value of A so far as it depends upon initial charge. If further, there is initial magnetic energy, it must be allowed for as in (62). It is important to think of the normal function u as a single function. It may, indeed, have various forms of algebraical expression in different parts of the combination, but that is of no consequence in the present connection.

§ 323. Example should supplement precept, if it does not precede it, which may be better still. Therefore, let us apply

* This series of articles is a portion of Vol. II. of Mr. Heaviside's work on "Electromagnetic Theory." All rights of reproduction are reserved.

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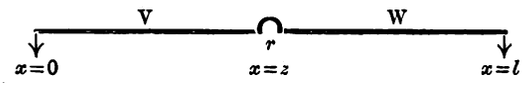
the above to the case of two cables of different types joined in sequence, with an intermediate insertion. Let r be the



resistance operator of the insertion (containing no leak), which is made at the distance z from $x=0$. The resistance operator of the combination, reckoned at z, is

$$Z = r + \frac{R_1}{s_1}\tan s_1 z + \frac{R_2}{s_2}\tan s_2(l-z), \qquad (84)$$

the cables having different R and S. Here Z is such that e/Z is the current at z due to e there.

Now put Q at y, less than z. If the normal potential function u of the last section is v in the first cable and w in the second, and the resulting potentials are V and W, we have

$$V = \Sigma \frac{Qv_y}{U-T} v\epsilon^{pt}, \qquad W = \Sigma \frac{Qv_y}{U-T} w\epsilon^{pt} \qquad (85)$$

But if Q is in the second cable, then

$$V = \Sigma \frac{Qw_y}{U-T} v\epsilon^{pt}, \qquad W = \Sigma \frac{Qw_y}{U-T} w\epsilon^{pt}. \qquad (86)$$

In these, v, w, V and W refer to the variable point x, whilst Q refers to y.

We have next to specify the nature of v, w. Since the first cable is earthed at $x=0$, and the second at $x=l$, we may put

$$v = \sin s_1 x, \qquad w = a\sin s_2(l-x), \qquad (87)$$

provided a is settled so as to harmonise them. This is to be done by the continuity of the current at z; that is,

$$\frac{s_1}{R_1}\frac{dv}{dx} = \frac{s_2}{R_2}\frac{dw}{dx}, \quad \text{at} \quad x=z. \qquad (88)$$

This makes

$$w = -\frac{R_2 s_1}{R_1 s_2}\frac{\cos s_1 z}{\cos s_2(l-z)}\sin s_2(l-x). \qquad (89)$$

The normal function being complete, it remains to evaluate U – T for it. Since we know Z at the point z, the shortest way is by $-c^2Z'$. Thus

$$V = \Sigma \frac{Q\sin s_1 x \sin s_1 y}{-\left(\frac{s_1}{R_1}\cos s_1 z\right)^2 \frac{dZ}{dp}} \epsilon^{pt} \qquad (90)$$

is the potential at x due to Q at y, when both x and y are in the first cable, Z being given by (84). The summation ranges over the roots of $Z=0$. There is no steady term, because of the earth connection. For d/dp may be substituted differentiation to s_1 or s_2 for trigonometrical convenience, and so we come to the fully-developed formula, suitable for calculation if required. In general r is a function of p. But we do not need to allow for that unless there is initial energy in r itself.

If x is in the second cable, y being still in the first, we must put w for v in (90). If x and y are in the second cable, use w_x and w_y in the numerator. If y is in the second cable and x in the first, use w_y and v_x. In short, follow (85), (86).

If the effect of a localised impressed voltage is wanted, we may use the resistance operator at the place. Thus, when e is at Z, then

$$C = \frac{e}{Z} = \frac{e}{Z_0} + \Sigma \frac{e}{pZ'}\epsilon^{pt}, \qquad (91)$$

where z is as in (84), and Z_0 is the steady resistance. To find C at any other place x, introduce the factor c_x/c_z in the general term. It is the ratio of the normal current functions at x and z, and is known.

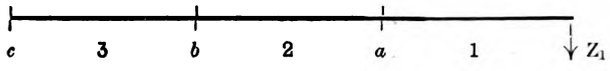
If e is at $x=0$, a different Z is needed. We may regard it as the resistance operator of the first cable with a terminal arrangement, say Z_1, given by

$$Z_1 = r + \frac{R_2}{s_2}\tan s_2(l-z). \qquad (92)$$

It is then a special case of (59), § 291. Again, if e is at $x=l$, we may bring the case under the same formula by treating it as a cable (the second one) with a terminal arrangement

$$Z_2 = \frac{R_1}{s_1}\tan s_1 z. \qquad (93)$$

It may also be noted that the same formula allows us to construct the resistance operator of any number of cables of the same or different types put in sequence, with intermediate insertions. For instance, we know the resistance operator at



a of cable 1 with Z_1 at its end. Call it Z_2. It is

$$Z_2 = \frac{R}{s}\frac{(R\sin + Z_1 s\cos)sl}{(R\cos - Z_1 s\sin)sl}, \qquad (93A)$$

using the proper R and s for the first cable. Then, by the same formula, we know the resistance operator at b of cable 2 with Z_2 at its end. Call it Z_3. Then we know the resistance operator at c of cable 3 with Z_3 at its end. That is, we know the resistance operator at c of the complete combination. This process may be continued to any extent, and results in a continued fraction, which soon assumes gigantic size. There may be intermediate insertions (without leaks), without essential change. But leaks require a little change of treatment. Say there is a leak at a, then Z_2 is to be the resultant resistance operator of the leak and that of the cable 1 with Z_1 at its end; that is, the reciprocal of the sum of their reciprocals. Using this modified Z_2, we may proceed as before till we come to the next leak, say at b, where we make a similar modification.

If an intermediate resistance operator is wanted, that is merely the sum of the resistance operators to right and left, to be got by the same process, which applies when the cables are not each of uniform resistance and permittance, and when the inductance and leakance are not ignored. Of course, however, when R and S vary in any one cable, its resistance operator requires special investigation.

§ 324. Still keeping to two cables in sequence, for simplicity of illustration of broad principles, let one be an ordinary cable, the other with R and S varying in such a way as to produce another kind of normal function. In passing, it may be observed that by causing R and S to change gradually from uniformity of distribution to various other arrangements of the same total resistance and permittance, we can continuously deform the simple normal function $(\sin sx + a\cos sx)$ so as to make it assume the shape of any other kind of normal function. In case of two kinds of cables, the results will be exhibited in two series, say a Fourier series for one cable, and a Bessel series for the other, properly harmonised.

In order to have the zeroth Bessel normal function, we need only let the conductance and permittance per unit length of cable both vary directly as the distance from $x=0$. There are other ways, but this is the simplest. Thus, the circuital equations

$$-\frac{dV}{dx} = RC, \qquad -\frac{dC}{dx} = Sp V, \qquad (94)$$

unite to make the characteristic

$$\frac{d}{dx}\left(\frac{1}{R}\frac{dV}{dx}\right) = SpV, \qquad (95)$$

without assumption of constancy of R and S. Therefore, if

$$\frac{1}{R} = \frac{x}{R_0}, \qquad S = S_0 x, \qquad (96)$$

R_0, S_0 being constant, we produce the characteristic

$$\frac{1}{x}\frac{d}{dx}x\frac{dV}{dx} = RSpV = q_0^2 V, \qquad (97)$$

where RS is the constant R_0S_0.

The proper solution for our purpose is

$$V = I_0(q_0 x)\,.\,A = \left(1 + \frac{(q_0x)^2}{2^2} + \frac{(q_0x)^4}{2^2 4^2} + \ldots\right)V_0, \qquad (98)$$

where V_0 is a time function, and I_0 is defined by the expansion given. The corresponding C is

$$C = -\frac{1}{R}\frac{dV}{dx} = -\frac{q_0}{R}I_1(q_0x)\,.\,V_0, \qquad (99)$$

where I_1 is the derivative of I_0.

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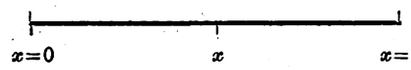
The meaning of V_0 is clearly the potential at $x=0$ itself, given as a function of the time. But we do not want that particularly. In fact, since the



conductance is zero at $x=0$, there is no current there due to any finite impressed voltage, and we should avoid the point $x=0$ for our immediate purpose. We have

$$\frac{V}{C} = -\frac{R}{q_0}\frac{I_0(q_0x)}{I_1(q_0x)} \qquad (100)$$

at x. Therefore, if e is impressed at λ, the resistance operator is

$$Z = \frac{R_0}{q_0\lambda}\frac{I_0(q_0\lambda)}{I_1(q_0\lambda)}, \qquad (101)$$

if we now reckon the current positive from λ to 0. That is, e/Z is the current entering at λ, if there is earth on the other side of e. Or, more generally, V/Z is the current at λ when the potential there is V variable anyhow, due to sources on the side of λ beyond the cable in question.

The formula for the potential at x is simply got by (98), observing that it must reduce to e at $x=\lambda$. Thus,

$$V = \frac{I_0(q_0x)}{I_0(q_0\lambda)}e, \qquad (102)$$

from which C follows by a differentiation according to Ohm's law.

By (102), we see that

$$I_0(q_0\lambda)=0, \quad \text{or} \quad J_0(s_0\lambda)=0, \qquad (103)$$

is the determinantal equation, if $q_0^2=-s_0^2$. Here J_0 is an oscillating function analogous to the cosine. Why we should have it so will be seen on remembering that there is no current at $x=0$, so that, if R and S were constant, the normal function would be $\cos sx$.

Applying the expansion theorem to (102), where e is steady, V expands to

$$V = e + e\Sigma\frac{I_0(q_0x)\,.\,\epsilon^{pt}}{p\frac{d}{dp}I_0(q_0\lambda)} = e + e\Sigma\frac{J_0(s_0x)\,.\,\epsilon^{pt}}{\frac{1}{2}s_0\frac{d}{ds_0}J_0(s_0\lambda)},$$

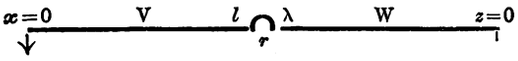
or

$$V = e - e\Sigma\frac{J_0(sx)\,.\,\epsilon^{pt}}{\frac{1}{2}s_0\lambda J_1(s_0\lambda)}, \qquad (104)$$

if J_1 is the negative of the derivative of J_0. This shows the manner of establishment of the final state of V, which is $V=e$ all over, owing to the vanishing conductance at the far end.

We can, of course, put on any terminal Z_0 in place of earth on the other side of e, and solve in a similar way, but that would be premature at present.

§ 325. Pass to the matter immediately in question—namely, the harmonisation of the solutions for two cables of different natures. Let the cable on the left be of the regular kind, and



that on the right be of the kind considered in the last section. Earth is on at $x=0$ in the first cable, but the $z=0$ end of the second cable is virtually insulated, if that is the point of vanishing conductance. We measure x from left to right in the left cable, in which the potential is V, and z from right to left in the other, where the potential is W. Between them, at $x=l$ in one and $z=\lambda$ in the other cable, is inserted any combination r without leakage. The complete resistance operator at r is

$$Z = r + \frac{R}{s}\tan sl + \frac{R_0\lambda}{q_0}\frac{I_0(q_0\lambda)}{I_1(q_0\lambda)}, \qquad (105)$$

by (101), using the notation of the last section for the Bessel cable, except that x is now z, to distinguish it from x in the first cable. So the impressed voltage e at r produces the current

$$C_\lambda = \frac{e}{Z} = \Sigma\frac{e\,\epsilon^{pt}}{pZ'}, \qquad (106)$$

subject to $Z=0$, with the form of Z shown by (105).

This being merely a special case, let us examine the result of charging both cables initially in any given way, and leaving them to themselves. The formulæ are (85) and (86), provided we harmonise v and w, and evaluate U – T. The form of v is obvious, so

$$v = \sin sx, \qquad w = bI_0(qz), \qquad (107)$$

where b has to be found so as to make w fit v properly. This may be done by the voltage equation at the junction, or

$$v - w = rc, \qquad (108)$$

where $x=l$ in v and $z=\lambda$ in w, and c is the current corresponding to v. It is also the current corresponding to w, and their equalisation produces the determinantal equation (105) already found. Now (108) is the same as

$$\sin sl - bI_0(q_0\lambda) = -\frac{rs}{R}\cos sl, \qquad (109)$$

which gives b, and makes

$$w = \frac{I_0(q_0z)}{I_0(q_0l)}\left(\sin sl + \frac{rs}{R}\cos sl\right). \qquad (110)$$

This w is the other part of the normal system u, for v and w together make it complete, except as regards the internal variation in r itself, which we do not want.

There is only left the evaluation of U – T. As before, the resistance operator at r being known, we may employ the $-c^2Z'$ form, and therefore get, subject to $Z=0$ in (105),

$$V = \Sigma\frac{Q\sin sx\sin sy}{-\left(\frac{s}{R}\cos sl\right)^2\frac{dZ}{dp}}\epsilon^{pt}, \qquad (111)$$

when x and y are in the first cable; it being v_xv_y that is used in the numerator. Substitute w_xw_y when they are in the Bessel cable, using (110); and v_xw_y or v_yw_x when x or z is in one and y in the other cable. Also, instead of $I_0(q_0z)$, use $J_0(s_0z)$.

When the initial state is given to be that the potential is U, the coefficient of the normal function is got by an integration, thus:

$$A = \frac{\int SUu\,dx}{U-T} = \frac{\int SVv\,dx + \int S_0zWw\,dz}{U-T}, \qquad (112)$$

where in the first form u is the complete normal function, whilst in the second it is separately exhibited for the two cables, the initial U becoming the initial V and W respectively.

§ 326. The above case of two cables of the ordinary kind having different uniform resistance and permittance, and more particularly the case in which one cable is uniform whilst the other is of a variable type, are meant to lead easily to a broad understanding of a normal distribution in general. It should be regarded as a single function of position in the combination, no matter how many forms it may assume in different parts. To illustrate this, imagine any number of cables put in sequence, with any terminal arrangements, any way of variation of resistance and permittance, and any number of intermediate insertions or leaks. A normal system of potential is one which, when left to itself, preserves its form when subsiding. To find it, we may first divide the whole cable into sections containing no intermediate insertions or leaks. Then, if R, S vary in any section according to a single formula, it may be treated by itself. But if there are two or more formulæ concerned, we must subdivide into smaller sections. So we come down to a section having a single characteristic. It is equation (95) above. Regarding p as a constant, there are two independent solutions, say $u=av+bw$, a and b being any constants, v and w the two solutions, functions of x. Every section has its u of this kind, with its own special v and w. They have next to be fitted together. This is to be done by the intermediate and the terminal conditions, introducing all the necessary continuities and discontinuities. The result is a single normal function u, represented by u_1 in the first section, u_2 in the second, and so on, but of arbitrary size. At the same time the conditions furnish a general determinantal equation. It is the characteristic of the whole combination, say $Z=0$, and the values of p satisfying it are *the* values of p permissible. Thus $Au\,\epsilon^{pt}$, where A is a constant, represents a complete normal system at time t, so far as the cable is concerned, and

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therefore $\Sigma A u \epsilon^{pt}$, including all the normal systems corresponding to the different p's, represents the solution arising from any initial state. The normal u may, if we please, be continued over all the intermediate and terminal insertions and leaks, to make it fully complete. The size of the normal systems is then settled by their conjugate property, which leads to the formula (62), and other forms. If any part of the combination contain no energy initially, its detailed consideration may be omitted, and its influence on the rest allowed for by a resistance operator. This applies to parts of the cable itself as well as to insertions and leaks.

(To be continued.)

CABLE COMMUNICATIONS WITH SOUTH AFRICA.

In consequence of recent events in the Transvaal, and the delay which has occurred to ordinary telegrams between that part of the world and Europe, much interest has been naturally shown in our cable communications with South Africa. The following statement may serve to remove much of the misapprehension which appears to exist on this subject. The present submarine connections, under normal conditions, with South Africa are as follows:—

The original cables on the East Coast, starting from Aden, where they join the Eastern Company's system of duplicate and triplicate lines to this country and the East. The sections are: Aden to Zanzibar, Zanzibar to Mozambique, Mozambique to Delagoa Bay, and Delagoa Bay to Durban, where they connect with the Government land lines communicating with the interior of South Africa and Cape Town. There are two cables between Zanzibar and Mozambique, and the East Coast lines are all provided with apparatus for duplex working.

From Cape Town the West Coast cables establish communication with England by way of Mossamedes, Benguella, Loando, Accra, Sierra Leone, St. Vincent, Madeira, Lisbon to the Land's End. From St. Vincent to Lisbon the cables are duplicated, and from Lisbon to the Land's End there are three submarine lines. It will be seen therefore that, starting from Lisbon, there is a complete telegraphic circle, forming two alternative routes, round the continent of Africa.

On Tuesday, December 24th, the cable between Aden and Zanzibar became interrupted, and at this time the Eastern Telegraph Company's cable steamer "Chiltern" was two days out from Suez on her way to Aden, where she arrived on the Friday night, and found a telegram awaiting the ship's arrival instructing her to proceed to the repair. Having coaled with all despatch, she left on Saturday evening for the position of the break, which was caused by suspension across a submarine valley. The interruption of this cable, it will be observed, was prior to the outbreak of hostilities in the Transvaal, and before any information that they were probable had reached this country. Notwithstanding, however, that the Company had no reason to apprehend any unusual pressure upon their cables, the Eastern and South African Telegraph Company, in order to save the six extra days which it would have taken their own repairing steamer, the "Great Northern," then at Cape Town fully manned, to restore the communication, chartered at considerable expense the s.s. "Chiltern." On the following Thursday, January 2nd, the ship arrived in the neighbourhood of the fault, fulfilling anticipations almost to an hour. With the second sweep of her grapnel she hooked the Aden end of the cable, and proceeded to pick up the fault. The end was then buoyed, and she proceeded to grapple for the Zanzibar end, which she was successful in securing at the first attempt. The necessary tests having been effected, the final splice was made, and the cable dropped into its position at 7 p.m., London time, on Saturday, January 4th.

Meanwhile, in addition to heavy traffic in connection with the Ashantee expedition, events had arisen which are too well known to need recapitulation, which flooded the remaining line of communication, viz., that by the West Coast, with Government telegrams sufficient to tax the cables to their utmost capacity, and as it is a provision of the International Convention that such traffic should take precedence of all other telegrams, it necessarily followed that Press and ordinary messages were excluded until the line was completely clear of official despatches. The first telegram containing information of the events alluded to was handed in at the Cape Town office on December 30th, and from that day until January 4th, when the East Coast connection was restored, not a single ordinary telegram, either Press or commercial, left South Africa for Europe of later date than December 30th. The restoration of the East Coast line, in any case, would have afforded immediate relief to the pressure; but, as hostilities had ceased, the Government traffic was not so heavy, thus affording a double relief to the West Coast route. Owing to arrangements made in London, by which the different routes were judiciously utilised, the block of nearly a week's traffic from and to the Cape is now practically cleared. There has not, however, during the whole period, been the slightest delay on the messages of any Government, British or otherwise. It should be distinctly understood that the submarine companies are only responsible for delay upon messages received at their offices on the seaboard, the land lines in this case being solely controlled by the governments of the Transvaal and Cape Colony.

It should be borne in mind that the carrying capacity of every cable is strictly determined by the size of its conductor and its length, and allowing for the comparatively slow rate at which long submarine cables must of necessity be worked, it does not require much calculation to see that the unusually heavy Government traffic could not fail to cause considerable delay to ordinary messages. And obviously cable companies cannot be expected to expend millions of money in laying triplicate lines to provide for a contingency which may only occur once in a generation, and which was caused in this case by the most inopportune interruption of one of the existing lines of communication.

The existing cables have a great reserve of carrying capacity over all ordinary traffic, and no delay was caused by the abnormally heavy telegraphing recently in connection with South African mining.

Centralisation of Light, Power and Traction in Germany.—At a recent meeting of the Elektrotechnischer Verein of Berlin, Dr. M. Kallmann, electrical engineer to the municipality of Berlin, read a Paper on the centralisation of the supply of light, power, and traction. He showed by means of statistics, and diagrams representing the average figures of seven provincial supply stations in Germany, that it would be of great advantage to the electric light stations if the supply of power for motor and traction purposes was carried out by lighting stations. In provincial towns little has been done in this direction, but in Berlin there are at present about 700 motors of a total capacity of 2,500 H.P. connected to the different central stations. The energy consumption of these motors during last year was a little over 1,000,000 kilowatt-hours. This is about 16 per cent. of the year's output of the stations. Dr. Kallmann then touched on the economic aspect of the question. It is the practice of Germany to connect in continuous-current plants two 275-volt dynamos to each steam engine, which can then either be connected in series, making 550 volts for traction work, or run in parallel for lighting purposes on the three-wire system. Such arrangements permit of the alternative use of the sets for either traction or lighting purposes, and each set may also serve as reserve to the other. Such a combination will be put to a practical test in Berlin in 1896, when two electric tramways, which are now being built to connect the city with the Industrial Exhibition at Treptow, will be supplied with current from the lighting stations. The charge is fixed at 1·2d. per kilowatt-hour, and it is estimated that the year's consumption of each line will be over 1,000,000 kilowatt-hours. If the Berlin tramways, with their 210 miles of line and 19,000,000 car-miles per annum, were electrically equipped, and assuming the traffic to increase to 25,000,000 car-miles per year, the total year's consumption would be over 20,000,000 kilowatt-hours, which would be three times the present total output of the Berlin stations.

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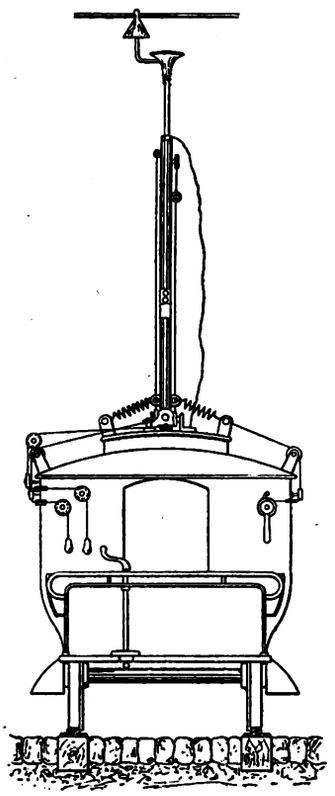
THE WESTINGHOUSE SIDE-CONTACT TROLLEY WHEEL.*

The trolley and its accessories have given rise probably to as many modifications as any one of the other numerous details which go to make up the electric railway system of to-day. Early work began with the over-running trolley, which, however, was soon found to be ill adapted to the task, and hence was soon followed by the under running contact, which is at present in universal use. Like many devices of the kind in electrical work which have proved successful, the under-running contact has given rise to litigation, and inventors have been at work to devise other adequate and practical means. A recent striking example of this is exhibited in a patent issued to Mr. George Westinghouse, Jun., which describes a trolley designed to make contact with the side of the trolley wire.

The accompanying illustration shows the method. As will be seen, the trolley wheel, if it may be so designated, is of a tapering



Westinghouse Side-Contact Trolley wheel.

inverted bell form, having a wide flange which extends above the top of the trolley wire. The trolley pole on which the wheel is mounted swings in a plane at right angles to the direction of the car, so that it is always pressed toward the side of the wire. The arrangement is such that by suitable springs the wheel can be made to effect contact with either side of the wire. Suitable arrangements also provide for variations in the height of the wire. The tension of the springs controlling the contact trolley is effected by cords under control of the motorman.

DEVICE FOR PROTECTING PHYSICAL INSTITUTES AGAINST DISTURBANCE BY ELECTRIC RAILWAYS.†

BY DR. O. FRÖLICH.

In the *Elektrotechnische Zeitschrift* of July 4th, I made two proposals by which measuring instruments in physical institutes could be protected from the disturbances caused by the earth return of electric tramways. The principle was one of compensation, and consisted of wires in which flowed either part of the earth current or a shunt current appearing at the same time as the earth current, the wires being led over or around the instruments intended for protection in such a fashion that the immediate action of the earth current would cancel itself. In the first proposal the compensation wire or wires terminated in earth plates which were buried near the building intended for protection, and which received part of the earth current. In the second proposal the compensation wire was connected to several points of the rails near the institute, then led over the building and connected to the end of the rails near the power house. The first proposal was intended to compensate all earth currents passing under or near the building, and the second only the leakage from the tramway. The second proposal had the advantage over the first, that earth plates and the difficulty connected with them were avoided and only metal conductors were employed. Without, however, dropping the first proposal, I thought it was more profitable to work out the second and bring it into a practical shape. I have been successful in attaining this aim, and the disturbances due to electric lines have been reduced 75 per cent. to 80 per cent. on one line, and 95 per cent. on another. In a small model a 95 per cent. reduction was obtained. The first experiments were made by Dr. Raschorn on the Steglitz-Lichterfelde and Dresden-Blasewitz electric lines, but as far as compensation is concerned, no practical results were then obtained, and it is therefore unnecessary to describe these experiments. To solve the problem on an actual line was a difficult matter, as only a few hours during the night were available. As, therefore, the method of experimenting was likely to want remodelling and correcting, a small model of an electric line was put up, and so arranged that a magnet needle placed near indicated any disturbance when the model car was on the line. The disturbance curve for every position of the car was first traced out, and the compensation wires then arranged accordingly. As it has been found that the so-called stray earth currents are the main cause of the disturbance, and the direct effect of the conductor of the tramway disappears as compared with the action of the earth currents, the model line was arranged accordingly. A curve such as T, in Fig. 5, was then obtained. When a car leaves the generating station a disturbance is noticeable as the car approaches the instrument; this disturbance increases slowly at first, then more quickly, and continues to increase until the car has left the instrument a certain distance behind; it then settles down to a constant amount until the car has arrived at the far end of the line. This typical course of the disturbance represents the case of a straight tram line running parallel to the needle, but is modified when the line has curves, and is in a different direction to the needle. In reality, however, these modifications do not appear to be very important, at least when needle and line are in the same direction. Curves have been traced for the lines at Dresden and Pankow. It will be observed that the main action of the earth currents commences when the car has passed the instrument. Earth currents mostly appear near the parts of the rails in which a current is passing, and they persist until the car is at a great distance. Disturbances caused by direct influence exhibit a different course to the earth currents. While the latter act mainly upon the instrument when the car passes, and for a certain time afterwards, the direct action behaves like a powerful but short magnet which moves behind the car at a lower speed. By Ampère's law the rectangle which is formed by the overhead conductor, the corresponding part of the rails, the conducting parts of the car and the conductor between generator and overhead wire, can be replaced in its action upon the instrument by a magnetic double plane, which, however, again can be replaced by a short magnet, the axis of which is perpendicular to the tram line, and which lies in a certain central portion of that plane, the magnetic intensity of which increases with the length of the rectangle—that is to say, with the distance of the car from the generating station. The conductor rectangle grows steadily with the movement of the car, and and while one of the short sides remains stationary at the generator, the other formed by the car moves over the line. The magnet representing the conductor rectangle is situated near the geometrical centre of the rectangle, but its exact position depends upon the position of the instruments. When the car travels over the whole length of the line this magnet will only go as far as the middle of the line—that is to say, it only moves at about half the velocity of the car. The course taken by the action of this magnet on the instrument depends largely on the position of the instrument and the direction of the needle, but will not be further investigated here. Except when the instrument is quite close to the line, the influence is considerably weaker than the influence of the earth current.

From Fig. 1, in which O O′ represents the overhead conductor, S S′ the rails, G the generator, and W the car, it will be seen that the current coming from the car does not return only by the rails behind the car and the earth near them, but returns also partly through the rails in front of the car and the earth to the generator. This is mostly the case when the rails are in a bad condition, and the consequence is that the influence of the earth current appears in advance of the car, and the effect may have been reversed before the car has passed the instrument. The disturbance curve shown in Fig. 7 was observed on the Dresden-Blasewitz electric tramway, and shows at the beginning a negative deflection, which was very likely caused by the earth currents being in advance of the car. It may be possible that the types of disturbance curves already

* From the *Electrical Engineer* of New York.

†Abstract of a Paper read before the Elektrotechnischer Verein of Berlin.

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obtained are not the only ones, and further investigation may increase them; but practically it may be taken that in most cases the earth currents are the main cause, and the typical curve is practically that represented in Fig. 5. Other causes than earth currents will only modify the curve, but will not essentially alter it.

Let us now consider the compensation curve. As this is required to abolish the disturbance, arrangements must be made that the compensation curve is as similar as possible to the disturbance curve in size and shape. The question is whether this was attained in the first proposal, and if not how the compensation arrangement has been modified.

Let us assume that the current in the rails is only flowing between car and power house—that is to say, behind the car. In reality, as we have seen, current flows also in front; the current flowing behind forms, however, the main part, and assuming this condition, the nature of the problem appears at once. Further, we will assume that the current in the car motor as well as the current in the rails always remains constant. Let us consider at first the case of the first idea, which is represented in Figs. 2 and 3. O O′ is the overhead conductor, S S′ the rails, G the generator, A′, A, A″

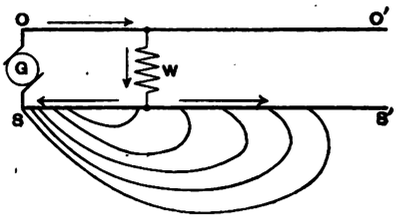

Fig. 1.

the points where the compensation wire is connected to the rails, J is the physical institute, and U the windings which are laid round the institute for the purpose of compensation. The other end of the compensation wire is connected to the rail ends at the power house. I have assumed that current is flowing only in the conducting parts between car and power house. As the points of connection, A′, A, A″, act very much like one point, say A, I will assume that this latter only exists. Then a potential difference will prevail between the contact point of the car and S, but none between the former and S′. In the circuit S, A, U, the potential difference between car and the rail ends at the power house acts as an E.M.F. This will increase as the car moves along until it reaches the point A. During the movement of the car from A to S′, however, the potential difference remains constant. If the curve of the compensation current is set out, a line, K, will be obtained, as in Fig. 3. On comparing this curve with the disturbance curve T (Fig. 5) it will be observed that there is only an approximate agreement when

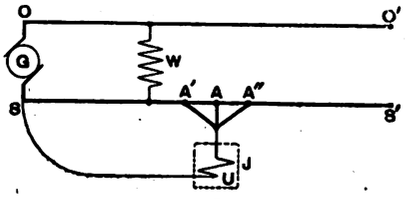

Fig. 2.

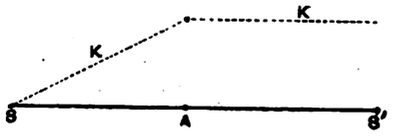

Fig. 3.

the institute happens to be so near to the power house that the disturbance commences immediately the car leaves the latter. The further away the institute happens to be from the power house the less the two curves of disturbance and compensation coincide, and the less the compensation of disturbance. The earlier proposal, therefore, does not offer the right solution of the question.

Let us now alter the arrangement so that the compensation circuit is not connected to the rail-end at the station, but to the points A and B of the rails (Figs. 4 and 5). No current will enter the "loop circuit" until the car has arrived at A, but then it rises evenly as far as the car position B, after which it remains constant. The compensation obtained in this case is shown by K, K in Fig. 5. The "loop-circuit" must be so adjusted that in the middle between A and B the disturbance and compensation current act equally in opposition to each other upon the needle of the instrument.

The disturbance curve is not always of the shape assumed in Fig. 5, and if the physicist wishes for the entire removal of the disturbances, arrangements must be made so that the compensation curve imitates the path of any given curve as closely as possible. This can be achieved by the use of several compensation circuits. Let the disturbance curve, for instance, have the shape T, T in Fig. 7, which consists of a negative dip, a positive rise and a positive fall. We replace this curve by the dotted line K, K, which consists of the straight lines A B′, B′ C′, C′ D′. We shall have to lay a corresponding compensation circuit round the instrument (*see* Fig. 6), and select the points of connection A, B, C, D in such a way that they correspond to the abscissæ of the corners A, B′, C′, D′. The windings U form a continuous circuit, certain points of which are connected to the rails.

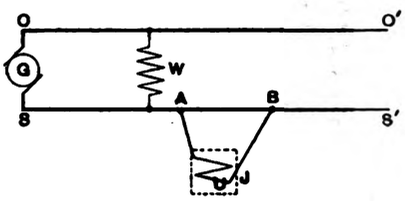

Fig. 4.

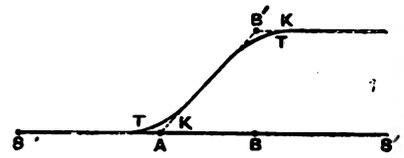

Fig. 5.

The adjustment is carried out in the following way: The circuit is switched in and then so adjusted that when a car is in a position between A and B, the compensation current acts in exactly the same way as indicated by the line A, B′. If no other loop circuit were provided, the compensation current would keep the value of B′. The car is now given a position between B and C and the circuit B, U, C is switched in, without the circuit U, A, B being cut out, and the former is so adjusted that the effect equals the disturbance, or the value indicated by the line B′, C′. If, then, the car runs beyond C, the effect of compensation would retain the value C, C′ if no other circuits were switched in, and would thus differ from the disturbance curve. In consequence the circuit C, U, C′ is switched in while the other circuits remain still in

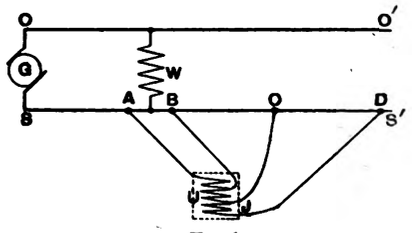

Fig. 6.

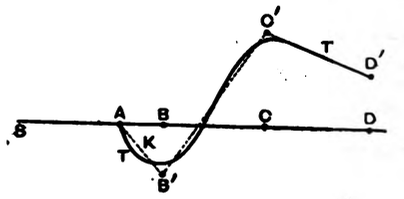

Fig. 7.

action, and is so adjusted that if a car is between C and D the compensation indicated by C′ and D′ is obtained. In this way the compensatory action follows the broken line A, B′, C′, D′, and represents within a certain degree the disturbance curve. The switching in of the compensation circuits, therefore, annuls the disturbances to within a small amount, which can be regulated by the number of circuits employed.

Let us now consider the properties of the compensation arrangement. The question is first whether the variation of the current in the car has any influence on the correctness of the compensation. But consideration will show that the amount of current has no influence on the compensation arrangement. For instance, a disturbance curve for 100 amperes will be very similar to one for 50 amperes, only the scale for the ordinates has to be altered. The amount of the main current has therefore only influence on the balance of disturbance not compensated. The ratio of the balance to the main current remains always the same. It follows

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that the compensation takes place in a percentage ratio—that is to say, for every current value a certain percentage of the disturbance is annulled and a certain percentage of it remains. The number of cars and their positions are of no importance to the compensatory action. If the compensation is so arranged that a car can run over the whole line with different current values without creating important disturbances, it seems clear that any number of cars can run with the same effect either in the same or opposite direction. Of course, the unbalanced disturbances will increase in proportion to the number of cars. The trace of the tramway cannot make compensation impossible, but may perhaps cause some difficulty. A complicated trace produces a complicated disturbance curve, and more compensation wires are required ; but the greater part of the disturbances can always be got rid of. This kind of compensation has the advantage that it not only influences the disturbances caused by earth currents, but also such as are caused by the effect of the loop, the direct effect of the conductors, and the magnetism of the car motor. Therefore, the institute to be protected can be quite close to the power house—the compensation will still retain its efficiency. The peculiarities of the building must, of course, be taken into consideration. When compensating arrangements are put down care must be taken that the windings are in the proper direction.

Details of the experiments on the lines at Dresden and Pankow I shall make public on a later occasion, but I may state here that with one loop circuit on the first-named line 75 to 80 per cent., and on the last named with three circuits, 95 per cent. of the disturbances was annulled. Herr Ulbricht has proposed to connect the loops not to the rails, but to the overhead conductors. This alteration would simplify the adjustment, as in a overhead conductor there is scarcely any "forward" current. No great objections exist to the adoption of this proposal.

For actual application there are two systems from which to select, viz., compensation of the whole building by means of coils round it, and compensation of each individual instrument by means of a set of coils. The first method possesses the advantage that the instruments are kept free from additional wires, but has the disadvantage that the compensation is only perfect in the middle of the building, and rather defective near the walls. The second method, however, gives good protection to all instruments, but necessitates a certain complication, as each instrument has to be provided with a compensation arrangement. Both systems are to be put to a practical test on the Pankow line shortly, but it can already be predicted that single protection is preferable. With regard to the cost of such a compensatory installation, I do not think that it will amount to £500.

ELECTRIC MOTORS IN GOLD AMALGAMATING PLANT.*

A somewhat unique application of electricity, and one of interest to the mining industry, has recently been made in the adaptation of electric motors to the operation of a Bennett amalgamator. The amalgamator consists essentially of the following parts :—A truck and frame for supporting the larger part of the machine—arranged to be run forward on a track as the work progresses ; a turntable supporting a boom and dipper ; the boom and dipper for excavating the dirt, and a revolving cylinder or screen with a hopper. Into this the earth is thrown from the revolving screen, the finer material passing through into the amalgamator, the coarse material being discharged at the end of the drum into the tailings carrier.

The amalgamator is a large trough in which the fine material, after passing through the screen, is amalgamated. In the bottom of the amalgamator is an agitator, moving backwards and forwards to keep the material well stirred up, and a wheel for raising and discharging the fine tailings after the removal of the gold.

The four motors used in operating this machine are so constructed as to be thoroughly protected from water or dust. One of these motors is mounted on the frame of the machine between the turntable carrying the cab and the revolving screen. It is geared to a shaft connected by a sprocket chain to the revolving cylinder, the tailings carrier, the agitator in the amalgamator and the wheel for discharging the tailings at the outer end of the amalgamator. A clutch is provided to throw it into gear with the trucks for moving the entire machine backwards and forwards.

The second motor is placed in the cab and operates the dipper by means of a fine-wire rope passing around the drum to which the motor is geared.

The third motor is mounted on the dipper boom, and is geared to a drum placed just above it. Fine-wire ropes pass around this drum, and are attached to both ends of the dipper handle. The dipper may thus be thrust out or in according to the requirements of the work.

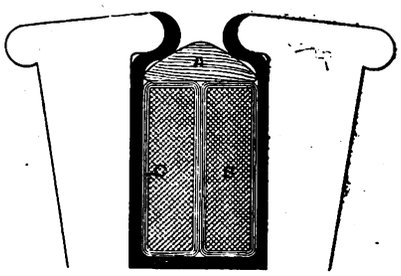
* Abstract from the *Electrical Review* of New York.

The fourth motor occupies a place in the cab, and drives, by means of a bevelled gear and large sprocket chain, the turn table. This motor is also used to swing the dipper boom around from the front of the amalgamator to a position which allows of the dirt being thrown into the hopper of the revolving screen. The motor operating the cylinder, the tailings carrier and the agitator in the amalgamator runs continuously when the machine is in operation, and is provided with a simple starting rheostat only. The other three motors are controlled by reverse rheostats in the cab, and are handled by one man.

A 1,500 KILOWATT RAILWAY GENERATOR.

A good example of recent American practice in railway generator construction is afforded by a 1,500-kilowatt machine, which is now being built for the West End Street Railway Company, of Boston. The armature core of this generator is built directly upon the shaft of an Allis cross-compound engine ; the shaft is 2ft. in diameter, and weighs something over 60 tons. The diameter of the armature is 10ft. 6in., and its weight, with commutator, approximately 40 tons.

The armature core is being wound while in position on the shaft. The core is built up of nine lammelar sections separated by eight brass spiders, leaving ventilating apertures at those points ; each section contains about 210 sheets of soft charcoal iron. The core is provided with 696 slots, each of which contains two copper conductors insulated from the slot and from each other. The conductors are firmly locked in the slot by driving in a long wooden wedge above them, and the slots are liberally lined with fuller board and mica before the insertion of the bars, which are individually insulated with tape and mica, as shown in the accompanying diagram.



The rectangular copper bars are $\frac{1}{4}$in. by $\frac{3}{4}$in., and are fastened to the connectors by a copper clamp, the joint being afterwards sweated with solder. The peculiar shape of the armature tooth renders it next to impossible to dislodge a conductor either by magnetic drag or centrifugal force.

The spiral method of connection is used on this machine. The bars are usually inserted carrying the front connector already soldered on, and the rear connector is attached after the bar has been locked in position. The machine has 12 poles, and therefore the connectors partake very little of the spiral form, being only slightly curved. Two weeks are needed in which to wind the armature, one of which is required for preparing and insulating the grooves. The clearance of the armature will be about $\frac{1}{4}$in. The armature is multiple-wound, and 12 sets of brushes are to be employed. The field-magnet is to be of cast steel. The commutator is 20in. across the face and 7ft. in diameter.

The set is interesting from a mechanical as well as an electrical point of view. The Allis cross-compound engine takes steam at 180lb., and expands in two cylinders 32in. and 62in. in diameter respectively. The stroke is 60in. and the speed 75 revolutions per minute. The 73-ton flywheel is 24ft. in diameter and therefore has a circumferential speed of 5,655ft. per minute. It is substantially built to withstand this stress, being made up of 19 1in. wrought-iron plates. The second and the eighteenth plates form webs going clear to the hub. The wheel is fastened together with 128 $1\frac{1}{4}$in. iron rivets, and is composed of 69 web sections.

Electrical Mining Plants.—Messrs. Siemens and Halske have recently secured a contract for an electric boring plant for the State salt mines at Hallein. The plant will comprise a high-pressure turbine coupled direct to a continuous-current dynamo and two boring machines. The Gerhard Stone Coal Mining Company has recently put down a new ventilating plant at its Rammelt pit at Luisenthal. The plant is interesting from the fact that it is the first of the kind to be operated by electricity in the Saarbrücken mining district.

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CORRESPONDENCE.

THE AUDIT OF ELECTRIC LIGHT COMPANIES' ACCOUNTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The correspondence between the Institute of Chartered Accountants and the Board of Trade with reference to the audit of Electric Light Companies' accounts opens up several very interesting questions.

It is not, perhaps, generally known that there is no enactment in the Companies Acts requiring an audit of a limited company's accounts, except in the case of a banking company registered after August 15, 1879, as a limited company. It is true that the specimen form of articles given in Table A of the Companies Act of 1862 provides for an audit, and that it is most unusual for any company to dispense with provisions in its articles requiring an audit, but an audit is not made obligatory by Act of Parliament.

By Section 9 of the Electric Lighting Act of 1882 it is provided as follows:—

"9. The undertakers shall, on or before March 25th in every year, fill up an annual statement of accounts of the undertaking made up to December 31st then next preceding, and such statement shall be in such form, and shall contain such particulars, and shall be published in such manner as may from time to time be subscribed in that behalf by the Board of Trade."

And the model form of Provisional Order provides as follows:—

"8. The annual statement of accounts of the undertaking before being published, as provided by Section 9 of the Electric Lighting Act, 1882, shall, so long as the local authority are not the undertakers, be examined and audited by such competent and impartial person as the Board of Trade shall appoint, and the remuneration of the auditor shall be such as the Board of Trade shall direct, and the same and all expenses incurred by him in or about the execution of his duties to such an amount as the Board of Trade shall approve shall be paid by the undertakers on demand, and shall be recoverable summarily as a civil debt.

"The undertakers shall give to the auditor, his clerks and assistants access to such of the books and documents relating to the undertaking as shall be necessary for the purposes of the audit, and shall when required furnish to him and them all vouchers and information requisite for such purpose, and shall afford to him and them all facilities for the proper execution of his and their duty.

"The Board of Trade may make and vary regulations prescribing the times at and the mode in which such audit shall be made and conducted or otherwise for the purpose of giving effect to the provisions of this section.

"Any report made by the auditor, or such portion thereof as the Board of Trade shall direct, shall be appended to the annual statement of accounts, and shall form part thereof for the purposes of the said Section 9."

There is no clause similar to Section 9 of the Act of 1882 in the Gas Works Clauses Act or in the Railway Clauses Act, and the Companies Clauses Act of 1845 merely provides for the election of auditors *by the Company*, except where, by the Special Act, auditors shall be directed to be appointed otherwise; and these auditors are directed to examine the accounts, and either to make a special report on the accounts or simply to confirm the same, such report or confirmation to be read with the report of the Directors at the ordinary meeting.

On the other hand, the Metropolis Water Act of 1871 provides that every company for the time being supplying water for domestic use within the limits of the Act is to forward to the Board of Trade and certain other authorities a statement of account in such form and giving such particulars as may from time to time be prescribed by the Board of Trade, and there is to be an auditor from time to time appointed by the Board of Trade.

Section 40 of this Act provides as follows:—

"40. The auditor shall once in every half-year audit the accounts of the companies.

"If he finds the accounts correct he shall certify the same; but if in any instance he finds the accounts of any company incorrect in principle or in detail, he shall require such company to correct such accounts in such manner as he thinks right, and no future dividend shall in any case be declared by any company until their accounts are certified by the auditor, provided that the suspension of a dividend under this section shall not operate until after the expiration of nine months from the date of the audit."

But any company thinking themselves aggrieved by any Act or determination of the auditor can, under Section 42, bring the matter to arbitration.

Now it will be noticed that there is a great deal of difference between the provision for the annual statement of accounts to be made to the Board of Trade under the Electric Lighting Act, even when coupled with the audit clauses of the Provisional Order, and the provisions of the Metropolis Water Act of 1871, under which power is given to the auditor to require a company to *correct* any accounts which he finds incorrect in principle or in detail. And I submit that the audit of an electric lighting company's accounts by the Board of Trade is merely made for the purpose of obtaining independently statements as to the expenditure and as to the application of revenue with a view to the special provisions of the Act and Provisional Order, and particularly with a view to the anticipated purchase by the local authority at the expiration of the statutory period, and that the Board of Trade auditor has no power to direct such a company to alter its accounts in principle or in detail unless he can show that the Company has committed a breach of the terms of the Electric Lighting Acts or Provisional Order.

The letter from the Board of Trade recently published states, as I claim in support of this suggestion, "That the Board of Trade audit is of a different character to that of a shareholders' audit, and has in view different objects." Moreover, *there is no audit clause in the model Provisional Order, the "undertakers being a local authority."*

Now the object for which the shareholders' audit is made is that as between the Directors and the shareholders it shall be shown that capital is not paid away in dividends, that all payments are duly vouched and all receipts duly entered, and proper provision made for bad debts or contingent liabilities, and, in fact, that the accounts are properly kept, having regard to the constitution of the Company. If the above suggestions are correct, the importance will at once be seen of drawing the line between the two audits, and limiting the rights of each auditor to interfere in the management of the accounts to the special provisions under which his appointment is made. If this is not done, each auditor may by degrees get into the way of directing, not only how the accounts shall be kept, but also what amounts are properly chargeable to capital and revenue respectively, and if they do not take the same view very serious difficulties may arise; whereas if, as I submit, the duties of the Board of Trade auditor are limited to ascertaining and seeing that the provisions of the Acts and Order are duly carried out, while the shareholders' audit deals with matters arising out of the special constitution of each company and the proper keeping of the accounts, there need be no difficulty. But I do submit that there is this distinction, and that it should be carefully observed.—Yours, &c.,

SYDNEY MORSE.

4, Fenchurch-avenue, E.C., January 6, 1896.

EARTHED CENTRE MAIN.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In connection with possible dangers from the use of pressure of from 400 to 500 volts on the mains of electrical supply companies, I beg to hand you the following opinion from Mr. Musgrave Heaphy, who has recently discussed this matter with me. I need scarcely state that an opinion from a gentleman with such unrivalled advantages for estimating the dangers of electric power distribution is worth serious attention.

It is commonly assumed in a three-wire system of supply with centre wire earthed that it is impossible for there to be a difference of pressure on any premises, wired on one side of the system, greater than that between one of the outers and the middle wire. Mr. Heaphy points out that the full pressure may be brought into one house under certain conditions.

Assume two adjacent houses, the one connected to the positive and middle wire, and the other to the middle wire and the negative, and let there be in the party wall: (*a*) An iron door frame, wall box, or piece of shafting, &c., communicating between the two houses, insulated by dryness of the wall, by

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dry woodwork, or other means securing practical insulation; or (*b*) leakage of water into a portion of the wall thus insulated. Assume accidental connection between one of the outer mains, say through a defective flexible wire, and one of the insulated pieces of metal or the damp portion of the wall. The leakage to earth will be probably too small to blow the fuses, and so to disconnect the house. Next assume an accidental leak on the other pole of the system in the adjacent house, say through the metal case of a switch or lamp holder. It is clear that if the piece of insulated wire, or damp wall, be touched at the same time as the defective fitting, that a shock due to the full pressure will be felt.

These conditions are not likely to occur often, for two earths on opposite poles have to be made concurrently and in adjacent houses. Yet the risk is increased by the consumer's difficulty in detecting either leak except by a shock.

An obvious safeguard is to earth all isolated pieces of metal; but this does not get over the risk from walls which are damp locally. Iron barrel or concentric wiring, with the outer earthed, appear to be the safest method of wiring under the conditions assumed. For, with either it is probable that a single leak would blow one of the fuses, and thus call attention to the defect. In fact, if the middle wire be earthed all iron-work in buildings should be effectively earthed also.—Yours, &c., ALBION T. SNELL.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think Mr. Campbell-Swinton's views and my own are very little at variance, and I desire to add to my communication of last week my hearty approval of his ninth proposition—viz., the establishment of a class of associate members with corporate privileges similar to that in the Institution of Civil Engineers, in which gentlemen who may not be thought qualified for full membership may be placed, the present associate class being retained for outsiders whom it is to the interest of the Institution to include in its ranks and who wish to be included.

From correspondence that has reached me, I gather that there is a very strong feeling among men who have done good service in the cause of electrical science, but who have been denied the privilege of full membership, that at present they hold no better standing in the Institution than the man who holds shares in an electrical company does.

I think it should not be forgotten, also, that electrical engineering is different from every other branch of engineering. A man can hardly be an expert in bridge building, for instance, unless he gets his living by it; but many men are experts in electrical engineering, and have done important work, not because they were obliged to do the work, but almost entirely because they were not—because they had money to spend.

To take a case in point. Sir David Salomons' work on the accumulator can hardly be regarded as other than valuable, and it can hardly be doubted that its value was greatly enhanced by the absolutely independent line his position enabled him to take.—Yours, &c., SYDNEY F. WALKER.

Cardiff Electrical Works, Severn-road, Cardiff.

IMPORTED INCANDESCENCE LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with great interest the article in your issue of the 3rd inst., based upon the "Report of a Committee of Representatives of German Electric Supply Undertakings." I quite endorse the opinion expressed at the outset that the glow lamps in the market are not, according to quality and life, all that could be desired. But it is regrettable that it should obtain in our own market to an equal, if not to a greater extent than appears to be the case in Germany. But the results of recent tests prove the English-made lamp to be superior to those imported from abroad, and it is obviously unfair that such inferior goods should be placed in open competition upon our markets, without test, guarantee, or warranty of any kind. The shapes marking the general conformation of these foreign-made lamps are so nearly approximate in every detail that the ordinary consumer or purchaser cannot note the difference, since it appears by your article that the general public cannot detect the photometrical difference between an 8, 16 or 20 c.p. lamp, even when these are disposed among others.

Whilst admiring the principle of fair dealing which led to the formation of an executive representative committee, I cannot but hold the opinion that in the first case a very forcible action must have taken place among justly indignant customers abroad, and secondly, that whatever may be the beneficial working result of the Committee in Germany, it will have a very detrimental effect upon our home industries in this direction, since no restriction is placed upon lamps for export, and the ultimate effect of the standardising of foreign-made lamps will be to flood our home markets with the bad ones necessarily rejected.

It is certainly requisite that a purely representative committee, each member to be of sufficiently high professional status, and sequestrated from all commercial influence, should be established for the purpose of standardising the lamps sold in this country. The English makers in this case have no fear, and may safely rely upon the high quality of their goods to realise the best advantage to the consumer.

The tests naturally would limit the variations in photometric value to from 8 to 10 per cent., and above all things, the nominal watts per candle to 20 per cent., relatively to the useful life of the lamp. This, again, should be so regulated that after the period at which the increased absorption of energy has fallen to this degree, the lamp, of whatever type, should be replaced.

British enterprise should by Britons be supported under any circumstances, but when the adverse spirit is represented by the imported scum of the German incandescence lamp mark[illegible], it is time to organise a spirited and strong opposition.—Yours, &c., FREDK. WALKER.

January 7, 1896.

THE THERMOPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In 1887 I constructed and employed for clinical purposes an apparatus precisely similar to that described on p. 285 of your issue for December 27th, and can speak to its efficiency for the measurement of temperature under conditions which preclude the use of other forms of thermometer, its application being almost independent of distance, and covering a wide range of temperature. In one form of the instrument constructed by me small extra resistances were added at each end of the slide wire, the entire length of which then represented temperatures between certain limits (as 90°F. to 110°F.).

In this form the apparatus is capable of giving very accurate measurements.

As you will observe from an inspection of the enclosed patent specification (No. 11042, 1890) it had been my intention to make the instrument self-recording, but unfortunately lack of time has hitherto prevented me from giving the necessary attention to the matter.—Yours, &c.,

47, Russell-road, Kensington, W., C. ASHMORE BAKER.
January 7, 1896.

[We have examined the patent specification mentioned by Mr. Baker, and we concur in his opinion that it describes an invention which is, in general principle, the same as that described in our article of December 27, 1895; although there are some differences in detail. Both inventions depend on balancing two resistances of different metals by means of a sliding contact on a potentiometer wire; that of Mr. Baker would appear to be the earlier of the two.—ED. *E.*]

BOOKS RECEIVED.

"Submarine Telegraphy." By James Bell and S. Wilson. (London: "Electricity," 29, Ludgate-hill, E.C.) Price 1s. 6d.

"Calvert's Mechanics' Almanack." By Joseph Nasmith. Twenty-third year of publication. (London: John Heywood.) Price 4d.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is in active preparation, and will be ready at the end of January. Orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. Full particulars post free on application.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES can be obtained of the Booksellers or direct from the Publishing Offices :—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth, is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

CORRECTION.—By a slip of the pen in our last issue a Trade Note, referring to the bankruptcy of Messrs. Smeaton and Bennett, electrical and general engineers, of 135, Minories, E., was made to read Smeaton and Page. This has, we learn, caused some annoyance to Mr. Page, who trades under the name of Smeeton and Page, electrical engineers, at 163, Queen Victoria-street, London, E.C. We very much regret that such a clerical error should have occurred, and should have caused Mr. Page any annoyance. The announcement should have read : "Mr. W. Izard, 52, Gracechurch-street, E.C., has been appointed trustee in the bankruptcy of Smeaton and Bennett, electrical and general engineers, 135, Minories, London, E." We need scarcely add that the announcement in no way related to the firm of Smeeton and Page, electrical engineers.

TENDERS INVITED.—The Gas and Electric Lighting Committee of the Wigan Corporation invite tenders for the erection of a dynamo house and boiler house for their proposed electricity generating station. Tenders to the Town Clerk (Mr. J. J. Charnock) by the 20th inst.

——— The Shoreditch Vestry require tenders for the supply and erection of buildings, including engine house, offices and building enclosing dust destructor. Tenders to Dr. H. Mansfield Robinson, Vestry Clerk, Town Hall, Old-street, E.C., by the 20th inst.

——— The National Telephone Company require tenders for larch poles and also creosoted round pitch-pine poles. Particulars from the Stores Department of the Company, Oxford-court, Cannon-street, London, E.C.

——— The Kattowitz Direction of the Prussian State Railways require tenders for the supply of the arc-lamp carbons required for electric lighting purposes on the Kattowitz section of the State Railways. Tenders to the Königliche Eisenbahn-Direction, Kattowitz, Germany, by the 29th inst.

TENDERS INVITED.—The St. Pancras Vestry invite tenders for wiring and other work in connection with the electric lighting of the Vestry Hall and Offices in Pancras-road. Tenders must be sent in to Mr. A. E. Pycraft, at 57, Pratt-street, N.W., by noon of the 16th inst.

——— The Municipal Authorities of Burriana (Castellon) invite tenders for the concession for the electric lighting of the town for 10 years. Tenders to the Ayuntamiento de Burriana (Castellon), Spain.

——— The Roumanian State Railway authorities, Bucharest, invite tenders for the supply of 60,000 rolls of telegraph tape paper for the Telegraph Department. Tenders by the 23rd instant.

TENDERS ACCEPTED.—The Loughborough Town Council have conditionally accepted the tender of the Brush Company for the supply of the necessary plant for the electric lighting of the sewerage works.

——— The Walsall City Council have awarded the contract for wiring the Free Library to the Coventry Electrical Engineering Company. The amount of the tender is £140.

TENDERS RECEIVED.—The Chelsea Board of Guardians received 12 tenders for fitting up an electrical wiring installation, with fittings, in the Chelsea Infirmary Extension, Cale-street, S.W. The tenders have been referred to the General Committee for report.

APPOINTMENT VACANT.—The Lighting Committee of the Wolverhampton Corporation invite applications for the post of assistant and draughtsman to the borough electrical engineer; commencing salary £100 per annum. Applications to Mr. F. Harman Lewis (borough electrical engineer), Town Hall, Wolverhampton, by the 23rd inst. Some further particulars are given in our advertisement columns.

DISSOLUTION OF PARTNERSHIP.—Messrs. J. W. Martin and B. R. Fitt, hitherto trading as electric light contractors and ironmongers, at 7, High-street, Grantham, have dissolved partnership. Debts by Mr. B. R. Fitt, who continues.

COMMERCIAL CABLE COMPANY.—We are informed that Mr. G. H. Bambridge has resigned his position as General Superintendent in England of the Commercial Cable Company, and that Mr. Frederick Ward has been appointed manager in England.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MANUFACTURING COMPANY (LIMITED).—This Company have now removed from 109, Farringdon-road, London, to the new address at 186-188, Shaftesbury-avenue, W.C.

BANKRUPTCY DIVIDEND.—A first and final dividend of 6s. 2d. in the £ is payable at 39, York-street, Manchester, on the 20th inst., in the bankruptcy of Dr. J. Whatmough, trading as an electrical engineer, &c., under the styles of D. J. Whatmough, J. and P. Dyer, and lately as W. Mason, at 39 and 41, High-street, Oldham. The bankrupt will apply for his discharge at the County Court, Oldham, on the 22nd instant at 11 a.m.

COMPANY LIQUIDATION.—A notification has been made by the Senior Official Receiver's Office that in future the Press is not to be supplied with copies of Official Receivers' "Observations" on the statements of affairs issued from time to time by the Department in regard to outstanding liquidations. Creditors, contributories and others interested will be considerable sufferers by this decision, and it is to be regretted that such a course has become necessary, as public attention being called to these matters has been of much service in the past.

BRITISH ELECTRIC LIGHT COMPANY, LIMITED (IN LIQUIDATION).—A notification from the Receiver in this liquidation is to the effect that every creditor may write off as a bad debt the amount due to him from this Company, as the Receiver was only able to collect about £10.

ADVERTISEMENTS.—The publisher of *The Electrician* has received several complaints lately from foreign readers that the advertisement pages of the paper have been cut away in order to save postage. This, of course, can only happen where subscriptions are not sent direct from the office. The publisher will be obliged if any subscriber receiving a mutilated copy of the paper will communicate with him, in confidence if necessary. It is a matter of frequent complaint by advertisers that copies of journals sent abroad are mutilated in this way. This can easily happen with papers which are unstitched; and it was this amongst many other reasons that decided the proprietors to make each number of *The Electrician* a compact and complete book.

SOCIETÀ ITALIANA GENERALE DI ELETTRICITÀ (SISTEMA EDISON).—This Company has just raised its capital of £144,000 to £360,000 for the purpose of buying up the entire network of tramways at Milan, and equipping and working the same electrically. The new shares have been taken up by a syndicate formed by the Banca Commerciale of Italy.

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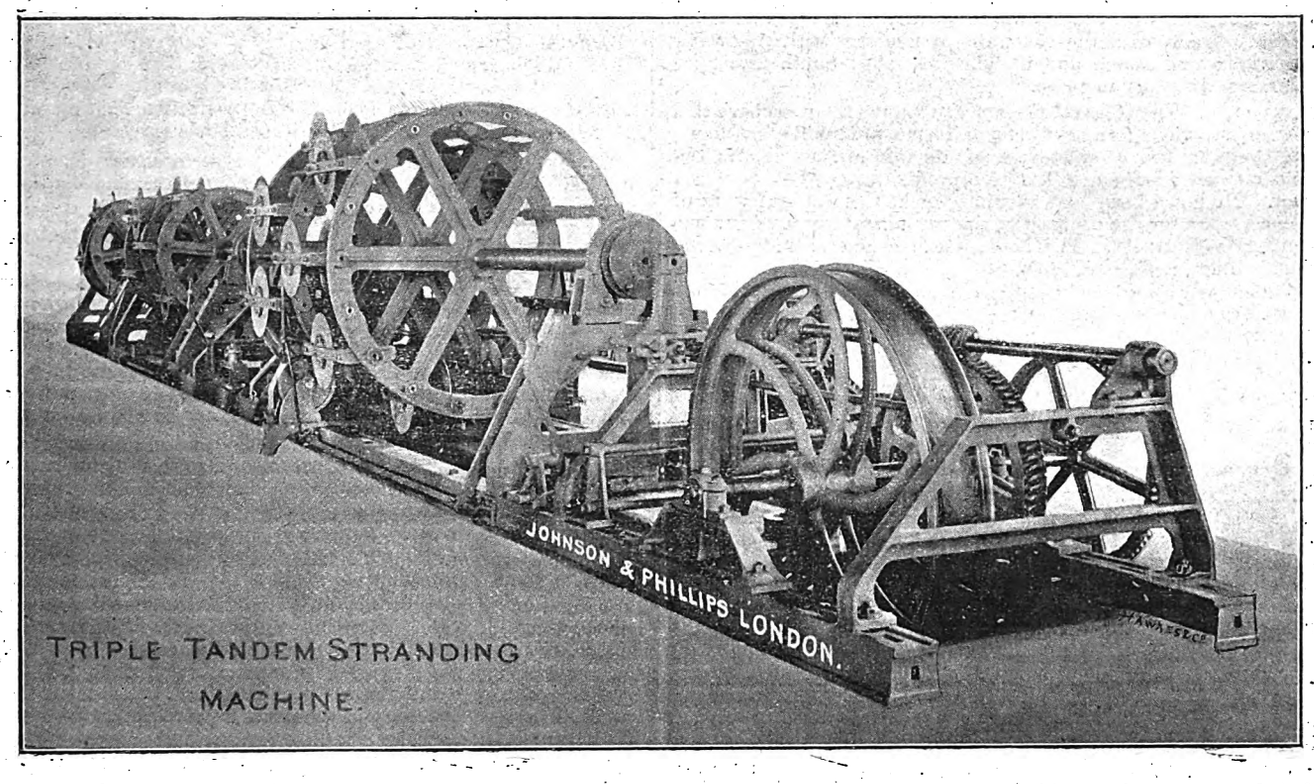
YORKSHIRE HOUSE-TO-HOUSE ELECTRIC LIGHTING COMPANY.—When this Company originally started work in Leeds it was stipulated that a deposit of £1,000 should be made with the Corporation. On the request of the Company the Corporation have decided to return half this amount.

"UNIQUE" SWITCH.—Mr. A. P. Lundberg, of Bradbury-street, Kingsland, London, N., desires us to state that there is no truth in the rumour, which he understands is being circulated, that he is giving up the manufacture of the "Unique" patent switch. All that has happened is that at the request of some of his clients he has reconstructed the "Pioneer" type of switch.

TRIPLE-TANDEM WIRE-STRANDING MACHINE.—The great advance now being made in electric lighting and transmission has made the manufacture of electric cables an important industry. The following description and accompanying illustration of a large wire-stranding machine which has just been completed by Messrs. Johnson and Phillips will therefore be of considerable interest. The machine has been built to the order of a large firm of wire manufacturers on the Continent, and is what is termed a triple-tandem machine, and, as the name implies, consists really of three separate machines arranged "tandem." The first part is a 6-wire machine, the second a 12-wire, and the third an 18-wire machine, each part being arranged so that it may be run in the reverse direction to that of its neighbour, and at a different speed, and thus form a 37-wire cable in one operation. The centre wire being led through the centre hollow shaft, the first part of the machine lays six wires round it, forming a 7-wire cable; the second part lays 12 wires on this, forming a 19-wire cable, and the third part lays 18 wires over all, making up the 37 wires. The machine will equally well make cables with a lesser number of single wires, or if a flexible cable is required 37 strands made up of smaller wires can be used. The machine is also so arranged that each part may be run in the same direction and at the same speed, and provision is made for leading the wires from the first and second parts through the third, so that the whole of the 37 wires or any lesser number may be laid on a cable in one flake, as might be required, for instance, in the manufacture of a concentric cable. This also adapts the machine for making a much larger cable. For instance, if the 37-wire cable is passed through the machine again and covered with 24 wires, a 61-wire cable is formed; this passed through again and covered with 30 wires forms a 91-wire cable, and this, in turn, can be passed through and covered with 36 wires, making up a cable of 127 wires. The bobbins each hold about 3cwt. of wire, and are suitable for all sizes up to No. 6 B.W.G. All twist is kept out of the wires during the operation of cabling by means of the usual arrangement of cranks and eccentric rings. The ground space covered by the machine is 60ft. by 10ft., and it is erected on a continuous cast-iron girder bed running along its whole length. As will be seen on looking at the illustration, the draw drums are of large diameter, and they are driven by means of worm gearing, the speed being capable of considerable variation by means of change wheels to give the different lengths of "lay" for the wires. The various parts of the machine are driven from a shaft running its whole length near the floor level. A novel feature in this machine is that the three sections are driven by chain gearing, and the builders believe this is the first example for a machine of this sort, and they claim that it is much quieter working than the usual arrangement of spur gearing, the rattle of which causes so much annoyance. Another feature is that the central hollow shaft which carries the revolving part of the machine is provided at each end with heads which run on adjustable antifriction rollers, and as the centre discs also run on similar rollers, the machine requires comparatively little power to drive it. We understand that the machine is capable of making about three miles of cable per working day. Amongst other machines recently made by this firm is one for the Postal Telegraph Department for making 7-wire gutta-percha cables interlaid with yarns, the whole covered with compound tape, in one operation.



PAST YEAR'S WORK.—Continuing our reports from leading firms as to the progress of the electrical industries for 1895, we have received from Messrs. DRAKE and GORHAM a report that increased business has necessitated enlarged office accommodation and consequent additional staff, and the showrooms for exhibiting the firms' specialities, fittings, &c., have been extended. The Manchester branch has shown satisfactory progress, which has induced the firm to arrange for another branch at Glasgow to deal with the Scotch business. A long list of country installations includes Crewe Hall, where a complete steam and electric plant for 550 lights has been installed; Windlestone Hall, a similar plant, for 300 lights. Other installations include oil engine and water-power plants. The town-house installations include the town residences of the Marquis of Lansdowne, the Duke of Montrose, Lord Wynford, extensions at Devonshire House, Prof. Kennedy's house, and a long list of the town residences of many well-known public men. Public building lighting has included the Prudential Insurance Company's installation, equivalent to 375 H.P.; the Stafford Technical Schools (1,100 lights), Baliol College (370), Convalescent Home, Little Hampton (230), Stafford County Infirmary (230), Cancer Hospital (320), Lancaster Infirmary (240), St. Paul's Church, Deptford (110), St. Michael's Church, Chester-square (200), the gas stove showrooms of the Manchester Corporation; additional arc and incandescent lighting at the University Galleries, the extensive offices of the Council of Foreign Bondholders, the South-Eastern Railway Company's Offices at Edenbridge, the North-Eastern Railway Company's offices, Messrs. Allsopp and Sons' offices, &c., &c., the whole work showing the extensive range of Messrs. Drake and Gorham's business, and the facilities which the firm's experience offers for installations of almost every variety, whether with steam, gas, oil or water power. Other work carried out during the year has included the organisation and equipment of the Jandus Arc Lamp and Electrical Company, at Charlton, which enables the Company

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to manufacture and supply all parts of these lamps; the D.P. Battery business has been organised into a separate company; and business in connection with the sale of the earthing devices and other apparatus of the firm has also increased to a gratifying extent, the sale of the earthing devices showing 3,500 of these instruments now in daily use, and the report as to their efficient working is to the effect that "no single case is known to have occurred of the apparatus having failed to effect its purpose."

PAST YEAR'S WORK.—Mr. A. P. LUNDBERG, inventor and manufacturer of several well-known types of switches and other electrical apparatus and fittings, reports that business during 1895 has been satisfactory, and has shown considerable improvement on 1894. The close of the year brings up the total of the "Unique" switch invented by Mr. Lundberg to 90,000, turned out from his own works. Although Continental competition has proved severe, Mr. Lundberg reports that it has been satisfactorily met, and that fair orders have been received from Germany and other countries. Trade with the Colonies, particularly with Australia, South Africa and India, and in addition, with South America, has shown satisfactory increase.

CATALOGUE.—The General Electric Company (Limited) have this year surpassed their former efforts, and have produced a catalogue which, both in the completeness of its information and in the artistic manner in which it has been produced, may be considered perfect. No pains have been spared to make this a useful work of reference, alike for the contractor, the consulting engineer and the consumer of electricity. The book, which comprises nearly 1,000 copiously illustrated pages, includes special sections on almost every branch of electrical industry, and is strongly bound in serviceable stiff cloth covers. An Appendix contains an exhaustive index of all the sections, together with a code for telegraphic purposes, and a large quantity of generally useful information. Among this last-named we notice a glossary of electrical terms and a list of useful electrical books (in which there are, however, numerous misprints). We understand that a nominal charge of 10s. is made for the catalogue, and that this sum is returned upon receipt of the first order directly or indirectly obtained through it.

POCKET PRICE LIST.—We have received from the Chloride Electrical Storage Syndicate (Limited), 16, Victoria-street, S.W., a copy of the fourth edition of their useful pocket "Price List of Chloride Batteries." Battery users will find the pocket-book of assistance. It is strongly bound, and not being too small, the type is clear and readable.

CASSIER'S MAGAZINE.—Amongst the subjects of interest to our readers dealt with in the January issue of this magazine are the following articles:—"Municipal Electric Lighting from Underground Mains," by E. J. Houston and A. E. Kennelly; "Gas Engines for Electric Light and Power," by N. W. Perry; "When is it Advantageous to use Water Power for Electric Transmission?" by C. E. Emery; "The Induction Motor," by Louis Bell; "Electricity for Propelling Railroad Trains at Very High Speeds," by H. S. Maxim; "Electric Pumping Machinery," by C. A. Hague; "Direct Production of Electric Energy," by L. Duncan; "Electrically Operated Factories," by R. E. Crompton; "Electrical Power in Canada," by J. S. Robertson, &c. Many of the writers are leading electrical experts in America, in which country Cassier's Magazine has a well-deserved reputation.

MACHINERY LISTS.—We have received a copy of a new list just issued as a weekly edition of "Machinery Implements and Mill Furnishings Wanted Lists," by Mr. A. Tolhausen, Fountain-street, Manchester.

CALENDARS.—A useful date remembrancer is issued by Messrs. W. H. Willcox and Co., the well-known suppliers of engineers' stores, &c., of Southwark-street, London, S.E. In addition to its usefulness as a calendar, a large number of Messrs. Willcox and Co.'s specialities are illustrated on the sheets, which can be readily referred to when such goods are required.——Mr. J. Vickers, advertising contractor, of Nicholas-lane, E.C., sends a very useful sheet month-by-month calendar, neatly printed in colours, in which the dates stand out very prominently, a point sometimes lost sight of. ——Messrs. King and Co., of the Leith Electric Works, Leith, Scotland, have sent us a neat hanging calendar which shows originality of design.——A useful hanging Sheet Calendar is forwarded by Messrs. Sankey and Son, makers of fire-clay goods, of Canning Town, E., the sheets being illustrated and giving descriptions of boiler-seating blocks, flue covers, stoneware pipes, &c.——A neat and handy calendar pad is sent by an American firm, makers of the "Columbia" bicycles, Hartford, Conn. This is in the form of a desk-note pad, in flexible metal case, with tear-off memoranda sheets.

ALSAGER.—The Urban District Council have decided to light the district electrically. A meeting of ratepayers will shortly be held to discuss the proposal.

AYR.—The electric supply station at Ayr was formally opened on Wednesday evening by Lord Kelvin, who was accompanied by Lady Kelvin. The work has been carried out under the professional supervision of Mr. Robert Hammond and of the resident engineer, Mr. Ernest G. Pink. As our readers are aware the site of the central station is in Mill-street. The building, which cost between £2,000 and £3,000, has been designed to allow of considerable extensions when required. The capital expenditure up to date on buildings, plant, machinery, &c., has been about £20,000. Provost Willock presided at the inaugural ceremony, and gave details of the progress of the work from its initiation. Lord Kelvin, in opening the station, said he thought the work in connection with the station would prove a credit to all concerned. Mr. Hammond subsequently moved a vote of thanks to Lord Kelvin, and pointed to the fact that with the addition of Ayr to the list of municipal electric lighting stations the number of those now supplying current was 47, while the number of electric supply companies was also 47. Only a few of the principal thoroughfares are at present lighted. The price of current has been fixed at 7d.

BANGOR.—At the meeting of the City Council on Wednesday the Electric Lighting Committee recommended that application be made to the Local Government Board for sanction to borrow £15,000 for the purpose of establishing electric lighting works. After discussion, the Committee's proposal was agreed to.

BANGOR (CO. DOWN).—The Township Commissioners have again discussed the electric lighting question, and have now decided to apply for a Provisional Order.

BIRMINGHAM.—At the meeting of the Public Works Committee on Monday last the question of the adoption of the overhead system of electric traction on the Nechells tramway route was further considered, but owing to the absence of a prominent member no definite decision was arrived at. The report of the Committee will not, therefore, be presented to the City Council until the February meeting of that body. A petition in favour of the system, and which has been numerously signed by the inhabitants of the Nechells and adjoining districts, was presented to the Council at its meeting on Tuesday.

BLACKPOOL.—The Town Council have remodelled the discounts allowed to large consumers of electric current.

BRIGHTON.—At the last meeting of the Town Council the chief point of discussion was the lighting of the side streets by electricity. The councillors were almost unanimous in their appreciation of the labours of the Electric Lighting Committee; so much is this the case that it is reasonable to expect that a scramble will ensue for membership of that Committee in the near future. Even Councillor Evans, who struck a discordant note at the meeting, agreed that the electric light was a great improvement upon gas. Councillor Swaffham, in reply to the remarks of members, pointed out that it was the increased brilliancy of the street illumination that made the bad lighting of the side streets by gas so painfully conspicuous.

BRISTOL.—Mr. H. Faraday Proctor (the borough electrical engineer) has presented his amended report on the question of lighting the Mansion House electrically, and, as the members of the Finance Committee were divided as to the advisability of carrying out the work, the matter has now been referred to the Mansion House Committee for consideration and report.——The electric lighting undertaking of the Corporation is evidently progressing in a very steady and satisfactory manner. It is stated that the number of customers has greatly increased since October 1st, and that the works are now being run at an actual profit. At present there are over 24,000 lamps connected, but there are orders in hand for 3,500 more, or a total of 27,500. It is anticipated that additional machinery will shortly be required if the demand continues to increase at the present rate. The Electric Lighting Committee have just decided to reduce the price of current for motor purposes to 4d. per unit, as an earnest of the Committee's efforts to increase the day load.

CHATHAM.—The instructions received from the Admiralty for the preparation of the "Theseus" and "Charybdis" for active service necessitated gangs of workmen being employed at night, and the electric light at the Dockyard proved of great service.

CHELTENHAM.—As usual, the report of the Electric Lighting Committee presented at Monday's meeting of the Town Council was very favourable, and gave evidence of a continually-increasing demand for electric current in this town. During the month 750 additional 8 c.p. lamps were connected, bringing the total to 5,050, while 500 are awaiting connection.

CHURCH LIGHTING.—The United Presbyterian Church, Palmerston-place, Edinburgh, is now lighted electrically. It is claimed that this is the first church in Edinburgh to adopt the electric light. About 170 incandescents, varying from 16 c.p. to 32 c.p., are employed.——The Dereham-road Methodist Chapel, Norwich, is now lighted electrically. The work has been carried out by Messrs. Woolnough, Proctor and Co.

CLACTON.—A member of the District Council has given notice of his intention to move at the next meeting of the Council that tenders be invited for the electric lighting of the town.

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DERBY AND ASHBOURNE ELECTRIC TRAMWAY.—In the Bill which the promoters of this undertaking propose to introduce in the next Session of Parliament power is sought for the incorporation of a Company, with a capital of £87,500. The first directors are: Sir H. Wilmot, Bart., Hon. F. Strutt, Mr. A. C. Duncombe, and Messrs. G. T. Meynell and J. Shaw. Power is also sought to enable the Company to pay interest out of capital during the construction of the tramway to an extent not exceeding £10,000.

ECCLES.—At a special meeting of the Town Council on Monday last, the electric lighting question occupied the attention of the councillors for several hours. In October last the tender of the Manchester Edison Swan Company for the supply of the necessary plant for the proposed electricity works was recommended for acceptance, but, owing to the proximity of the November municipal elections, no decision was then arrived at. Recently the Council authorised the Electric Lighting Committee "to take measures to inform the ratepayers of the details of the plan which had been considered by the Committee," and the Committee subsequently decided to distribute several thousand explanatory pamphlets to the ratepayers. Mr. Mellor proposed that a public meeting should be called for the purpose of deciding on some course of action, but this motion was defeated by the casting vote of the Mayor.

EDINBURGH.—At the meeting of the Town Council on Tuesday, Councillor Mackenzie, in moving the adoption of the Electric Lighting Committee's report, referred to in our last issue, said the members of the Committee were desirous of leaving the entire responsibility of deciding whether the streets mentioned in the report should be lighted electrically or not with the Council, but he made a detailed statement of the expenditure which the suggested extensions would involve, and of the cost of maintenance, &c. Mr. E. W. Monkhouse's recent report shows that up to December 26th the number of units of current sold was equal in value to between £1,400 and £1,500 more than the Electric Lighting Committee had anticipated. Up to the present it is estimated that a capital expenditure of £12,500 has been incurred for the public lighting. The current (480,000 units) for the 250 public lamps has been calculated to have cost the Corporation 1¼d. per unit, and has shown a small profit at this low figure. Ultimately the subject of the proposed extensions was remitted to the Cleaning and Lighting Committee for report.

ELECTRIC TRACTION IN RUSSIA.—It is reported that the construction of a system of electric tramways in Riga is in contemplation.

EXETER.—Col. J. Ord Hasted, R.E., held a Local Government Board inquiry yesterday (Thursday) into the application of the City Council for leave to borrow £11,000 for the purchase of the plant and undertaking of the Exeter Electric Light Company.

FAREHAM.—At the ordinary meeting of the District Council on Tuesday electric lighting matters occupied considerable attention. A resolution was proposed by the Chairman in the terms of which the solicitors to the Council were instructed to accept the offer of the Fareham Electric Light Company to carry out the contract of August 16, 1894, by which the purchase of the Company's undertaking by the Council was agreed upon in lieu of paying the damages awarded in the recent action, and, further, to apply for a stay of execution of that order to enable the Council to complete the purchase. This resolution was carried. A proposal that the application now before the Local Government Board granting powers to the Council to borrow £7,000 for the purchase of the electric light works, &c., be abandoned was not seconded. The vanquished at Fareham do not appear to take their defeat at all kindly, but the resolution of the Council clears the way for an amicable understanding.

HAMPSTEAD (LONDON).—Further extensions of the electric light mains to Redington-road, Goldhurst-terrace, and Canfield-gardens, have been sanctioned.

ISLINGTON (LONDON).—The Lord Mayor has fixed Wednesday, March 4th, for the formal opening of the electricity works at Eden-grove.

KIMBLESWORTH AND PLAWSWORTH (DURHAM).—The ratepayers of these townships in September last adopted the Lighting Act and decided to light the villages by electricity. The Kimblesworth Colliery Company having been approached on the subject of supplying the necessary current, satisfactory arrangements have been made, the Colliery Company providing the generating plant and the two Councils the mains, lamps, &c. The Corlett Electrical Engineering Company secured the contract for the work, which has now been completed, and is giving every satisfaction.

KING'S NORTON.—At Wednesday's meeting of the Rural District Council a letter was received from the Birmingham and Central Tramways Company, asking for sanction to continue running their cars through the Council's district, on a portion of the Bristol-road route, for the ensuing year, and pointing out that under present conditions the Company were restricted to one kind of motor. There were now several improved kinds of motors on the market, and the Council were asked to cancel the restriction. Mr. T. A. Bayliss said that the Company evidently intended to introduce the overhead electric system upon the Bristol-road route, and, if that was so, he should strongly oppose it. The Council decided to grant the licence to the Company, and to allow them to alter their motors in any way they thought fit, so long as they did not adopt the overhead system.

KINGSWOOD (BRISTOL).—At the meeting of the District Council, on Wednesday, a resolution was passed legalising the recent extension of the elcctric tramways from the King's Arms to Warmley Hill.

"KNOWLEDGE."—With the number for January, *Knowledge* commences a new volume. A coloured supplement plate is issued of the planet Jupiter.

LEICESTER.—The Waterworks Committee have decided to adopt Mr. George Jennings' system of electro-mechanical apparatus for indicating and registering between the new reservoirs and engine houses at Swithland, Hallgates and Cropstone, the varying levels of water in the reservoirs.

LINCOLN.—At the last meeting of the Town Council a joint report from the Lighting, Building and Improvement Committee and the Gasworks Committee, was presented and discussed. The report recommended the Council to oppose the application of the County of London and Brush Provincial Company for a Provisional Order, and that a Special Committee be appointed to consider and report upon the advisability of adopting an electric lighting scheme for the town. Alderman Page, in moving the adoption of the report, said the members of the Committee were unanimously in favour of electric lighting being in the hands of the Council.

LLANELLY.—At the meeting of the Town Council on Monday last a letter was received from Mr. J. C. Howell, asking if the Council would be prepared to entertain an offer from his firm for the electric lighting of the Market, the New Town Hall, and the Athenæum, and for erecting about 20 arc lamps in Vaughan, Stepney, Powell, Murray and Salamanca-streets, and the New Town Hall-square to Bridge and Market-streets; and, if so, to state the maximum price they would be prepared to pay for a ten-years' contract. The letter was referred to the Estate Committee for consideration and report.

MANSION LIGHTING.—The contract for the electric lighting of the Duke of Fife's new mansion on Deeside has been given to Messrs. P. C. Middleton and Co., of Aberdeen.

MERTHYR TYDFIL.—The District Council have referred the question of opposing the application of Messrs. J. C. Howell (Limited) for a Provisional Electric Lighting Order to a committee for consideration and report.

NEWCASTLE-ON-TYNE.—At the meeting of the Town Council, on Wednesday, the letters received from the British Thomson-Houston (Limited) and the British Electric Traction (Pioneer) Company, offering to electrically equip the Newcastle tramways on terms referred to in our last issue, evoked a long discussion. On the suggestion of Alderman Sir Charles Hamond, M.P., the letters were referred to the Town Improvements Committee for consideration and report. At a public meeting in the Hunters'-road Board School, on the same evening, a resolution protesting against the Council's tramway scheme was passed.——The Quayside Committee of the Corporation intend to make a survey of the Quayside on Monday next, for the purpose of ascertaining what increased shipping accommodation and other facilities can be provided, and also to see whether it is advisable to instal the electric light, and thus enable shippers to load and unload their vessels with greater despatch and convenience than they do at present with the very primitive torch lights.

NEWCASTLE-UNDER-LYME.—The General Purposes Committee reported at the meeting of the Town Council on Tuesday last that they had a final interview that afternoon with Messrs. Sellon, Carruthers Wain, and Milward (representing the North Staffordshire Tramways Company), when it was recommended that a communication be sent to the Board of Trade objecting to the granting of the Provisional Order to extend the tramway to Newcastle. The minutes were agreed to.

NEWPORT (SALOP).—The District Council intend to appoint a committee for the purpose of considering the question of lighting the district electrically.

NIAGARA FALLS.—Power, street railway and electrical circles generally in the Dominion of Canada are fully aroused by a legal notice appearing in the Canadian papers stating that application will be made at the next session of Parliament for an act to incorporate "The Canadian Electric Railway and Power Company with power to build, operate and maintain an electric railway from the City of Montreal in the Province of Quebec to the city of Windsor in the county of Essex *vid* Brockville, Kingston, Belleville, Toronto and London, with power to build a branch line to Suspension Bridge (Niagara Falls), with power to build branch lines for a radius not exceeding 25 miles from any point or points on the main lines; to

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enter into contract and arrangements with all existing or authorised firms or corporations along the said route, and particularly with existing street or electric railway, light or power companies for the purpose of acquiring, leasing, amalgamating or making running arrangements with same, or to supply same with heat, light or power; to establish, maintain and carry on street railway services in such cities and towns on the line of said railway as the Company and municipalities interested may agree on; to build said railway in sections as may be authorised; to acquire water powers and sites for and build electric works in connection with said railway for the purpose of generating electrical energy, to acquire the right of way to transmit and also the right to sell and otherwise dispose of electrical energy for heat, light, power and other purposes and to distribute the same; with power to expropriate lands for the purposes of the undertaking as provided by the Railway Act; with all other powers necessary for constructing and operating the said electrical works, and to otherwise fully carry on the said undertaking, with power to issue paid-up stock of the Company in payment of its obligations for all or any of the said authorised purposes, and with all proper or usual powers given or granted to companies incorporated for any of the purposes aforesaid."

PATENTS.—The total number of patents applied for for 1895 was 25,116, against 25,386 and 25,067 in 1894 and 1893.

STAINES (MIDDLESEX).—Messrs. Reffel and Co. have introduced the electric light into their extensive range of stables and cow-sheds, and the two farms belonging to the Company are now connected by telephone.

SWANSEA.—The Corporation intends to promote a Bill in Parliament to confirm an agreement with the Swansea Improvements and Tramway Company for the sale of the Company's tramways to the Corporation, and for the granting of a lease to the Company for 21 years of the same, together with any additional lines that may be constructed by the Corporation. Power to borrow £149,000 in connection with this scheme is also sought.——At a public meeting convened by the Mayor and the residents of the four central wards of the borough, the triple scheme of electric light, tramways and dust destructor, was discussed. The Mayor pointed out that the Corporation had an opportunity of acquiring the tramways on favourable terms, and it was the general opinion that the lighting of the town should be in the hands of the governing authority. The time had come when they must decide either to supply electric current themselves or hand its supply over to a Company. With regard to the dust destructor portion of the scheme, their engineer was of opinion that the erection of a dust destructor would save them £400 a year, and relieve them of the difficulty of dust disposal. Mr. Manville, who was present, and whose scheme was under discussion, went fully into the merits of the combined undertaking, and especially pointed to the district of Swansea as one in which special sources of profit would be available, enabling the price charged for current to be abnormally low. The meeting, on the whole, was favourable to the scheme.

WALLASEY.—The engineer recently submitted to the District Council the details of an electric lighting scheme, which was estimated to entail an initial expenditure of about £12,500. The engineer recommended the Council to adopt the high-tension alternating-current system of distribution, and to erect the generating station on the site of the Liscard pumping station, while transformer sub-stations would be built at New Brighton, Egremont, Seacombe, Liscard, and Wallasey. The Council have decided to carry out the engineer's scheme.

WESTMINSTER (LONDON).—As a result of a report by the Surveyor on the advisability of establishing joint refuse destructor and electric lighting works, the Joint Works and Sanitary Committee have decided to appoint a sub-committee to obtain further information.

WESTRALIAN TELEGRAPHS.—The telegraph line is now completed as far as Menzies, placing that town in telegraphic communication with Coolgardie and other important mining districts. The first message was sent over the wires on December 3rd.

WIGAN.—At the last meeting of the Town Council Alderman Holmes, in moving the adoption of the Gas and Electric Lighting Committee's report, stated that considerable progress had been made with the arrangements for lighting the borough electrically; tenders for the buildings had been invited, and every effort would be made to have a supply of current available for the next winter.]

WILMSLOW (CHESHIRE).—At the last meeting of the District Council the subject of the establishment of electric light works was considered, and, after a lengthy debate, it was decided to adjourn the matter for 12 months.

WITTON GILBERT (DURHAM).—The principal thoroughfares of this township are now lighted by electricity, the inaugural ceremony taking place last week. The work has been carried out by the Corlett Electrical Engineering Company. The incandescent lighting has been adopted, a Crompton dynamo supplying current to about 180 16 c.p. lamps. The farthest light is two miles from the machine. The installation has created considerable interest in the neighbourhood, many of the surrounding districts being represented at the opening ceremony.

WORCESTER.—An action has been commenced against the Corporation by Messrs. T. C. and W. H. Quarrell and T. White claiming damages and an injunction in connection with Powick Weir, the waters of which are used in the Corporation's electricity scheme.

YEADON.—The District Council recently decided to canvass the principal ratepayers in order to ascertain the amount of support likely to be given to their suggested electric lighting scheme. Of the 263 voting papers which have been returned, 154 were blank, 33 favourable to the establishment of electricity works, and 76 against. At their last meeting, the Council decided not to hold the adjourned ratepayers' meeting, which had been fixed to discuss the subject, and to drop the scheme altogether.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

November 27, 1895.

22,660. W. THOMSON (Baron Kelvin). Glasgow. Apparatus to protect against danger from overhead electric wires.

22,661. W. THOMSON (Baron Kelvin). Glasgow. Improvements in apparatus for indicating and recording electric supply.

22,679. G. WADELY. London. Improvements in the construction of electric light fittings.

22,686. C. D. ABEL. London. Improved automatic electromagnetic interrupter for protecting electrical installations. (Compagnie pour la Fabrication des Compteurs et Materiel d'Usines à Gaz, France.)

22,696. W. P. THOMPSON. Liverpool. Improvements in alternating-current arc lamps. (W. Mathiesen, Germany.)*

22,717. M. KOTYRA and C. MILDÉ. London. Improvements in telephonic apparatus.

November 28, 1895.

22,783. J. D. GREENE and B. WARNE-BROWNE. London. An improved attachment for telephone receivers.

22,793. W. ROWBOTHAM. Birmingham. Improvements in and relating to electric vapour engines for vehicle and launch propulsion in particular.

November 29, 1895.

22,846. F. G. ROBINSON. Liverpool. Improvements in and connected with automatically operated electrical switches.

22,864. A. PIEDFORT. London. Improvements in and relating to telegraphic receivers, especially applicable for submarine telegraphy.

22,866. A. F. B. GOMESS. London. Improvements in the extraction of copper from its ores by electrolysis.

22,898. R. T. GROCOTT. London. Improvements in the manufacture of electrical fuseboards and other like articles.

22,899. J. E. BOUSFIELD (of the firm of G. F. Redfern and Co). London. Improvements in and connected with secondary batteries. (G. Dorville and Co., France.)

November 30, 1895.

22,936. T. F. J. TRUSS. Liverpool. Improvements in and connected with electrical commutators and collector rings, and collectors therefor.

22,939. F. G. GRIFFITH. London. Improvements in electrical sounding apparatus.

22,976. J. SWINBURNE. London. Improvements connected with electric telegraphs, organs, condensers, deposition of nickel and cobalt, and with packing eggs and other fragile articles, and coating eyelets and such objects, and making bleaching powder.

22,985. C. BREMER. London. A contact device for the transmission of electric current.*

22,987. M. M. HARRIS and G. CUTHBERT. London. An improved electrical lamp and battery, especially applicable for use in bedrooms, but applicable for various other purposes.

December 2, 1895.

23,002. F. H. PERRY. Birmingham. Improvements in electrical batteries.

December 3, 1895.

23,083. E. HODGSON, J. WALKER and A. BLACKBURN. Cleckheaton. An improved armature for dynamo-electric machines.

23,097. R. HEATHFIELD and W. S. RAWSON. London. Improvements connected with the electrical deposition of zinc.

23,109. W. M. CLOSE. Cobham. Improved electric switch for key, socket, main, or ordinary switches.

23,111. H. F. JOEL and F. FANTA. London. Improvements in electric incandescent lamps.

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23,165. A. C. Miles and B. F. de Morgenstern. London. Improvements in and relating to galvanic batteries.

December 4, 1895.

23,174. J. Hewett. London. Improvements in electric arc lamps.

23,189. H. A. Schlesinger (as agent for L. Sandoz, Geneva). New pantelegraph for transmitting in fac-simile autographic telegraphic messages in handwriting, print, sketch, design, &c.

23,250. F. W. Schneider. London. Improved paste carrying plates for electric accumulators.*

December 5, 1895.

23,259. S. Rowbottom and J. Roe. Manchester. An improved reflector for incandescent electric light globes or bulbs.

23,332. W. J. Davy. London. An improved rheostat.

23,338. H. J. Fisher. London. Improvements in or relating to electric arc lamps.

23,354. F. Le Roy. Liverpool. Improvements in electric heating devices.*

December 6, 1895.

23,404. F. Zapata. London. Improvements in electric motors.

23,415. M. Freudenberg. London. Improvements in or relating to electric arc lamps.

23,426. R. Belfield. London. Improvements in electric signalling.

23,427. A. W. Cramer and B. I. Milligan. Manchester. Improvements in the manufacture of material suitable for insulating purposes.

December 7, 1895.

23,459. E. Andreoli. London. Electro-depositing on and stripping gold from cathodes.

23,462. H. G. Cotsworth. Swindon. Improvements in the striking and regulating mechanism of arc lamps.

23,496. R. Belfield. London. Improvements relating to electric railways.

23,515. A. F. Borel. London. Improvements in the manufacture of electric cables.

23,519. A. J. P. Whitaker and F. G. Treharne. London. Improvements in electrical insulators and insulating compositions.

December 9th, 1895.

23,564. Alexander Schanschieff. London. Improvements in alloys applicable for solders, electrical safety plugs, fire alarms, heat indicators, and the like.

December 10th, 1895.

23,658. A. Rosenholz and H. E. Poehlman. London. Switches for underground electric railways.

23,670. P. H. Guerin. London. Improvements in methods of lighting by electric arc lamps.

December 12th, 1895.

23,811. W. de Graaff. Liverpool. Improvements in or connected with dynamo-electric generators.

23,841. H. G. Brain. London. An electrical system and apparatus for synchronously indicating at one or more distant points the distance registered by a ship's log.

23,844. E. Shore. Liverpool. Improvements in mooring swivels or apparatus for use in connection with lightships, guardships, or other floating bodies that are connected with the shore by electric or telegraphic cables.

23,855. The Edison and Swan United Electric Light Company (Limited) and C. F. Proctor. London. Improvements in electrical switches.

23,857. R. J. Crowley. London. New or improved system of telegraphy and telephony.

23,865. A. J. Boult. London. Improvements in or relating to thermo-electric generators. (A. Wimderlich, Belgium.)

December 13th, 1895.

23,892. W. J. McCaw. Glasgow. Improved means for conveying currents to electric motor cars, or streets, or roadways.

23,894. C. L. Clarke and W. P. Theerman. Manchester. Improvements in telephones and telephone switches or line selectors.

23,922. Siemens Bros. and Co. (Limited). London. Improved means for compensating variations of load at electrical stations. (Messrs. Siemens and Halske, Germany.)

23,943. R. C. Quin and H. Reason. London. Improvements in the lighting of streets and the like by incandescent electric lamps.

23,952. H. Fewson. London. Improvements in and relating to electric batteries.

December 14th, 1895.

23,976. J. J. P. Barker and J. S. Blackwell. Leicester. Improvements in ball-joint fittings to be used for electric lighting.

23,994. A. G. Adams. Bedford. Dynamo machines for producing alternating electric currents of low tension.

24,020. Siemens Bros. and Co. (Limited). London. Improvements in safety-fuse devices for electrical installations. (Siemens and Halske, Germany.)

24,021. Siemens Bros. and Co. (Limited). Improvements in switches for connecting two or more electromotors.

24,037. L. H. Watters. London. Electric programme or bell ringing clock.

December 16, 1895.

24,049. A. J. Moulart and Adrien de Galard. Brussels. Improvements in electrical contacts.

24,055. R. C. Quin. Brighton. Improvements in the construction of electric cable joint boxes, more especially for those of concentric type.

24,079. W. E. Parry. London. Improvements in collectors for electric railways and tramways. (J. Parry, United States.)

24,092. C. Vreede. London. Contact apparatus for night and sound signalling and telegraphing.

24,098. A. de Puydt and M. Poncin. London. Improvements in continuous-current generator dynamos or motor dynamos.*

December 17, 1895.

24,136. H. Brecknell and Thomas B. Holliday. Bristol. An automatic check or governor for controlling the trolley (trolley-wire system of electric traction).

24,165. L. Epstein. London. Process for hardening the active material on the positive plates of secondary voltaic batteries.

24,166. The Edison and Swan United Electric Light Company (Limited) and E. A. Gimingham. London. Improvements in incandescent electric lamps.*

24,172. A. C. Iwanowski. Liverpool. Improvements in or connected with galvanic batteries.

December 18, 1895.

24,222. D. Sinclair. Glasgow. Improvements in multiplex telephony.

24,264. Siemens Bros. and Co. (Limited). London. Resistance switch apparatus for starting electro-motors. (Siemens and Halske, Germany.)

24,296. A. B. Blackburn and W. L. Spence. London. Improvements in or connected with rotary electric transformers.

24,304. M. Bailey and J. Warner. London. Improvements in incandescent electric lamps.

December 19, 1895.

6,565A. H. Tee. Liverpool. Improvements connected with the electrolysis of chlorides and other salts and the evaporation of solutions. (Date claimed under Patents, Rule 19, March 30, 1895.)

24,354. C. M. Dorman, R. A. Smith and H. G. Baggs. Manchester. Improvements in electrical switches.*

24,375. J. H. Hegner. Liverpool. Improvements in electric arc lamps.*

24,394. Audley C. Miles and B. F. de Morgenstern. London. Improvements in and relating to galvanic batteries.

24,398. C. Pollak. London. Improvements in means for controlling or directing electric currents.

December 20, 1895.

24,437. The Anglo-Swedish Trading Association (Limited) and O. E. Wollert. London. Improvements in electrical and other gas-lighters and extinguishers.*

24,443. S. F. Walker. Cardiff. Improvements in portable electric lamps for use in mines and other places.

24,444. E. Hungerbühler and The Electrical Company (Limited). London. Improvements in holders for electric lamps for use in mines and other places.

24,465. A. C. Miles and B. F. de Morgenstern. London. An improved electric contact button.

24,466. A. C. Miles and B. F. de Morgenstern. London. Improvements in electric indicators.

24,467. A. C. Miles and B. F. de Morgenstern. London. Improvements in incandescent lamps.

24,471. V. A. Fynn and Easton, Anderson and Goolden (Limited). London. Improvements in devices for protecting electric circuits and apparatus from injury by excessive electrical potential due to lightning or other causes.

24,472. V. A. Fynn and Easton, Anderson and Goolden (Limited). London. Improvements in dynamo-electric machinery.

24,473. C. H. Stearn. London. Improvements in or connected with incandescence lamps and filaments therefor. (C. F. Topham, Switzerland.)

December 21, 1895.

24,503. R. Atherton. London. Improved electric insulators.

24,514. R. Hacking and J. Bennett. London. Improved means or devices for holding electric incandescent or glow lamps.*

24,516. Ludwig Epstein. London. Improvements in secondary voltaic batteries.*

24,539. A. C. Miles and B. F. de Morgenstern. London. Improvements in electric regulators.

24,556. E. Jullien. London. Improvements in suspension devices for electric and other lamps.

December 23, 1895.

24,577. T. Laurie. Falkirk. Improvements in movable supports for movable flexible electric conductors.

24,578. D. Urquhart and F. Wynne. London. Improvements in the application of electricity to vehicles on tram and railways, and in the apparatus for effecting the same.

24,618. C. Adams-Randall. London. Improvements in telephony.

24,622. C. Mackintosh. London. Mercury gravitation safety valve for kitchen and certain low pressure boilers for electric and machinery engines and water heaters.*

24,630. W. H. Tregaskis. London. Improvements in dynamo-electric and electro-dynamic machines.

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December 24, 1895.

24,680. P. H. Emanuel and H. G. Baker. Portsea. Improvements in electric lighting of cycles, carriages and other vehicles, and portable and any other lamps.

24,705. G. C. Marks. London. System of electric telegraphy and central station connections and apparatus therefor. (W. H. Cooley, United States.)*

24,710. J. Devonshire. London. Improvements in lightning arresters for high potential electric circuits. (W. B. Potter, United States.)*

24,711. J. Devonshire. London. Improvements in or relating to electric brakes. (W. B. Potter, United States.)*

24,716. L. Pritzius and F. Straube. London. Improved switch for tramways, electric railways and the like.*

24,735. W. H. Smith. London. Improvements in electric arc lamps or lighting apparatus.

December 27, 1895.

24,800. J. B. Meiklejohn. Glasgow. Improvements in and relating to electric light adapters for oil lamps and candlesticks.

24,834. C. Thery and A. Oblasser. London. Improvements in electric accumulators. [Date applied for under Patents, &c., Act, 1883, Sec. 103, June 28, 1895, being date of application in France.]

24,836. G. Asmussen. London. Improvements in electrically-operated windlasses.

24,837. P. Jensen. London. Improvements in the method and apparatus for washing alkali-amalgam obtained in electrolytic apparatus. (H. C. F. Störmer, Norway.)

December 28, 1895.

24,851. J. E. O. Kumberg. London. Development and combination of the telephone and the phonograph.

24,852. W. P. Adams. London. Insulating material for electrical purposes.

24,868. W. Thomson (Baron Kelvin). Glasgow. Improvements in recording instruments for telegraphic and other purposes.

24,804. J. W. Ewart and G. Ewart. London. Automatic switch for electric water heater.

24,885. J. R. C. Gale. London. Improved apparatus for electrically controlling the supply of gas and other fluids, and for like purposes.

24,888. G. W. Goldring. London. Improvements in hinges or joints for electrical purposes.

24,892. P. R. Jackson and Co. (Limited) and J. S. Lewis. London. Improvements in regulators for dynamo-electric machines.

24,895. P. R. Jackson and Co. (Limited) and J. S. Lewis. London Improvements in dynamo-electric machines.

24,905. T. J. Rorke. London. Improvements in and relating to telephone transmitters.

December 30, 1895.

24,945. H. J. Fisher. London. Improvements in and relating to carbon holders for electric arc lamps.

24,949. S. S. Allin. London. Improvements in electric arc lamps.

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1894.

16,686. Vogt. Galvanic cells.

25,031. Hookham. Electricity meters.

25,231. Radcliffe and Philips. Incandescent electric lamp gauge.

1895.

107. Levetus and others. Primary batteries.

148. Shallenberger. Measuring electric currents.

185. Bassano. Telephonic apparatus.

437A. Barton (Jandus). Arc lamps.

671. Andrews. Magnetic cut-outs.

825. Mann and Hermand. Arc lamps.

1,442. Clarke and Theerman. Electrical ceiling roses.

1,477. Bevis and Binswanger. Arc lamps.

1,676. Marchant and Woolley. Electrical storage batteries.

1,697. H. and R. Niewerth. Arc lamps.

1,717. Pirsch. Electric accumulators.

1,899. Mapple. Electric railways or tramways.

1,940. Hopkinson and Wood. Electric switches.

1,906. Threlfall (Thelfall). Electric condensers.

2,228. Clatworthy. Operating electric motors.

2,316. Siemens Bros. and Co. (Limited) and Lauckert. Electro-dynamometers.

2,343. Pope (Pope). Electric incandescent lamps.

2,373. Bullers (Limited) and Chambers. Telegraph pole socket joints.

2,570. Meason and Ford. Chandeliers, electroliers, &c.

2,604. Crompton. Arc lamps, &c.

2,650. Quincey. Electric bells or gongs.

2,817. Edmunds. Electrical conductors.

3,003. Thompson (Lauhoffer and others.) Regulating electric motors.

7,600. Rowbotham and Others. Primary batteries.

11,728. Shaw. Electric switches.

13,900. Gordon. Galvanic batteries.

14,638. Chapman (Potter). Electric brakes.

14,639. Chapman (Potter). Electric cars.

14,858. Harris. Electric meters.

15,686. Thompson (McLaughlin). Electric railways.

17,269. Jungnickel. Galvanic dry cells.

17,290. Davies (White). Electric lamp, &c., support.

17,495. Feeny (H. W. Johns Manufacturing Company). Electrical heating apparatus.

17,851. Zerning. Incandescence lamps.

18,033. Thompson (Bradley). Rotary magnetic fields.

19,104. Buxton. Electric rail-bonds.

19,204. Gibson. Electric signalling.

19,317. La Burt. Electric railways.

19,318. Smith and Vassar. Telephone and signalling systems.

19,461. Cox. Thermo-electric generators.

19,696. Woodbridge. Electric light display systems.

19,861. Devonshire (Potter). Electric railways.

19,862. Devonshire (Thomson). Dynamo electric machines.

19,863. Devonshire (Steinmetz). Alternating-current regulators.

20,047. Edison and Swan United Electric Light Company (Limited) and Woodley. Incandescent electric lamps.

20,214. Boynton. Galvanic batteries.

20,215. Boynton. Galvanic batteries.

20,216. Boynton. Galvanic batteries.

20,306. Langelaan. Storage batteries.

20,392. Wheless. Steam boilers.

20,431. Rooney. Secondary batteries.

COMPANIES' MEETINGS AND REPORTS.

Fowler-Waring Cables Company (Limited).

The report of the Directors of this Company, which was presented at the sixth ordinary general meeting of the Company, held on the 30th ult., calls attention to the negotiations which were proceeded with during the year with the object of bringing about a reconstruction of the Company, which would have secured to the shareholders a valuable interest in the new Company at that time projected. These negotiations, however, fell through, and at the meeting further proposals were presented. The report continues:—"It has long been clear that it is essential to add to our productions other classes of electrical cables than the special lead-covered type for the manufacture of which the Company was originally formed. Applications to the shareholders for capital to aid thed evelopment of their business have been found to be useless, and the Directors have themselves found the necessary funds for its continuation. The time, however, has now come when a decision must be taken between two alternatives, liquidation, or the introduction of new capital to allow of the extension of the Company's operations to other branches of the industry, in which, for lack of capital, it has hitherto been unable to compete." The Directors at the meeting recommended the latter course, and a scheme for reconstruction, setting forth their financial proposals, was submitted. The report further stated that the losses on trading were very heavy during 1894, in consequence of heavy fixed charges, which could not be materially reduced so long as the Company was kept in a position to execute the large orders which might then have been expected, and which, to some extent, have come to us. These orders were not sufficiently numerous, and the competition was severe for those which were obtained. The loss on trading was not so heavy during 1895, but until a few months ago it has been continued, and, were it not for the fact that recently much larger contracts have been secured, and that there have passed into the hands of the Company several important improvements relating to cable manufacture, the Directors would not feel themselves at all justified in recommending the continuance of the business. In the many important contracts carried out by the Company its work had been uniformly successful; but changes in electrical business are continually occurring, and it has become evident that, however important in itself, the manufacture of lead-covered cables alone cannot ensure success. Having, therefore, secured for the Company a high reputation for the manufacture of this class of cable, the Directors proposed to save the business by increasing its scope and extending its operations. In connection with the improvements referred to above, the Directors state that they have obtained an advantageous option for the purchase of a patent for the production of a substitute for india-rubber and gutta-percha. This material has been thoroughly tested at the works, and the Directors are satisfied that it possesses properties of a real commercial value in various directions, and especially in the manufacture of electrical wires and cables, and that this development should render possible a great extension of the business. To wind up the Company at once and realise its assets might, the report continues, appear the simplest and least troublesome course; but under a break-up it is scarcely possible that the shareholders would receive any return of capital, as it must involve the loss of a connection and experience which have cost much, as well as the forced sale of assets

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which are of great value to a going concern. The Directors therefore recommend reconstruction.

At the meeting we learn the Directors' proposals were agreed to, the retiring Directors and auditors re-elected, and the resolutions approving the reconstruction of the Company, and appointing Mr. B. J. Diplock (the Secretary) as liquidator in the voluntary winding-up of the old Company, were passed, to be finally approved at a subsequent meeting.

The scheme for reconstruction of the Company provides for a new Company being formed, bearing the same name as the existing Company, with a capital of £200,000, divided into 40,000 shares of £5 each, Ordinary or Preferred. The present Company to be wound up voluntarily, and its property and assets, subject to its liabilities, to be transferred to the new Company in exchange for 4,060 fully paid-up shares of the new Company. As the issued capital of the existing Company is £101,500, or 20,300 shares, this will give to each shareholder of the existing Company one fully paid-up share of the new Company in exchange for each five shares of the present Company, whether Ordinary or Founders' shares. Holders of Mortgage Debentures and prior lien charges of the existing Company, aggregating £28,850, to release their charge upon the property and assets of the Company, and receive in exchange debentures of the new Company to the same amounts at 5 per cent. per annum, and forming part of an issue of £30,000 of debentures, ranking *pari passu* as a first charge upon the undertaking and all property of the Company, subject only to a prior mortgage or mortgages to be created upon the lands and buildings of the Company, to an amount not exceeding £21,000. To provide additional working capital, 4,000 shares of the new Company will be forthwith offered for subscription at par, entitled to a cumulative preferential dividend of not less than 6 per cent., and thereafter to participate rateably with the Ordinary shares in any further division of profits, or on such other terms as the Directors may hereafter determine. The new Company will take over the business and assets as from September 30th last, the trading since that date to be considered as having been carried on on behalf of the new Company. The new Company is to complete all contracts, to pay all debts, and to discharge all liabilities of the existing Company. The expenses of the liquidation of the old Company and the reconstruction of the new Company to be paid by the latter.

The officials of the new Company are the same as those who have for many years managed the old Company, which was established on August 13, 1889.

NEW COMPANIES, STATUTORY RETURNS, &c.

LANGHANS-BERRENBERG-CHAPLIN PATENTS (LIMITED).—This Company was registered on December 31st with a capital of £175,000, in £1 shares, to carry into effect an agreement made between Albert Myers Gibson and the Company, to carry on the business of manufacturers of incandescent and other electric lamps, and of all filaments, wires, bulbs, and other parts and requisites of such lamps; to manufacture pumps, plant and other appliances necessary in the manufacture of incandescent electric lamps; to carry on the business of an electric light company in all its branches, and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity for the purposes of light, heat and motive power, and manufacturers of and dealers in all apparatus required in connection with the generation, accumulation, supply, utilisation and distribution of electricity. The subscribers are: H. L. Pilkington, P. J. Miller, Templer L. Down, W. A. Smithe, David S. Porteous, A. da Costa and William Wallace.

AFRICAN TRANSCONTINENTAL TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, to December 28th, shows that the whole capital of £140,000, in £1 shares. has been subscribed, and the full amount has been called on 1,306 shares, while a call of 10s. per share has been made on the remaining 138,694, resulting in the receipt of £53,201, leaving £17,537 in arrears.

ARC ACCUMULATOR COMPANY (LIMITED).—This Company's annual return to December 6th, shows that the whole nominal capital of £1,000, in £1 shares, has been taken up, and 993 issued as fully paid. The full amount has been called on the remaining 7, but without result.

ATLAS CARBON MANUFACTURING COMPANY (LIMITED).—The annual return of this Company, to December 2nd, just filed, shows the whole nominal capital of £2,000, in £1 shares, has been taken up, and 1,992 of these have been issued as fully paid, while no calls have been made on the remainder. A resolution for the change of the name to "The Atlas Carbon and Battery Company (Limited)" was passed on November 25th, and confirmed on December 11th.

AUTOMATIC ELECTRIC SIGN COMPANY (LIMITED).—The statutory return of this Company, to December 3rd, has just been filed. The Company has a capital of £5,000, in £1 shares, of which 158 have been subscribed. The full amount per share has been called, resulting in the payment of £108. 15s., leaving £49. 5s. outstanding.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—The annual return of this Company to October 7th has just been filed. Out of a nominal capital of £750,000, divided into 150,000 Ordinary shares of £3 each, and 150,000 Preference shares of £2 each, 90,000 of each class have been taken up, the full amount called, and £450,000 paid.

CALIFORNIA GAS, WATER AND ELECTRIC LIGHT SYNDICATE (LIMITED).—It is notified that this Company has left its registered office, and repeated requests have been made for the filing of the returns, but without result. Unless this information is forthcoming, the name of the concern will be struck off the register.

CARBON BATTERY COMPANY (LIMITED).—This Company has failed to comply with the regulations of the Companies Acts, and will be formally dissolved unless the returns are forthcoming.

CHELMSFORD ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return to December 21st has been filed. The capital is £10,000, divided into 7,500 Preference and 2,500 Ordinary shares of £1 each. The whole of the former and 2,378 of the latter class have been taken up, and the full amount has been called and paid.

ELECTRO-CHEMICAL COMPANY (LIMITED).—The annual return of this Company, to November 19th, has been filed. The capital is £200,000, in 26,000 Preference and 14,000 Ordinary shares of £10 each. 17,710 of the former and all the latter have been taken up, and 5,000 Preference and the Ordinary have been issued as fully paid. The full amount has been called on 12,710 Preference, and £50,699 has been paid.

TOWN AND VILLAGE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return of this Company, to November 7th, has been filed. The capital is £100,000, in 19,800 Ordinary shares of £5 each and 1,000 Founders' shares of £1 each. Seven of the former class have been subscribed for, but nothing has as yet been called or paid.

VAL D'AOSTA ELECTRIC POWER COMPANY (LIMITED).—The statutory return of this Company to November 13th shows that 250 shares have been subscribed for and allotted, out of a capital of £80,000, in £10 shares, and a call of £5 per share has been made and £1,250 received.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30 9/16d. per oz. (Jan. 9th). Consols (2¾ per cent.) 105⅞—106 for money, 105⅞—106 for account; 2½ per cent. 102½—103 (Jan. 9th). Stock Exchange Settling Days: Consols, Feb. 3rd; Stocks and Shares Continuation Day, Jan. 14th; Ticket Day, Jan. 15th; Pay Day, Jan. 16th.

BRIGHTON AND ROTTINGDEAN SEASHORE ELECTRIC TRAMROAD COMPANY (LIMITED).—A meeting of the members of this Company has been convened for the 20th instant, for the purpose of considering the Company's proposed Bill for extending the time for completing the line, and for the raising of additional capital.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended January 5th were £1,017, against £1,003 in the corresponding week of 1895, an increase of £14.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Directors of this Company have declared an interim dividend of 2s. per share, free of income tax, being at the rate of 2 per cent. per annum, for the quarter ended December 31st last, payable on and after the 24th inst., setting aside £10,000 to reserve fund account and carrying forward a balance of £4,148. 14s. 4d.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of December are £2,514, against £1,671 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The general meeting of the shareholders of this Company will be held at Winchester House, on Thursday, the 23rd inst.—The traffic receipts for the month of December, 1895, amounted to £71,577, against £55,598 in the corresponding period of 1894.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The interest on this Company's Four per Cent. Mortgage Debenture Stock for the half-year ended January 31st inst. will be paid by warrant on February 1st next. The Stock Register will be closed from the 28th to the 31st inst., both days inclusive. The traffic receipts of this Company amounted to £49,131 for the month of December, 1895, and to £39,783 for the corresponding period of 1894.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).—An interim dividend of 1s. 6d. per share has been declared by the Directors of this Company. This dividend is payable on the 20th inst.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company in December, 1895, were £26,000, and the total receipts for the year ended December 31st, 1895, £312,400; against £269,200 and £285,800 in 1893 and 1894 respectively.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 5th inst. amounted to £1,150. The amount for the corresponding week last year was £926; increase, £224.

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to appoint a special settling-day in and to grant a quotation to 200,000 shares of the Castner-Kellner Alkali Company (Limited), and to allow the further issue of 469 Five per Cent. Perpetual Preference shares of the City and South London Railway Company, and £60,000 Four per Cent. Debenture stock of the St. James's and Pall Mall Electric Light Company (Limited), to be quoted in the Official List.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—Notice is given that Six per Cent. Debenture Bonds of 1880 will be drawn (series A, to the nominal amount of £7,100; series B, £8,800) for payment at the offices of the Company, on Monday next, the 13th inst., at 12 o'clock. This Company's traffic receipts for the week ended January 3rd, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,640.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half-month ended December 31st are £2,639, against £1,949 in the corresponding period of 1894.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Dec. 31	Price Wednesday, Jan. 8.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Jan. 4. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£250,000	£10	..	Amazon Telegraph	..	8 8½	..	..	..	..
$1,012,880	Stock	10/0	Anglo-American	41 43	41 43	5 4 8	Jan., Apr., July, Oct.	42⅜	..
$2,993,560	Stock	20/0	Do. Preferred	79 81	79 81	5 11 1	" "	80⅜	80½
$2,993,560	Stock	5/0	Do. Deferred	6 6½	5⅞ 6⅛	..	..	..	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)..xd	101 105	100 104	3 16 11	January and July	..	..
120,000	£10	3/0	Brazilian Submarine	13½ 13⅝	13½ 13⅝	5 9 1	Mar., June, Oct., Dec	13⅝	13⅝
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906) ..xd	110 114	110 114	4 7 9	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock .....xd	160 170	160 170	4 2 4	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	13 14	13 14	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 13 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	3½ 4½	3½ 4½	4 8 11	April and October ..	4½	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 5 8	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each .....xd	102⅝ 105⅝	102⅝ 105⅝	4 5 9	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8 8½	8 8½	4 14 2	Jan., Apr., July, Oct.	8⅞	..
400,000	10	2/6	Eastern	16 16½	16 16½	3 18 9	" "	16½	16
70,000	10	6%	Do. 6 per Cent. Preference	17½ 18	17½ 18	3 6 8	" "	..	..
£1,297,83'	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	125 128	125 128	3 2 11	May and November	..	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899.....	107 110	107 110	4 13 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17 17½	17 17½	4 0 0	Jan., Apr., July, Oct.	17½	17⅜
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	127 130	127 130	3 10 1	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900..xd	102 106	100 104	4 16 2	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900xd	102 106	100 104	4 6 2	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) ..	108 111	107 110	3 13 11	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.).....	112⅞ 115⅞	112⅞ 115⅞	3 10 0	May and November	..	..
180,227	10	1/8	Globe Telegraph and Trust	9½ 10	9½ 10	4 5 0	Jan., Apr., July, Oct.	9⅞	9½
180,042	10	6%	Do 6 per Cent. Preference	16½ 17	16½ 17	3 10 7	" "	16⅝	..
150,000	10	5/0	Great Northern	21½ 22½	21½ 22	3 18 0	Jan., April, and July	..	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue.....	104 107	104 107	4 14 7	March & September	..	..
17,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	..	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 110	106 110	5 11 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942xd	108 111	108 111	3 12 1	.. ..	..	..
11,339	8	4/0	Reuter's	4 5	4 5	..	April and October ..	..	..
3,581	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	127 132	127 132	4 10 11	" "	..	..
15,609	10	2/0	West African Telegraph	5⅝ 6⅛	5⅝ 6⅛	..	January and July ..	..	..
£238,300	100	5%	* Do. 5 per Cent. Debentures (red.)	103 105	102 105	4 16 10	March & September	..	..
30,000	10	2/0	West Coast of America	1 2	1 2	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902 .....xd	94 99	94 99	8 1 7	June and December	..	..
88,321	10	1/8	West India and Panama	⅞ 1⅛	⅞ 1⅛	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10⅝	10½ 10⅝	5 11 7	May and November	..	..
4,689	10	6%	Do. 6 per Cent. 2nd Preference	8⅝ 9⅛	8⅝ 9⅛	6 6 4	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.) ..xd	103 112	109 112	4 9 3	June and December	..	..
64,248	15	3/9	Western and Brazilian	9 9½	9 9½	5 4 0	May and November	9½	..
33,129	7½	3/9	Do. 5 per Cent. Cumulative Preferred	6½ 6⅝	6½ 6⅝	..	..	..	..
33,129	7½	1/6	Do. Deferred Ordinary	2⅜ 3⅛	2⅜ 3⅛	..	..	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 14 10	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 14 10	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds....	113 118	113 118	5 13 8	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100 103	100 103	5 18 10	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3½ 3⅝	3½ 3⅝	..	..	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance ..	⅛ ⅜	⅛ ⅜	..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid).....	⅛ ⅜	⅛ ⅜	..	Yearly	..	..
484,597	5	2/6	National	5½ 6⅛	5⅝ 6	4 3 4	June and December	..	..
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)....	15½ 16½	15½ 16½	3 12 9	" "	..	..
119,284	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6½ 6⅝	6½ 6⅝	3 16 11	.. ..	..	..
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)..... xd	105 107	104 107	3 5 5	January and July ..	105½	..
58,000	5	3/0	United River Plate	2⅜ 3	2⅜ 3	..	" "	..	..
£146,783	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)....xd	90 95	90 95	5 5 3	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12⅛ 13⅛	12⅛ 13⅛	1 17 9	—	13⅜	13
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15⅛ 16	15⅛ 16	3 15 0	—	..	..
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.) .....xd	131 135	131 135	3 14 1	June and December	132½	..
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½ 5⅝	5½ 5⅝	..	—	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. —	.. —	..	—	..	..
22,475	£8	..	County of London & Brush Prov. Ord. (fully paid).	—	8 9	..	—	..	..
10,000	£10	9½d.	Do. Pref. (£6 paid)	..	10½ 11	..	—	..	..
8,332	£5	..	House-to-House Electric	.. —	.. —	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	—	—	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	January and July ..	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 8½	7⅞ 8½	..	—	..	..
111,000	5	..	London Electric Supply	..	..	..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	10 11	10 11	2 0 11	—	..	..
150,000	Stock	4½%	* Do. 4½% Debs. .....xd	5 118	114 117	3 16 10	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9	8½ 9	..	—	..	..
..	..	..	Rand Electric	¼ ½ prem	¼ ½ prem	..	—	..	..
19,980	£5	2/0	St. James and Pall Mall	8½ 8⅝	8½ 8⅝	..	—	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	9 9½	9 9½	3 18 8	—	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8½ 8⅝	8½ 8⅝	3 2 10	—	—	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1½ 1⅝	1½ 1⅝	10 17 4	—	..	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝ 2⅛	1⅝ 2	6 0 0	—	1⅞	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 19 4	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref..	2 2½	2 2½	..	January and July ..	..	..
89,261	5	1/6	Edison and Swan United	1⅝ 2	1⅝ 2	..	..	1 ⅜	1⅝
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock..... xd	101 107	104 107	4 4 1	..	101	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	—	.. ..	..	..	..	..
110,000	2	..	Electric Construction	⅜ ½	⅜ ½	..	..	..	..
12,845	2	2/9½	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 11 0	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	¼ ½	¼ ½	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¼ ½	¼ ½	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	18 19	18 19	3 18 11	February & August	19	..
£210,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101 103	101 103	4 8 8	March & September	..	..
15,995	£10	..	International Okonite Ordinary	..	..	..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	—	..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	¼	¼	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	41 43	41 43	4 3 9	March and July.....	..	..
£150,000	100	5%	* Do. 5 per Cent. Bonds..... xd	104 107	102 105	4 15 3	January and July .	..	..
37,514	£5	—	Woodhouse and Rawson Ordinary (£8 15s. paid)..	..	.. ..	..	—	..	..
41,098	£5	..	Do. Preference (fully paid)	..	.. ..	..	—	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary.....	13½ 14½	13½ 14½	4 2 9	—	..	..
£10,000	10	7/0	Do. 7 per Cent. Preference	15½ 16½	15½ 16½	4 4 10	—	..	..
£40,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock.....	108 111	108 111	4 2 2	—	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway	40 42	40 42	2 13 6	May and November	..	..
7,650	10	5%	Do. 5% Perpetual Preference	14⅜ 15¼	14⅜ 15¼	3 5 7	.. ..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	128 130	128 130	3 1 11	May and November	..	..
37,500	£10	2½%	Liverpool Overhead Railway	11½ 11⅝	11½ 11⅝	1 13 4	—	..	..
10,000	10	5%	Do. 5% Preference	15½ 15⅝	15½ 15⅝	3 3 6	—	..	..
135,000	Stock	4%	Do. 4% Debenture	114 116	112 114	3 10 2	January and July	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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NOTES.

TO-DAY we re-publish the steel-plate portrait of Dr. JOHN HOPKINSON engraved on the occasion of his election to the Presidency of the Institution of Electrical Engineers in 1890, and we are glad to think that the hand of time has dealt so gently with Dr. HOPKINSON that the portrait of the President of 1890 is the "counterfeit presentment" of the President of 1896. Much has been said of late about the high-standing in the electrical profession and the many qualifications which ought to distinguish a President of the Institution of Electrical Engineers. In Dr. HOPKINSON we have a Senior Wrangler, a Smith's prizeman, the founder of the scientific method of dynamo designing, and one whose magnetic investigations rightly earned for him a Royal Medal; his recent beautiful research on the rate of propagation of magnetism in iron cores will be within the recollection of all who were able to attend the memorable meeting in the rooms of the Society of Arts last February. The new President of the Institution of Electrical Engineers is peculiarly representative of electrical engineering, which probably contains within its ranks a greater proportion of men in whom science and practice are harmoniously blended than any other branch of "the art of directing the great forces of Nature for the use and convenience of man."

THE central-station engineer sighed in his youth for the electrical analogue of the gasometer. Then he yearned for a day-load, which came not, notwithstanding motors and cooking, and basement-lighting. The great problem has, however, at last received a solution. One need only use parish refuse for fuel, store the heat *à la mode de* Halpin, and negotiate with an obliging tunnel-electric-railway to take a few hundred thousand units per annum, at a fixed price during the hours of light load only. With these three aids to economy, the Shoreditch Vestry seems to be approaching the discovery of the Philosopher's Stone or of Perpetual Motion. This fortunate local authority, as will be seen in another column, has just closed a contract to supply the *in futuro* London, Walthamstow and Epping Forest Railway Company with a minimum of 800,000 units, at 1½d. per unit; the current to be used for tunnel and station lighting, with storage batteries for the evening supply.

THE Railway Company expects to use about 420,000 units a-year. Now, 420,000 units at 1½d. means, as the Electric Lighting Committee point out, £2,625 per annum, and as the engineers are reported to have estimated "that the extra expenses of running the machinery for this quantity of electricity would only amount to about £50 per annum," it is needless to add that the contract was straightway accepted. The offer of the Railway Company is undoubtedly a most advantageous one both to itself and to the Vestry, and we can only hope many more such offers will be made to other metropolitan and provincial electric supply concerns. At the same time it would seem that there must be a cipher missing in that estimate of extra cost. Up to now ·7d. per unit for fuel, leaving oil, waste, water and wages out of consideration, has been considered a good minimum figure without the aid of day-load, dust-fuel and thermal-storage. Can it be that these are going to reduce this figure to less than 0·03d? Perhaps if we multiplied that £50 by 10, we might be somewhat near the *total* extra cost of those 420,000 units.

THE technical gas journals are doing their best to make out that the growth of municipal electric lighting enterprise is a sign of electrical decadence. Doubtless the wish is father to the thought. According to their way of regarding the matter, it is the electrical engineers who, failing to gain the confidence of the capitalist, are attempting to foist a decaying industry upon the hands of sleepy and ignorant municipal corporations. The capitalist, having been bitten and grown twice shy, is, they say, no longer keen upon investing in electricity supply works while any fool can fool a vestry. And our gas friends back up their opinions by pointing out that, in the past, municipal control has been the haven of refuge for more than one shipwrecked commercial venture, *e.g.*, making illuminating gas from sewage or from dustbin refuse. But facts are against our gaseous contemporaries. Many, if not most, of the existing municipal electric lighting schemes have been carried out under Provisional Orders snatched from eager capitalists who would have been glad to have undertaken the work. Take the latest example, at Lincoln, where the application of the County of London and Brush Provincial Electric Lighting Company for a Provisional Order has been refused because the City Council themselves are considering the advisability of providing a supply. Moreover, the gas people should not forget that it is not electric lighting alone that is so "decadent" as to come under municipal control. This tendency towards municipalisation may indeed contain the germs of commercial decadence or of that long overdue New Era; but the eagerness of the Local Authorities to do their own electric lighting, far from

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denoting the decadence of the electrical industry itself, is an outward and visible sign of a well-founded belief in its vigour and profitableness. Even a Vestry may be trusted not to indulge in an obviously losing business.

Of the various methods of reducing the light from an incandescent lamp, and they are many, perhaps the most ingenious is that which has been invented by Mr. Macfarlane Moore, and which was described by him in a Paper which he read before the American Institute of Electrical Engineers in 1893. Recently-published tests of this method show it to possess, at any rate, a higher efficiency than can be claimed for any other contrivance intended for the same purpose, not excepting the choking coil or the opposition of storage cells. Mr. Moore's method, which sounds "terribly scientific," consists in placing in circuit with the lamp, the light of which is to be controlled, a regulator composed of a make-and-break contact rapidly working in a vacuum. The whole apparatus, excepting the magnet, may be placed in a tube not more than an inch in length, and of the diameter of an ordinary lead pencil. Tests have been made of this apparatus in circuit with a 17 c.p. lamp, and have been compared with the results obtained when an ordinary rheostat replaced the interruptor. The difference, as might be expected, is more marked in proportion to the amount of dimming of the lamp. Thus, when the light was reduced to 10 c.p. there was no observed difference between the current in the two cases; but when it was reduced to 4 c.p. a current of only 0·38 ampere sufficed with the vibrator in circuit, while 0·45 ampere passed when the control was by means of the rheostat; and at 1·1 c.p. the currents were 0·26 and 0·36 ampere respectively. Notwithstanding the sound-deadening effect of the vacuum, we should not like to recommend Mr. Macfarlane Moore's device to a light sleeper. It is true that an old stocking would probably effectually quench the hubbub of the night-light buzzer, but why not put the stocking over the glow-lamp and dispense with the vacuum make-and-break?

It would be an odd cycle of events if acetylene, derived from calcium carbide made in an electric furnace, were to be used for driving a gas engine, say, to generate electric power. Dr. A. Frank, of Charlottenburg, however, has been investigating the advantages and disadvantages of this method of transmitting and obtaining power, and, in the *Journal für Gasbeleuchtung*, has given the results of his calculations. The basis of Dr. Frank's argument is that solid calcium carbide would be a cheap and convenient medium for the transmission of energy, the primary source of energy being a waterfall or some other not less cheap. He concludes that to obtain 1,000 H.P. for 25 days would require 295 tons of calcium carbide, as against 413 tons of coal, the latter being used for steam raising. The comparison is not devoid of interest, but it is woefully incomplete. The most flagrant omission is the absence of a comparison of costs, but perhaps —nay, certainly—this would have been less happy than the comparison of weights. Then again, Dr. Frank has ignored the possibility of using coal fuel in a gas engine, instead of raising steam; and his estimate of 1·543lb. (delightfully accurate though its four significant figures may be) of coal per horse-power-hour would be reduced to about 1·000lb. if a gas engine were used instead of a steam engine. Lastly, he has forgotten that Nature has provided us with a richer fuel than even calcium carbide in ordinary petroleum. To make the comparisons complete, therefore, we may add that about 267 tons of coal for gas power, and about 274 tons of petroleum for oil engines, would be the dynamical equivalent of the 295 tons of calcium carbide. We may take it, then, that it will be some time before the remarkable state of affairs mentioned at the beginning of this note will be brought about.

The Transfer of Trunk Telephone Lines.—It has not yet been found practicable to carry out the proposed transfer of the trunk telephone lines of the National Telephone Company to the Post Office Department on the 1st inst., as was originally proposed.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Puerto Plata—Martinique ...	December 19, 1895 ...	—
Perim—Obock	January 2, 1896 ...	—
Sierra Leone—Accra	January 13, 1896 ...	January 15, 1896
Bathurst—Sierra Leone	January 14, 1896 ...	—
Konakry—Sierra Leone	January 14, 1896 ...	—
St. Thome—Loanda	January 15, 1896 ...	—

Church Struck by Lightning.—All Saints' Church, Sheffield, built through the munificence of Sir John Brown, was struck by lightning just before the afternoon service on Wednesday. The gas ignited and the chancel was soon in flames. Help was forthcoming, but the seat of the fire was got at with difficulty, and only just in time to prevent the flames consuming the valuable organ and fittings.

High-Volt Lamps for Edinburgh.—At Tuesday's meeting of the Electric Lighting Committee of the Edinburgh Town Council it was resolved to invite quotations from leading manufacturers for 10,000 high-voltage lamps, in view of the contemplated change to 230-volt lamps. It was further decided to obtain the opinion of the consulting engineer, Prof. A. B. W. Kennedy, so that the very best lamp in the market might be procured.

The "Benevolent Fund" of the Institution of Electrical Engineers.—Notice is given that a meeting of the donors and subscribers to the "Benevolent Fund" of the Institution of Electrical Engineers will be held at the offices of the Institution, 28, Victoria-street, Westminster, on Monday, February 3rd, at 4 p.m., for the purpose of considering, and, if approved, of adopting the draft rules which have been drawn up by a Committee of the Institution, and further for the election of a Committee of Management and officers in accordance with such rules as may be finally adopted.

Telegraphic Communication with South Africa and Ashanti.—The temporary interruption of communication by the West Coast route, to which reference has been made in the public Press during the last few days, was caused at Sierra Leone by the burning, on the part of the sanitary authorities, of a quantity of rubbish at the water's edge just where the shore ends of the cables from Bathurst and Accra are buried. The intense heat burnt the spun yarn serving of the cables, and completely melted the gutta percha insulation. No less than three sections were interrupted in this way, but repairs were promptly effected by the Superintendent, and the lines are now working well.

Crompton Arc Lamp Patent.—On Friday next will expire Patent No. 346 of 1882, granted to Rookes Evelyn Bell Crompton for "Improvements in Electric Lamps and Apparatus used in Connection with Electric Lighting." There are four claims, of which the first is as follows:—The use in an electric regulator lamp of a combination of a gearing frame moved by an electro-magnet or solenoid in the main circuit, with feed mechanism consisting of the brake wheel and parts operating therewith, which feed mechanism is set in motion by

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the action of an electro-magnet or solenoid on a shunt or derived circuit, the whole forming a means of controlling the length of the arc substantially as described.

Institution of Junior Engineers.—At a meeting of the Institution of Junior Engineers, on the 10th inst., Prof. T. Hudson Beare, M.I.C.E., delivered a lecture on "Problems Connected with the Theory, Working and Testing of Gas Engines and Hot-Air Motors." In the course of his remarks Prof. Beare dealt with the use of regenerators for gas engines. He considered that possibly the efficiency could be increased, but at the cost of a bulkier engine for a given power. In regard to testing, it was shown that a complete thermal balance sheet of a gas engine can be obtained without direct measurement either of the volume of air or of the temperature of the exhaust, the temperature at the highest compression being the only assumption it would be necessary to make.

The Hopkinson Three-Wire Patent.—Notice is given that it is the intention of Dr. John Hopkinson and the Westinghouse Electric Company (Limited), of 32, Victoria-street, to present a petition to Her Majesty in Council, praying that Patent No. 3,576 of 1882 may be extended for a further term; and notice is further given that on February 24th next, or on such subsequent day as the Judicial Committee of Her Majesty's Privy Council shall appoint for that purpose, an application will be made to the Committee for a time to be fixed for hearing the petition; and any person desirous of being heard in opposition must enter a caveat to that effect in the Privy Council Office on or before February 24th next. This patent is the well-known three-wire patent, which would expire in the ordinary course of events on July 27th next. The claims of this patent as amended in June, 1891, are two in number. The first relates to the employment of "a differentially-wound indicating or regulating apparatus" to indicate when the difference potential between the positive and negative conductors at any point in a system of distribution differs from the normal by more than an assigned value, the generators being then automatically regulated accordingly. The second claim is as follows:—"In a system of electrical distribution or supply the employment of three (or more) conductors in combination with two (or more) dynamo-machines in series substantially as hereinbefore described with reference to Fig. 5 of the accompanying drawings whether the middle conductor be continuous or be replaced by an earth return, *as set forth*."

The Walthamstow and Epping Forest Railway.—At the last meeting of the Shoreditch Vestry the Electric Lighting Committee reported that they had had under consideration the question of entering into a contract to supply the London, Walthamstow and Epping Forest Railway Company with current for lighting their stations and tunnels. The engineers had fully reported on the subject, and it appeared that the Company will require about 420,000 Board of Trade units per year. This the Company will take purely as a day load, and will provide the necessary accumulators and all the subsidiary apparatus to enable them to supply themselves over the hours of heavy load, so that no extra plant would be required by the Vestry. The engineers estimated that the extra expense of running the machinery for this quantity of electricity would only amount to about £50 per annum, whereas the revenue at 1½d. per Board of Trade unit (the price recommended by the engineers) would be £2,625 per annum. In view, therefore, of the extremely beneficial effect of such a contract as this, which can be entered into at hardly any extra expenditure, the Committee decided to recommend "The Vestry to enter into a contract with the London, Walthamstow and Epping Forest Railway Company to supply them with electricity of a minimum amount of 300,000 Board of Trade units per annum, to be paid for whether they use this quantity or not, at 1½d. per Board of Trade unit on the above conditions, and to attach the Vestry's seal to the contract." The report was agreed to.

An Electrical Engineering Symposium.—The January issue of *Cassier's Magazine* is an "Electrical Number," and contains a wide variety of articles from the pens of frequent contributors to the American electrical press, not the least valuable feature of each article being a striking likeness of the author of it. The first contribution is a general-reader sort of discourse by Messrs. Houston and Kennelly on "Municipal Lighting from Underground Mains," the mains referred to being mostly Edison, and the municipal lighting mostly American. Dr. Louis Bell has a lucid little elementary article on "The Induction Motor," and articles on "Coalless Cities" and "Electricity for Propelling Railroad Trains at Very High Speeds," by Prof. F. B. Crocker and Mr. Hiram S. Maxim respectively, give the peeps into the future now so much in vogue. To English readers perhaps the most valued article will be that by Mr. R. E. B. Crompton on "Electrically-Operated Factories," in which he shows the immense saving (some 50 per cent.) which the thorough adoption of electric motors in engineering workshops would effect in the annual bill for the running and maintenance of the shop power-plant. Mr. Crompton also lays emphasis on the many side advantages offered by the presence of the electric current in the workshop, and his contribution, if it reaches those most concerned—*i.e.*, the owners of big engineering and similar shops—should prove of a very persuasive character. The "Electrical" number of *Cassier's* is a judicious blend of many sorts of information.

Electric Haulage Experiments on the Burgundy Canal.—Further electric haulage experiments are being carried on at the present moment on a selected section of the Burgundy Canal by the Société de Traction Electrique des Bateaux sur les Voies Navigables. Two modes of propulsion are being tested. Either an electrically-propelled iron boat is fixed to the sterns of the barges or they are *hauled* by a motor secured to a frame suspended from an overhead wire. The canal is 10 metres wide at the bottom and 1·8 metres deep, the draft of the barge, loaded to 186 tons (1,000 kilogramme ton), being about 1·5 metres. The current was supplied to the line at a pressure of 300 to 350 volts from a turbine-driven dynamo, the water used being, as described in a recent issue, that necessary to make good the losses by infiltration. Using the "bachot propulseur" and a barge 36 metres long with a square stern, the following results were obtained, the current varying from 12 to 14 amperes:—

Load (tons).	Speed (kilometre per hour).
100	3·0—0
150	2·7—2·8
180	2·5—2·6
230	2·3—2·4

With a more suitable type of barge, with a load of 70 tons, a speed of 4 kilometres was attained. The "electric horse" hauled two 200-ton barges at a speed of 2 kilometres an hour, the current varying from 10 to 12 amperes.

Contemporary Electrical Science.—As if in confirmation of Sauter's Paper referred to last week, the *American Journal of Science* gives particulars, furnished by Mr. O. C. Marsh, of a well-authenticated case of GLOBULAR LIGHTNING observed on board a yacht in Southampton Water. It fell slowly and directly from the mast on to the deck, and knocked down the mate, but not before he had observed that it was "four or five inches in diameter, and six or eight in length," and of a "delicate rose-pink colour." It dropped down a ventilator, "upset things generally in the culinary department," and finally exploded, but without doing any material damage or leaving any traces except a strong odour of ozone.—The *Proceedings* of the Physical Society for December contain, besides a most valuable NAME AND SUBJECT INDEX, some abstracts of Papers dealing with subjects recently treated in our columns. A model abstract is that of Grimaldi and Platania's Paper on the RESISTANCE OF COPPER WIRES IN PETROLEUM, which gives all the precautions and sources of error in a nutshell, and shows how Prof. Sanford's sensational observation concerning the influence of the dielectric is confirmed, but only to the extent of one-twelfth of its value. The quantitative result is, however, of much less importance than the qualitative.—In connection with Cardani's DETERMINATION OF THE RESISTANCE OF WIRES TO ALTERNATE CURRENTS, we find an abstract of Tuma's Paper from the *Wiener Berichte*. The heat developed in a thin-walled conducting tube formed by electro-deposition on a glass rod, was determined by a Bunsen ice calorimeter, with the help of machinery similar to Tesla's. The alternate-current resistance approaches the continuous-current resistance as the specific resistance increases, and the ratio of the two increases with the thickness of the conductor and the frequency of the current.

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THE CROMPTON POTENTIOMETER: ITS USE AND CAPABILITIES.—III.*

BY W. C. FISHER, ASSOC.MEM.INST.C.E.

There being no other points in connection with the main instrument to which attention need be drawn for the present, the writer turns to the consideration of the different adjuncts necessary to complete this system of measurement.

The first item of interest is naturally the source of the main E.M.F., as it is upon the constancy of the E.M.F. at the terminals of the instrument that expeditious measurement depends, for whilst it may always easily be checked and adjusted by reference to the standard, the time spent in so doing, if of frequent occurrence, is of material importance when a continuous succession of readings have to be taken at very small intervals of time. Ordinary primary batteries are too trouble-

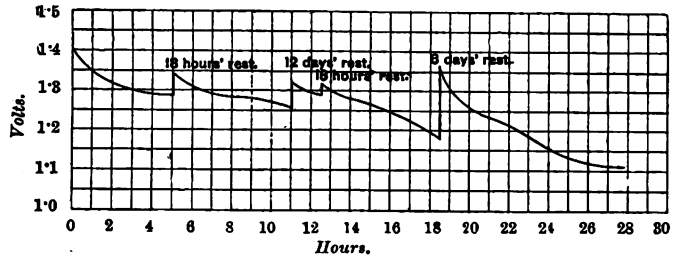


FIG. 11.—Obach Dry Cell. Average fall in E.M.F.=0·0037 volts in 10 minutes.

some to admit of their being tried, even experimentally, whilst of the many types of dry batteries experiments and experience show that the fall of E.M.F. is far too rapid to admit of their use. The following curves (Figs. 11 and 12) of the "E.C.C." and Obach dry cells—admittedly the best—prove this beyond any doubt. The size of the cells tried was that which approximated in weight to that of the secondary cell usually used for portable work, although two of them would be necessary to obtain the requisite voltage for use. They were placed upon a circuit equivalent in resistance to the potentiometer, and the fall in E.M.F. with time noted. It is a matter of regret that this rapid fall should take place, as they would be of inestimable use on account of their portability. When one has to roam the country testing plant the inevitable and apparently unpreventable leakage of electrolyte in a secondary cell, if carried about

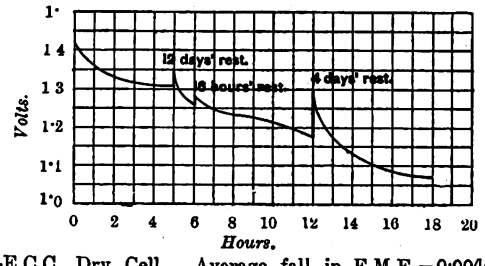


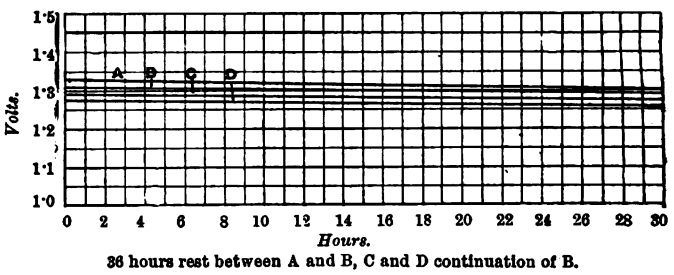
FIG. 12.—E.C.C. Dry Cell. Average fall in E.M.F.=0·0046 volts in 10 minutes.

full, and the nuisance of preparing or adding electrolyte at one's destination, if empty, is very annoying, and is a matter that requires some improvement; to this has to be added the want at times of facilities for charging.

But where the instrument is a fixture the secondary battery is *facile princeps* the source of E.M.F. best adapted—given adequate means of charging the same. The fall in E.M.F. when what is termed the flat portion of the discharge curve is reached is so very small for quite long intervals of time as to be almost negligible for any but the most careful and accurate tests in the case of the size cell usually adopted it amounts to less than $\frac{4}{10000}$th of a volt in 15 minutes or thereabouts. Fig. 13 is a curve of the E.M.F. of such a cell used with the potentiometer described. It is to the same scale as Figs. 11 and 12, the test being carried out in a similar manner; it shows strikingly the difference existing between them in the most essential point desired.

Where the instrument is stationary it is also an advantage to have secondary cells of fairly large capacity, say 15 or 20 ampere-hours, so that the current may always be left on the instrument, and the consequent wait for the E.M.F. to settle down when first connected is so avoided. By adopting this plan the instrument is always ready for working throughout the week, the charging of such cells being made at a slow rate over the week end. To save time after a full charge, it is expedient to get rid of the initial voltage by partially discharging through a low resistance for a short time, in that manner steadying the cells. The constant charge and discharge of the cells, as mentioned above, is also productive of good, inasmuch as it tends to keep them in a healthy condition, for nothing is more irritating, especially when engaged upon careful or accurate work, such as the comparison of resistance standards, than a cell which tends to be at all in an unhealthy condition. Internal disturbances in the cell make themselves so very manifest in the behaviour of a sensitive galvanometer by a series of spasmodic jerks and kicks, the worst phase of the same being when they are of an intermittent nature; they then invariably put in an appearance just as one is in the act of completing a very careful measurement, so spoiling the result and ruining the most tranquil of dispositions. Continuous "gassing" of the cell is very productive of this source of annoyance; a cell which bubbles slightly, whether at rest or at work, is useless for delicate measurements, as every bubble off the plates is heralded by a slight kick in the galvanometer, whilst a stream of bubbles sets the mirror dancing.

Here a word of warning is necessary. *Never under any circumstances connect the instrument to one of a number of cells in series;*



36 hours rest between A and B, C and D continuation of B.

FIG. 13.—Secondary Cell. Average fall in E.M.F.=0·0008 volts in 10 minutes.

always use an isolated cell. If this is not attended to accidents are sure to happen, with resultant injury to the instrument. Several instances have occurred in which this has been done with disastrous consequences. Upon two, if not three occasions, incredible as it may appear, use was made of the milking cells of a central-station battery. An attempt to measure current or volts obtained off the same system of supply naturally resulted in "instrumental fireworks;" in the one case 100 volts, and in the second case 220 volts did something more than spoil the calibration of the instrument. A systematic use of fine fuses or fuse wire is strongly to be recommended.

The Galvanometer.

The potentiometer method of measurement being a null or zero method, the only points to be considered with reference to the galvanometer in ordinary work such as that obtained in central stations, are deadbeatness, commensurate sensibility, and freedom from vibration, together with freedom from interference of stray magnetic fields. For these reasons the so-called "D'Arsonval instrument" is usually employed, as more nearly fulfilling the specified points. Under some circumstances—where the time element is of no importance—the Thomson or Kelvin mirror galvanometer may be used. There is one case on record where, a test having to be made in a northern city, such an instrument *had* to be used, an accident having happened to the D'Arsonval instrument in transit. An endeavour was made to borrow one, but whilst almost every other philosophical instrument was obtainable, a D'Arsonval galvanometer was unknown.

The D'Arsonval instrument is nothing more than the Thomson or Kelvin recorder condensed and rendered more

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THE CROMPTON POTENTIOMETER: ITS USE AND CAPABILITIES.—III.*

By C. C. PATTERSON, Assoc.M.Inst.C.E.

There being no other points in connection with the main instrument to which attention need be drawn for the present, the writer turns to the consideration of the different adjuncts necessary to complete the system of measurement.

The first item of interest is naturally the source of the main E.M.F., as it is upon the constancy of the E.M.F. at the terminals of the instrument that expeditious measurement depends, for whilst it may always easily be checked and adjusted by reference to the standard, the time spent in so doing, if of frequent occurrence, is of material importance when a continuous succession of readings have to be taken at short intervals of time. Ordinary primary batteries are [illegible]

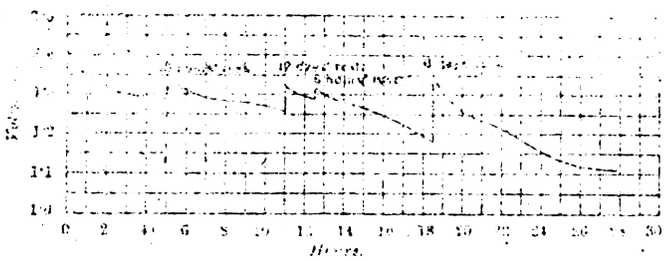

FIG. 11.—Obach Dry Cell. Average fall in E.M.F. = 0·0037 volts in 10 minutes.

some to admit of their being tried, even experimentally, whilst of the many types of dry batteries experiments and experience show that the fall of E.M.F. is far too rapid to admit of their use. The following curves (Figs. 11 and 12) of the "E.C.C." and Obach dry cells—admittedly the best—prove this beyond any doubt. The size of the cells tried was that which approximated in weight to that of the secondary cell usually used for portable work, although two of them would be necessary to obtain the requisite voltage for use. They were placed upon a circuit equivalent in resistance to the potentiometer, and the fall in E.M.F. with time noted. It is a matter of regret that this rapid fall should take place, as they would be of inestimable use on account of their portability. When one has to roam the country testing plant the inevitable and [illegible] unpreventable leakage of electrolyte in a secondary [illegible] carried at our

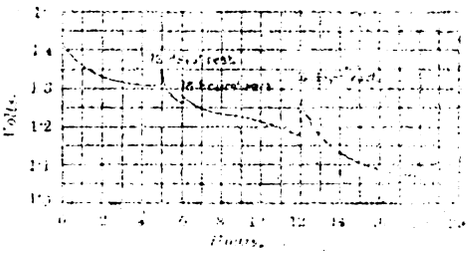

FIG. 12.—E.C.C. Dry Cell. Average fall in [illegible] 10 minutes.

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* All [illegible] Nov[illegible]

manner; it shows strikingly the difference existing between them in the most essential point desired.

Where the instrument is stationary it is also an advantage to have secondary cells of fairly large capacity, say 15 or 20 ampere-hours, so that the current may always be left on the instrument, and the consequent wait for the E.M.F. to settle down when first connected is so avoided. By adopting this plan the instrument is always ready for working throughout the week, the charging of such cells being made at a slow rate over the week end. To save time after a full charge, it is expedient to get rid of the initial voltage by partially discharging through a low resistance for a short time, in that manner [illegible] the cells. The constant charge and discharge of the [illegible] mentioned above, is also productive of good, inasmuch [illegible] to keep them in a healthy condition, for nothing is [illegible], especially when engaged upon careful or [illegible] work, such as the comparison of resistance standards, [illegible] cell which tends to be at all in an unhealthy condition. [illegible] disturbances in the cell make themselves so very [illegible] in the behaviour of a sensitive galvanometer by a series of [illegible] jerks and kicks, the worst phase of the same being when they are of an intermittent nature; they then invariably put in an appearance just as one is in the act of completing a very critical measurement, so spoiling the result and ruining the most tranquil of dispositions. Continuous "gassing" of the cell is very productive of this source of annoyance; a cell which bubbles slightly, whether at rest or at work, is useless for delicate measurements, as every bubble on the plates is heralded by a slight kick in the galvanometer, whilst a stream of bubbles sets the mirror dancing.

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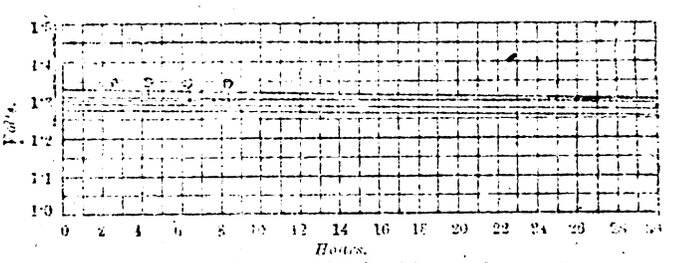

50 hours rest between A and B, C and D continuation of E.

FIG. 13.—Secondary Cell. Average fall in E.M.F. = 0·0006 volts in 10 minutes.

always use an isolated cell. If this is not attended to accidents are sure to happen, with resultant injury to the instrument. Several instances have occurred in which this has been done with disastrous consequences. Upon two, if not three occasions, [illegible]ible as it may appear, use was made of the milking cells [illegible] a central-station battery. An attempt to measure current [illegible] volts obtained [illegible] the same system of supply naturally [illegible] "instrumental fireworks;" in the one case 100 volts, [illegible] second case 220 volts did something more than spoil [illegible] of the instrument. A systematic use of the [illegible] wire is strongly to be recommended.

The Galvanometer.

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[illegible] instrument is nothing more than the [illegible] Kelvin recorder condensed and rendered more

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sensitive. Briefly described, it may be said to consist of a rectangular coil of fine wire freely suspended in a magnetic field, in which it normally rests in a direct line with the poles, but upon the passage of the current it tends to set itself at right angles with the poles, the amount of deflection being dependent upon the current passing. The instrument is dead-beat—that is to say, it comes, or can be brought, to rest very quickly. It is therefore of great value when quick working is desirable. Its sensibility should be somewhat commensurate with that of the potentiometer—that is to say, it should be such that with unit movement off balance on the potentiometer there should be at least two or three times that amount of movement of the galvanometer spot off zero. With reference to vibration, it is a matter purely of circumstances; where special means can be adopted to prevent communication of the cause, it should not be a source of trouble; where such means are not available, or, when tried, are not successful, in some makes of this type of instrument it may be obviated in a manner which will be mentioned later on.

It is usual with this type of instrument to read the deflection by means of a spot of light reflected off a small mirror attached to the coil, but a pointer of medium length attached to the coil is, when ordinary accuracy only is required, all that is necessary.

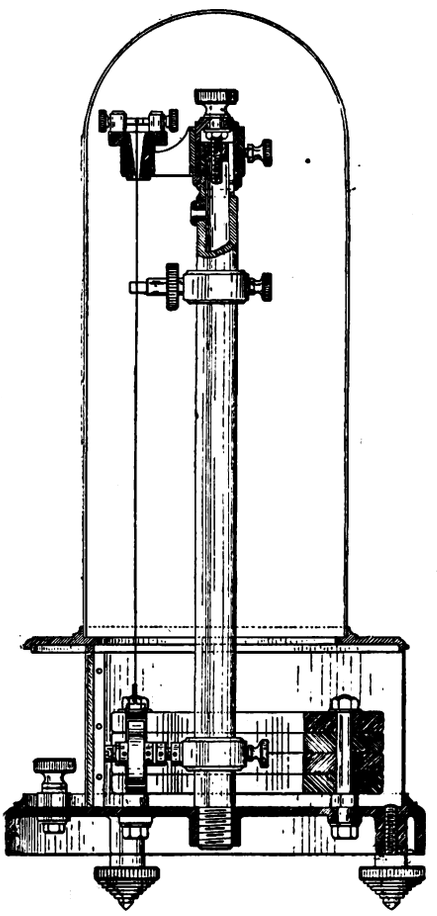
With reference to a reflected spot, it is usual to project it upon a wall or stand usually at some distance from the eyes. This is much to be deprecated, as the strain upon the eyesight is great with continued testing, more especially as in order to work effectively there should be semi-darkness; what is far more preferable and pleasant to work with is a portion of the image of an incandescent lamp filament thrown from the mirror on to the back of a piece of ground glass placed immediately opposite and close to the operator and on a level with his eyes; in this manner semi-darkness is avoided, together with smarting of the eyeballs, and the spot is easily discernible upon the brightest day.

Of the D'Arsonval type of instrument there are many makers, the majority of whom have faithfully followed in each other's footsteps in an endeavour to produce an instrument of the pattern originally adopted by Carpentier, of Paris, which consists of a compound magnet of U-form placed vertically upon a base, and between the poles of which a rectangular coil of copper wire is suspended from an overhanging arm by means of a fine silver wire; a similar wire attached below the coil keeps the whole taut by being fastened to an adjustable spring. The true Carpentier instrument has a sensibility beyond the average, the magnets being very powerful; but if the silver wire be removed, and a fine phosphor-bronze strip similar to that used by Prof. Ayrton be put in its place, the sensibility is invariably increased twentyfold.

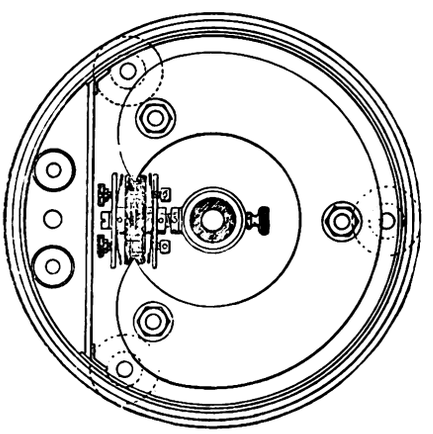
The first deviation from this form *in the market* was that introduced by Messrs. Ayrton and Mather, who abandoned the vertical magnet, rectangular coil and strain upon bottom connection, substituting a circular or cylindrical magnet with very small air gap, and pushing the recorder or shuttle-shaped coil to the extreme, they adopted a closed loop, a cross-section of which might be represented by the figure 8. This is enclosed in a silver tube and suspended from above by a flat strip suspension in the very intense field obtained by their form of magnet. The bottom connection is a loose spiral of fine strip. The degree of sensibility obtained has been put at various figures, but the writer is assured by Prof. Ayrton that an instrument constructed and in use at the Central Institution is capable of a 2mm. deflection at 2,000mm. distance, with one-millionth of a volt at its terminals. This figure of merit is the more remarkable, inasmuch as the coil is hampered by considerable magnetic control, having been constructed before means were found of freeing it from the same.

The Ayrton-Mather instrument, as constructed by Messrs. Paul, is exceedingly neat and compact. A description is not necessary, as it is well known. It has but one inherent defect, which is not so much due to design as to principle: the fact of the coil being suspended from above with a short suspension with no strain from below to steady it, renders it exceedingly susceptible to vibration *where any exists*, especially if caused by rapidly-revolving machinery.

Major Holden has also designed a very compact and efficient instrument, made by Messrs. Pitkin. The most striking features are the smallness of the compound magnet and its great lamination, consisting as it does of a number of thin horseshoe discs clamped together. The coil is square-shaped and strained in position upon a frame which is easily removable for the introduction of a coil of different resistance, &c., as is also the case with the Ayrton and Mather instrument.



Elevation.



Plan.

FIG. 14.

For delicate work the potentiometer method of measurement requires a galvanometer which differs from that ordinarily employed, inasmuch as it should be one that is exceedingly sensitive at zero point only, evenness or length of range being unnecessary. Up to the present, so far as the writer is aware, D'Arsonval instruments have invariably been designed for *deflection* work, the magnetic field accordingly being shaped so that the instrument has a scale of equal divisions. An extended use of the potentiometer, and an inquiry into its capabilities,

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brought out sundry important points in connection with very accurate work which necessitated a study of the galvanometer question, and resulted in the design of a galvanometer having the following points:—

1° Perfect insulation;

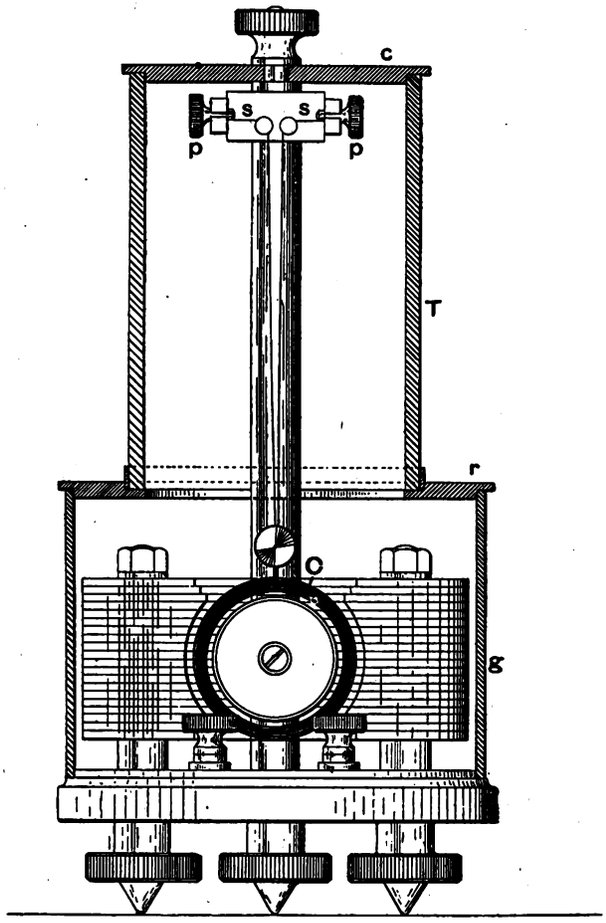
2° Maximum sensibility off zero with minimum voltage on terminals;

3° A sensibility alterable at will;

4° Coils easily interchangeable;

5° Solidity in mechanical construction, and the whole open to instant inspection;

6° Absolute freedom from ordinary vibration.



Elevation.

Plan.

FIG. 15.

The instrument depicted (⅓rd full size) in Fig. 15 was designed after several years patient investigation in Mr. Crompton's laboratory, and, having been recently fully described in these columns, needs but a brief description at present. Upon a gun-metal base of section shown, supported upon three levelling screws having ebonite milled heads of inverted pyramid shape, a compound horseshoe magnet is bolted down. From the centre of the base springs a pillar of tubular section, which is surmounted by a cap capable of vertical adjustment by means of the milled head shown at top, radial movement being prevented by the small set screw at side, which slides in a groove in the pillar. Encircling the cap is a sleeve, attached to which is an arm having a second but smaller sleeve at the end. This arm has a radial movement round the cap for necessary adjustment, being clamped in position by set screw at side; in the small sleeve is fitted an ebonite turntable carrying the small terminals, to which the suspensions are attached by means of taper plugs, connection with the main terminals upon the base of the instrument being made by means of insulated wires carried down inside the central pillar. A thin vane of ivory, fixed in a projecting pin having a milled rim, and free to turn on its axis in a sleeve capable of radial and vertical adjustment upon the pillar, and which may be clamped in any position, is the means adopted for altering the sensibility of the instrument by artificially lowering the point of suspension.

Fig. 16 (⅔rds full size) represents a smaller or more portable type of this instrument, practically similar to No. 15, but simpler in construction. The magnets are of the Holden type (being adopted by Major Holden's kind permission); the holding-down bolts are carried through the base and shod with the ebonite levelling shoes shown. The coil has a bifilar suspension, which is attached by means of two plugs to two brass blocks fixed upon an insulated bracket upon the central pillar. There is a simple clamping device, not wholly shown, which effectually secures the coil from injury whilst travelling. It may be of interest to point out that the instrument is protected by a brass guard having a bevilled glass front similar to the larger instrument; an annular ring upon the guard carries a thick glass tube having a brass cap, the whole being effectually clamped together by the milled nut which surmounts the instrument. The whole is very strong, handy and compact, going comfortably into a coat pocket, and it has the great advantage, possessed also by the larger instrument, of being open to inspection, so that the position of the coil is readily observable without that peering into almost obscurity common in the use of many instruments of this type. This instrument has a sensibility ordinarily of 2mm. at 2,000mm. distance when placed in shunt with $\frac{1}{100}$th of an ohm in series with 20,000 ohms and 2 volts, having therefore a potential of $\frac{1}{1000000}$ volt at its terminals, and a period of 2 seconds; the larger instrument under similar conditions having a sensibility six or eight times greater but slower period.

CALCIUM CARBIDE.

The first calcic carbide plant to [illegible] purposes in America, as a result [illegible] Mr. T. L. Willson, in North Carolina, [illegible] nearing completion on the land of the Niagara [illegible] Company. The product of this initial plant will be shipped to Philadelphia, Pa., and there made into acetylene gas for use throughout that city and Southern Pennsylvania. At the start it will be necessary to ascertain the amount of electric energy which will prove the most economical for a given output. So far the experiments have only been made with from 25 H.P. to 235 H.P. The contract of the Company with the Niagara Falls Power Company calls for 1,000 H.P. or more. One feature of the plant is that an alternating-current furnace is to be used, whereas all the other electric manufacturing plants at Niagara Falls use direct-current furnaces. The current will be used at a voltage of about 100. At the commencement it is likely that the furnace will be operated by 100 H.P. to 1,000 H.P.

The size of the first carbide plant is 40ft. by 90ft. at the foundations. The structure is of brick, the front portion being two storeys high, or 31ft. to the eaves, while the rear part is 21ft. It contains a furnace room, a crushing and grinding room, a laboratory, a switchboard room, a transformer room,

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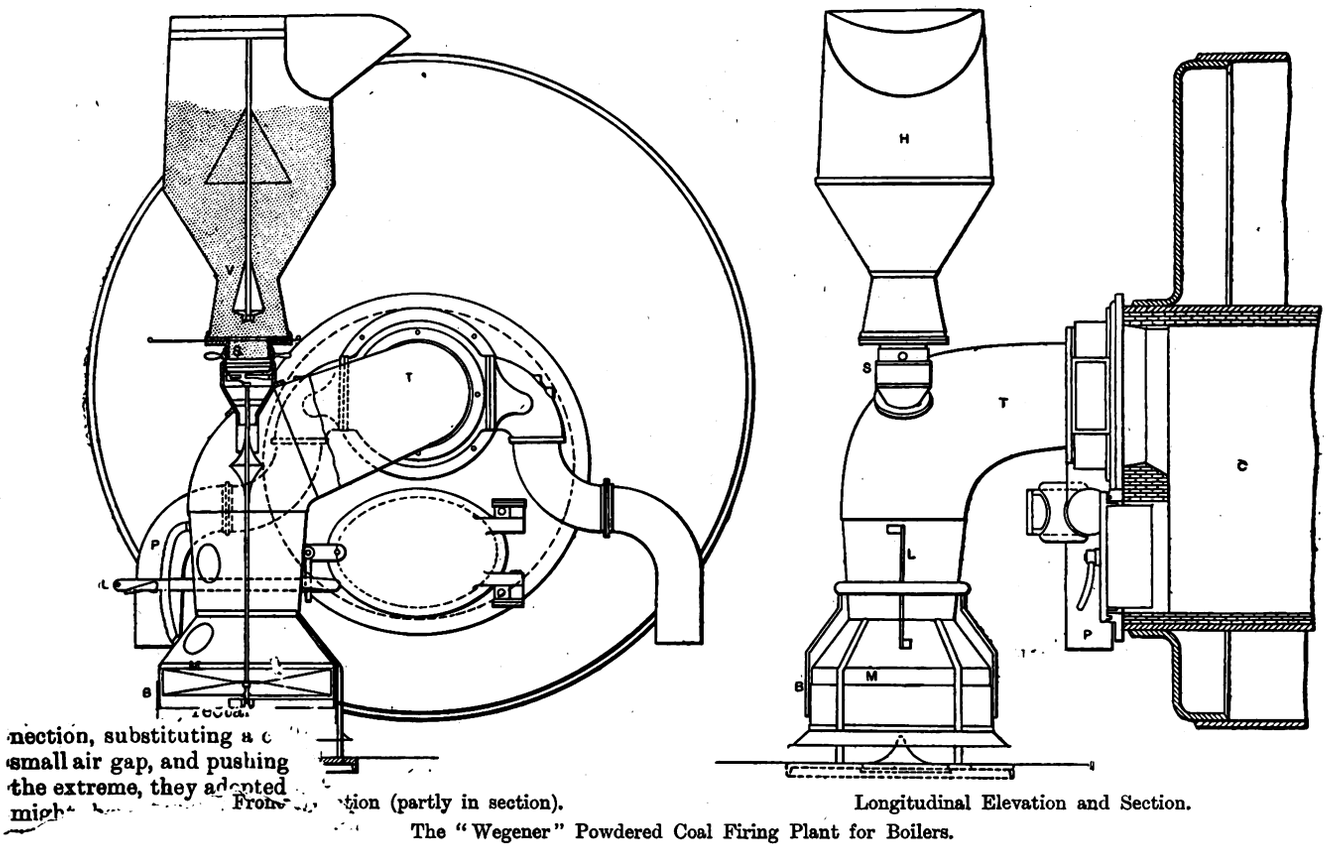
and a room for the help employed. The crushing and grinding portion of the outfit is to be of sufficient capacity to supply a plant of 50 tons capacity, whereas the capacity of the plant at the start will be at least five tons per day. A two-phase 75 H.P. motor will operate the grinding plant. In the furnace room four furnaces have been built, each containing cast-iron crucibles 3ft. 6in. long, 2ft. 8in. deep, and 2ft. 2in. wide. The current will be kept on each furnace for about three hours, one furnace being operated at a time. Each horse-power used is supposed to give 20lb. of calcic carbide every 24 hours.

It is thought altogether likely that calcium carbide will be manufactured by the Niagara plant at a cost not exceeding $5 per ton. The factory is expected to be in operation by the beginning of February.

POWDERED COAL FOR STEAM RAISING.

One of the most ingenious and, so far as we have been able to ascertain, economical systems for utilising breeze, smudge, and other cheap qualities of slack coal is that which is known as the "Wegener" process. Recently we had an opportunity of inspecting this system in operation at the boiler house of Messrs. Bryan, Donkin and Co.'s engineering works at Bermondsey. The extreme cheapness of most qualities of dust coal is a great temptation to use them for steam raising, but the results obtained are often far less satisfactory and economical than where good round coal is used. Finely divided coal is not easily burned on a grate, owing chiefly to the difficulty of supplying the fuel with air in an efficient manner. This difficulty is surmounted, in the "Wegener" process, by doing away with a grate, and by blowing the fuel in suspension in air into the closed combustion chamber of the boiler furnace. It is well known that finely-divided coal suspended in the right proportion of air is so inflammable as to be practically explosive, and in the "Wegener" process the firing is carried on by a quick succession of puffs of coal-dusty air into the furnace, producing a series of mild explosions. A little window in the boiler front enables these explosive flares-up to be watched for purposes of regulation.

The manner of producing the charge of fuel and air will be understood by examining the accompanying longitudinal and transverse sections of the plant, shown attached to a Cornish boiler front. In the hopper, H, the finely-divided coal is placed. The coal has previously been ground to powder, and passed through a 60-mesh sieve. A lift valve, V, enables the orifice at the bottom of the hopper to be partially or completely closed. When this orifice is open the dust coal rests upon a shaking sieve, S, which consists of a circular grid. While this sieve is not in motion the coal clogs on the top of the sieve and does not feed downwards; but when the sieve is tapped, by a mechanism provided for the purpose, a small portion of coal will tumble through in a kind of spray. The number of these taps per minute can be regulated to a nicety, and will control the rate of firing into the boiler furnace. To understand how the taps are produced we must turn to the lower part of the apparatus. At B there is a bell-mouth, suspended over a floor plate so as to provide an annular passage for the air into the apparatus. The height of this bell regulates the supply of air, and is adjusted by means of the lever and ratchet L. The air is drawn in by the natural chimney draught, which in the case of the boilers we inspected was a little under $\frac{3}{8}$in. of water. It will be noticed that inside the bell, and near the bottom of it, is a set of vanes forming an air motor, M, and this is set in revolution by the up passage of the air. The spindle of this motor passes up through the air up-take tube and actuates a tappet, which provides the quick succession of taps upon the sieve S, necessary to the continuous downpour of dust coal.



nection, substituting a c
small air gap, and pushing
the extreme, they adopted
mich[illegible] From[illegible]tion (partly in section). Longitudinal Elevation and Section.

The "Wegener" Powdered Coal Firing Plant for Boilers.

The shower of coal in its descent meets the uprising rush of air, mingles with it, and passes on in a highly inflammable mixture through the tube T into the brick-lined combustion chamber C. The effect is to fill the chamber with a large volume of flame, and the mixture of the coal and air being so intimate, combustion is both rapid and complete. Moreover, owing to the finely-divided state of the coal in suspension in the air, a lower proportion of air is required, *i.e.*, less surplus air is necessary than where round coal is burnt on a grate. This, it will be seen, cannot fail to enhance the economy of the process. The mineral matter in the fuel forms a fluid slag which falls to the bottom of the flame chamber and is removed when the boiler has been shut down. Ordinarily, of course, the boiler front is completely closed. When highly bituminous coals are to be burned, an extra supply of air beyond that

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entering through the bell is necessary to ensure complete and smokeless combustion. This is provided by means of the auxiliary air inlet pipe P, which is fitted with a regulator valve.

We have not had the opportunity of conducting any trials of this system, but we are assured that a high rate of evaporation is obtained by means of it, and we are quite prepared to credit the statement. The boilers which we saw were of the Lancashire type, and were fitted with two of these "Wegener" fuel plants. Cold feed at 62°F. was taking place, and an evaporation at 60lb. pressure of from 7·5lb. to 8lb. of water per pound of coal (as used) was obtained. The cost of treating the small coal so as to render it suitable for firing by this process is not, it is stated, more than about 10 per cent. of the price of the coal. Taking the average price of these classes of coal, the cost of treatment would be about one shilling or less per ton. The initial cost of the plant, not including the crusher, is about £100 for a double-furnace boiler of large or moderate capacity.

THE ALUMINIUM WORKS OF THE PITTSBURG REDUCTION COMPANY AT NIAGARA FALLS.

BY ORRIN E. DUNLAP.

The Pittsburg Reduction Company is practically the only manufacturer of aluminium in the United States; it controls and uses what is known as the Hall process, the invention of Mr. Charles M. Hall, who is now vice-president of the Company. This process of manufacture consists in dissolving alumina in a molten bath composed of fluoride of aluminium and the fluoride of some metal more electro-positive than aluminium. An electric current is passed through the molten mass, and aluminium is produced by electrolysis of the dissolved alumina. The fluorides of potassium and of calcium, with the fluoride of aluminium, are the most preferable salts used in the molten bath, although the fluoride of aluminium with the fluoride of sodium have been successfully used by the Pittsburg Reduction Company in much of their work. The double fluoride of aluminium and potassium is made by the action of hydrofluoric acid upon alumina and pearl ash or carbonate of potassium. The fluoride of calcium is obtained from the mineral fluorspar. When the Pittsburg Reduction Company use the fluoride of sodium they have in the past used largely the native mineral cryolite as the source of this portion of the salts, although of late improvements have been made by which cheaper methods of producing the double salts of fluorides of aluminium and sodium have been obtained.

In the present plant at Niagara Falls the Pittsburg Reduction Company have two lines of carbon-lined iron pots, arranged in series, and it is in these pots that the chemicals are placed. The electric current is passed through the molten mass by the aid of carbon cylinders used as anodes, which extend down into the molten metal. The pots themselves, with their lining and the metal deposited upon the bottom, becoming the negative electrodes or cathodes, the alumina is deposited by electrolysis in a molten mass at the bottom of the pot. The freed oxygen goes out as carbonic oxide or carbonic acid gas in connection with the carbon of the anode, wearing it away in proportion of a little less than an equal weight of the anode to the aluminium produced. The operation is kept continuous for months at a time, as the wear upon the pots is very slight, the metal being dipped out from the pots each day by heavy cast-iron ladles. In some countries the makers of aluminium are greatly troubled with noxious gases, and their employés work only for very short periods. The Pittsburg Reduction Company, however, owing to the advantages of the special chemical solvents which they use for dissolving the alumina and the particular strengths of current adopted, are not, it is said, troubled in this way, there being practically no discharge of other noxious gases into the atmosphere, practically the only gas evolved being carbonic acid. Now and then a carbon will heat above the bath and sputter out in a dark blue flame, showing the burning of carbonic oxide to carbonic acid gas.

In the Pittsburg Reduction Company's work, of course, very large currents at low voltage are used, the pressure required being only enough to overcome the electrical resistance of the number of pots arranged in series, each pot now in use requiring from 6 to 8 volts. The power used by the Pittsburg Reduction Company is supplied by the Niagara Falls Power Company, on the two-phase system, at 2,000 volts pressure. It is conducted from the power house to the factory on copper cables laid in a subway. In the manufacture of aluminium it is necessary that this current should be reduced as well as transformed from alternating to direct. By means of the static transformers shown in the illustrations (Figs. 1, 2 and 3), the voltage is reduced from 2,000 to 115, and the rotary converters shown change the current from the two-phase alternating variety of 115 volts to a direct current of 160 volts. The electrical equipment of the Reduction Company's plant was furnished by the General Electric Company of Schenectady. The rotary converter is practically a direct-current generator with proper collecting rings and connections attached to the rear of the armature to lead the alternating current into the apparatus. The Pittsburg Reduction Company's present electrical plant has a capacity of about 10,000 amperes at 160 volts, or 1,600 kilowatts, or about 2,000 E.H.P. on the direct-current side. In the static transformer,

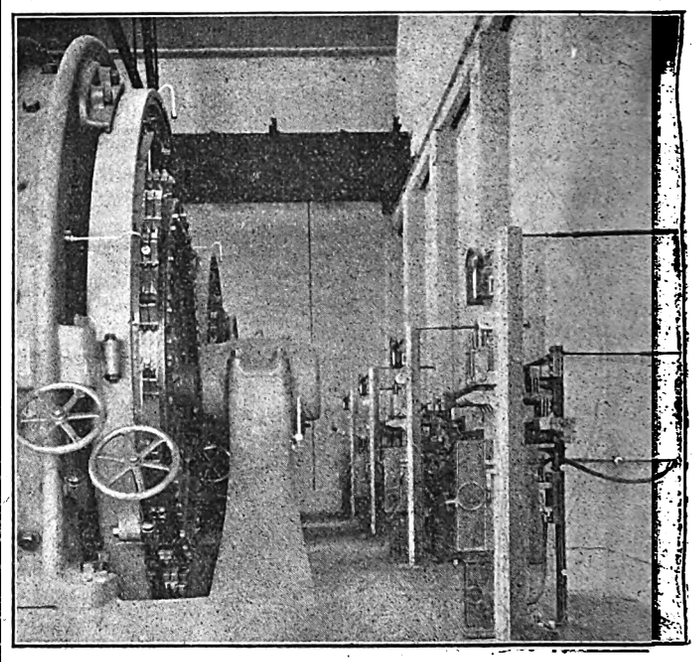

FIG. 2.—Direct-current Side of the Rotary Converters and the Low pressure Switchboards.

notwithstanding its high efficiency, the energy transformed into heat is so great that there is not sufficient radiating surface to throw it off. For this reason an air-blast is forced continuously between the coils from below, thus keeping the heat easily under control.

There is a commonly-accepted notion that clays are the ores of aluminium. The Pittsburg Reduction Company do not use clays, which are silicates of aluminium, in the manufacture of the metal, but the pure oxide of aluminium, called alumina, which is made from the native oxide of the metal in a mineral known as bauxite. This mineral is found in large deposits in Georgia and Alabama, and it is from these States that the Pittsburg Reduction Company secure their supply, they finding it possible to lay the ore down at their factory in Niagara Falls at a low rate. The bauxite belt of Georgia and Alabama extends in a north-easterly and south-westerly direction, its length being about 75 miles and its width about ten miles. The ore is found in pockets at the top of the Knox dolomite of the lower Silurian rocks in both of the States mentioned. It is noticeable that the bauxite ores in the United States are all in sections of the country which have been broken up by sharp folds and great thrust

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faults, in which the character of the rock has been greatly changed, probably the result of intense heat. The bauxite ores of Georgia and Alabama are associated with the manganese and iron ores, which similarly occur in the same district in "pocket" formations.

This ore exists in several peculiar forms, as follows:—(1) In round nodules, some of these being in sizes up to 2in. in diameter, and each nodule being separated from its fellows. (2) An agglomeration of these nodules into a conglomerate, the binding material between the nodules being pure alumina

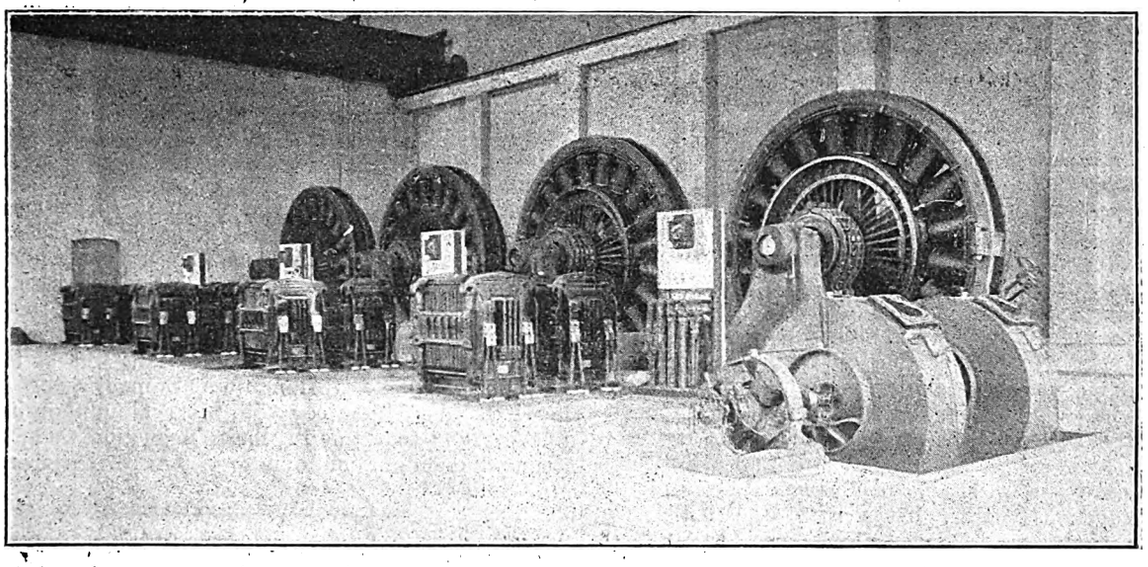

FIG. 1.—The Electric Plant of the Pittsburg Reduction Company at Niagara Falls.

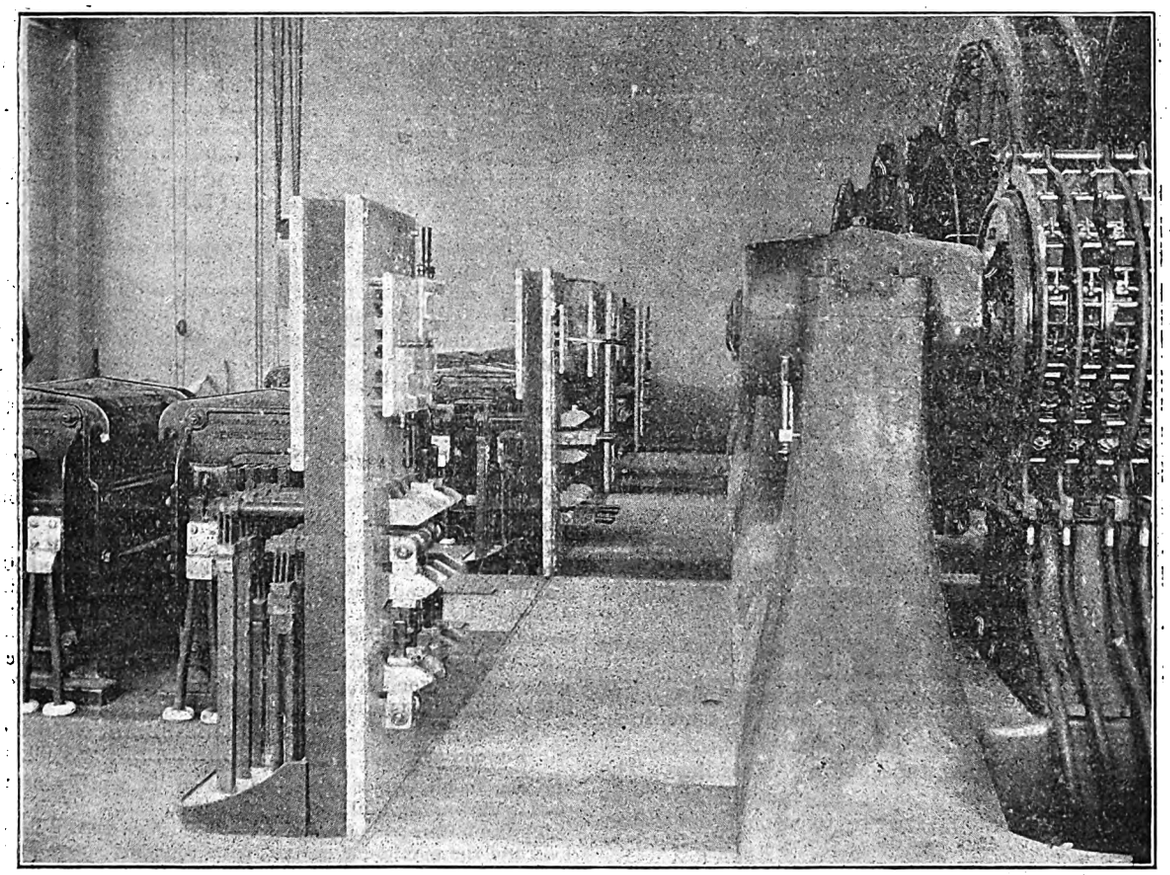

FIG. 3.—The Alternating-current Side of the Rotary Converters, the Static Transformers, and Alternating-current Switchboards.

The composition of the bauxite best adapted for the manufacture of alumina is as follows:—

Silica	3·00	per cent.
Titanic acid	4·00	,,
Oxide of iron	2·00	,,
Water of hydration	32·00	,,
Alumina	59·00	,,
Total	100·00	per cent.

(3) A massive formation. (4) A fine powdered condition in the beds at the banks, being mined in the form of plastic mud.

To form aluminate of soda, it only need be incinerated lightly with soda ash. This aluminate of soda is dissolved and decanted off and freed from the impurities of silica, oxide of iron and titanic acid which have not been acted upon and are insoluble in the hot water used for solution of the alumi-

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nate of soda. It is from this solution alumina is precipitated by passing carbonic acid, formed by the distillation of carbonic acid from limestone, through the solution, and also by agitation. The carbonic acid reforms carbonate of soda from the aluminate, and precipitates the pure aluminum very freely. This settles at the bottom of the tank, and after being thoroughly washed with hot water and then dried, it is heated for some time at a high red heat, to drive off the water of hydration, which makes the ore ready for the production of aluminium by the Hall process.

So successful has been the Pittsburg Reduction Company's plant at Niagara Falls that, although it was only started on August 26, 1895, the Company have already taken steps to double its plant. The plant, as erected with the Niagara Falls Power Company, was planned for doubling the capacity in the same buildings, and the contract arrangements which the Pittsburg Reduction Company has with the Niagara Falls Power Company are that it has the right to call for additional power up to any capacity that is unsold by the Niagara Falls Power Company at the time when such power may be asked for; so that the Pittsburg Reduction Company enjoys the right to enlarge its works almost indefinitely at comparatively very small cost for installation of new plant, as the capacity of the Niagara Falls Power Company and its rights to the use of water-power at Niagara are practically illimitable. Besides these favourable arrangements, however, the Pittsburg Reduction Company has contracted with the rival water-power company at Niagara Falls, the Niagara Falls Hydraulic Power and Manufacturing Company, for 4,500 E.H.P. additional. This plant is now progressing rapidly, and will be completed in the early spring. Thus the Pittsburg Reduction Company is in a position to enlarge its plant for the use of the Niagara power from both large water-power sources—one the Niagara Falls Power Company using the tunnel, and the other the Niagara Falls Hydraulic Power and Manufacturing Company using the hydraulic canal going through the city of Niagara Falls. This 4,500 H.P. will be used in a factory, now in course of construction, on the high bank of the gorge; thus the Company will have what is known as an upper and a lower works, one being on the upper river above the falls, and the other below the cataract. The plant in the new or lower works will consist of dynamos directly attached to the turbine shafts. These generators will be of 750 E.H.P. each, the turbines being furnished by the James Leffel Company, Springfield, O. In this plant the electric current will be transmitted from the power house at the water's edge in the gorge to the pot room in the factory on the high bank above on *aluminium* conductors. This new plant will be ready for operation next spring, and it is officially stated that by June 1, 1896, the Pittsburg Reduction Company expect to be making 10,000lb. of aluminium per day at Niagara Falls.

In addition to the plant manufacturing aluminium at Niagara Falls, the Pittsburg Reduction Company has, of course, its old plant of some 2,000 E.H.P. successfully working in the manufacture of aluminium at New Kensington, Westmoreland County, Pennsylvania. This plant is especially located for generating steam power economically.

The product of the Niagara plant is now being shipped in ingot form to the New Kensington Works, where the foundries, rolling mills, and hammer shops are located for forming the metal into sheets, bars, plates, tubes, wire and castings. The Pittsburg Reduction Company does not manufacture any articles of aluminium, as it does not care to become competitors of its own customers.

It is a significant fact of the efficacy of the cheap electric power of Niagara that it is a successful competitor of the Kensington plant. The latter factory is located most favourably in the heart of both the natural gas and cheap coal fuel districts which have made Pennsylvania famous, and the Pittsburg Reduction Company buys coal delivered at their boilers for 65 cents a ton, still it has found their Niagara location more advantageous.

When it is considered that this Company within a few months will be turning out 10,000lb. of aluminium a day, its importance to the industry is best shown by a table showing the product of aluminium in the United States each year since 1882, which is as follows:—

Year.	Lbs.	Year.	Lbs.
1883	83	1889	47,468
1884	150	1890	61,281
1885	263	1891	1[illegible]0,000
1886	3,000	1892	259,385
1887	18,000	1893	339,629
1888	19,000	1894	550,000

The total output in the United States for 1895 will reach about 850,000lb. The output for 1896, it is estimated, will be fully 10,000lb. a day for the 366 days of the year, or a total of 3,660,000lb., which (if it happens) will be the most notable increase in the output during any one year since aluminium was discovered.

The latest price list of the Pittsburg Reduction Company quotes aluminium, guaranteed to be 98 per cent. pure, at 55 cents per pound in small lots, 52 cents per pound in 100lb. lots, and 50 cents per pound in ton lots, which price is likely to be reduced next year. It was in 1885 that the first step towards the manufacture of aluminium for industrial purposes was taken in the United States. This was in the Cowles Electric Smelting and Aluminium Company's works in Cleveland, O., where they began to make aluminium-bronze. It was in 1888 that the Pittsburg Reduction Company began the production of aluminium for commercial purposes by the Hall process.

TRIALS OF ALTERNATE-CURRENT PLANT AT DOVER ELECTRIC SUPPLY STATION.*

The tests described in the following report had as object the determination of the capacity and efficiency of supplied by the Brush Electrical Engineering Company (Limited) to the Dover Electricity Supply Company (Limited) under a memorandum of agreement and specifications dated November 20, 1892.

The chief conditions in the specification affecting the capacity and efficiency of the plant were the following:—

1. The output of the alternators to be 50 kilowatts, 75 kilowatts and 100 kilowatts respectively at an E.M.F. of from 2,000 volts to 2,200 volts.

2. The output of each of the two exciters to be 12·4 kilowatts, or, say, 190 amperes at 65 volts.

3. The output of each of the two feed-pumping engines to be equivalent to the full power of all the boilers.

4. The combined efficiency of the steam alternators to be 78 per cent. for the 50-kilowatt and 75-kilowatt sets, and 80 per cent. for the 100-kilowatt set.

5. The steam consumption of the engines at full load not to exceed 19·5lb. of water per I.H.P. hour for the 50-kilowatt set, 19lb. for the 75-kilowatt set, and 18·5lb. for the 100-kilowatt set.

6. The energy absorbed in exciting the field-magnets of the alternators not to exceed 2½ per cent. of the full output of the generators.

7. After a six-hours continuous run at full output the temperature of no part of the armature or magnets is to exceed 60°F. above that of the atmosphere of the engine house taken one minute after stopping the machine, on the side remote from the engine, and at no time to exceed 90°F. above the temperature of the atmosphere.

8. The insulation resistance between the whole of the conductors and the framework of the generator taken before and after a test at full load at any time not to be less than

For the armature ..... 500,000 ohms,
For the magnets ..... 400,000 ohms,

and the insulation of the armature to be capable of resisting a testing current at 4,500 volts alternating.

9. The fall in potential on a non-inductive circuit between half-load and the maximum output, with constant speed and constant excitation, not to exceed 150 volts.

10. Each of the main engines and alternators and the exciter engines and exciters to be subjected to a six-hours continuous trial at full load, and subsequently the two exciters to be tested in parallel with each other, and in like manner all the alternators to be tested in parallel with each other, for two consecutive hours on from three-quarters to full load.

11. The circulating and feed pumps and engines connected to them to be tested at full working capacity for six consecutive hours.

* Extracts from a report by Profs. A. B. W. Kennedy and S. P. Thompson, FF.R.S., forwarded to us by the Brush Electrical Engineering Company.—Ed. *E.*

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Table II.*—*Efficiency Tests of 50-kilowatt Alternator with Brush Engine, being Set No. 1 in Station.*

October 9th, 1895 (on Tubs).

Nominal condition.	Number of sets of diagrams.	Mean pressure reduced to L.P. piston.	R.P.M.	I.H.P.	Primary.		Kilowatts, self-excitation.	Total K.W.	E.H.P.	Efficiency per cent.	Exciting energy.	
					Amperes.	Volts.					Kilowatts.	Percentage of output.
Excited†	3	4·54	274	9·38	0	2002	0	0	0	...	1·30	...
¼-load†	3	16·89	270·3	34·4	8·67	1998	0	17·32	23·2	67·5	1·33	7·68
½-load‡	3	23·62	268·3	47·8	11·77	1997·7	1·38	24·89	33·4	69·9	1·38	5·55
Full load‡.....	7	44·42	269·4	90·2	25·1	1994·7	1·58	51·65	69·3	76·8	1·58	3·06
Over load‡	3	52·73	258	101·6	27·8	2105·3	2·20	60·73	81·3	80·0	2·20	3·62
October 7th (on circuit).					Apparent.					Apparent.		
—	1	43·0	274·5	44·5	13·3	2010	0	26·7	35·8	80·4	—	—
—	1	43·6	273·5	44·9	13·7	2010	0	27·5	36·9	82·1	—	—
—	1	50·4	273·0	51·8	15·8	1995	0	31·5	42·2	81·4	—	—
—	1	51·7	273·0	53·2	16·4	1992	0	32·7	43·8	82·3	—	—
—	1	59·1	275·0	61·3	19·1	2000	0	38·2	51·2	83·5	—	—
—	1	59·9	275·0	62·1	19·4	2010	0	39·0	52·3	84·2	—	—
—	1	66·9	271·0	68·4	21·5	2005	0	43·1	57·8	84·5	—	—

* Table I. and some other portions of the Report appear to have been omitted from the Extracts sent to us.—Ed. *E.*

† In these cases the excitation was derived from the separate exciters.

‡ In these cases the machine drove its own exciter, the watts for which are therefore added in in the column headed "Total kilowatts," and taken into account in calculating the efficiency.

Table III.—*Efficiency Tests of 75-kilowatt Alternator with Brush Engine, being Set No. 2 in Station.*

October 9, 1895.

Nominal condition.	Number of sets of diagrams.	Mean pressure reduced to L.P. piston.	R.P.M.	I.H.P.	Primary.		Kilowatts.	E.H.P.	Efficiency per cent.	Exciting energy.	
					Amperes.	Volts.				Kilowatts.	Percentage of output.
Excited	3	3·77	255·0	13·63	...	2002·0	...	...	...	1·36	...
¼-load.....	3	13·47	249·2	47·59	12·33	1997·0	24·63	33·01	69·36	1·39	5·64
½-load.....	3	19·19	247·7	67·4	20·0	1996·6	39·93	53·51	79·4	1·39	3·48
¾-load.....	3	28·43	247·2	99·63	29·5	2000·6	59·03	79·13	79·4	1·37	2·34
Full load	7	36·67	254·7	132·5	39·5	2017·4	59·7	106·8	80·6	1·44	1·81
Over load	3	41·19	255·2	149·1	40·9	2203·7	90·11	120·8	81·0	1·61	1·79

Table IV.—*Efficiency Tests of 100-kilowatt Alternator with Brush Engine, being Set No. 3 in Station.*

October 8th, 1895.

Nominal condition.	Number of sets of diagrams.	Mean pressure reduced to L.P. piston.	R.P.M.	I.H.P.	Primary.		Kilowatts.	E.H.P.	Efficiency per cent.	Exciting energy.	
					Amperes.	Volts.				Kilowatts.	Percentage of output.
Excited	3	3·42	235·7	16·04	0	2005·0	...	...	...	2·36	..
¼-load.....	...	...	...	...	...	...	...	...	...	...	...
½-load.....	3	20·4	230·3	93·54	26·03	2000·7	52·08	69·8	74·6	2·57	4·94
¾-load.....	3	27·09	331·7	124·9	36·7	2008·3	73·4	98·4	78·8	2·58	3·52
Full load	3	34·99	236·7	164·6	49·77	1997·7	99·4	133·2	80.92	2·67	2·69
Over load	9	41·63	233·9	193·0	54·88	2197·9	120·6	161·6	83·7	3·19	2·64

Table V.—*Efficiency tests of 100-kilowatt Alternator with Brush Engine, being Set No. 4 in Station.*

October 7, 1895.

Nominal condition.	Number of sets of diagrams.	Mean pressure reduced to L.P. pieton.	R.P.M.	I.H.P.	Primary.		Kilowatts.	E.H.P.	Efficiency per cent.	Exciting energy.	
					Amperes.	Volts.				Kilowatts.	Percentage of output.
Excited	4	3·73	236·0	17·52	...	1995·25	...	...	...	2·24	...
¼-load.....	4	11·41	233·7	53·08	12·8	1989·0	25·46	34·13	64·3	2·27	8·9
½-load.....	4	23·01	232·2	106·4	30·92	2001·0	61·84	82·9	77·9	2·42	3·91
¾-load.....	4	29·32	232·5	135·7	40·07	1996·0	79·99	107·2	79·1	2·56	3·20
Full load	6	35·39	234·2	165·0	50·0	2000·6	100·03	134·1	81·3	2·74	2·74

The tests took place in the station at Dover on October 7th, 8th, 9th, 10th, and 11th last, and were carried out by ourselves and a special staff of trained observers, whom we sent down to Dover for the purpose. The leading results of the experiments are set forth in the annexed tables; and on the whole matters referred to we have to add the following remarks, taking up the various points in the order in which they have been enumerated above:—

1. No. 4 set was tested first at various loads, and finally during a continuous run of six hours at full power (50 amperes at 2,000 volts). *The next morning the remaining machines were tested, not only at full load, but at an output 20 per cent. in excess of full load.* No. 3 set was run at 55 amperes and 2,200 volts for five hours, and then at normal full load for another hour. No. 2 set was run at 39·5 amperes and 2,000 volts for five hours, and then at 41 amperes and 2,200 volts for an hour. No. 1 set was run at 25 amperes and 2,000 volts for five hours, and then at 27·5 amperes and 2,100 volts for an hour.

Thus No. 1 machine was overloaded by 16 per cent., and Nos. 2 and 3 by about 20 per cent. *All machines ran satisfactorily at these overloads, as well as at their nominal maximum output.* In every

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case the load was obtained by the use of tubs, so as to be strictly non-inductive. The current was measured on Kelvin ampere gauges and the volts on Ayrton and Mather electrostatic voltmeters, in addition to the switch pillar instruments, and we believe that the measurements so made are, for all practical purposes, completely accurate.

2. Each of the exciters was run, on an external resistance, at full load for about six hours, and gave its full output.

3. The feed pumping engines could not be tested to their full output, as we were unable to get more than enough work for one boiler. The maximum load which we were able to put upon any pump was between 7,500lb. and 8,000lb. of water delivered per hour. Each of the two pumps appeared able to furnish this delivery with ease.

4. *The specified combined efficiency has been on the whole considerably exceeded.* No. 1 gave 76·8 per cent. at full load and 80 per cent. at 17 per cent. overload.† No. 2 gave 80·6 per cent. at full load and 81 per cent. at 20 per cent. overload. Nos. 3 and 4 gave a mean of 81·1 per cent. at full load, and No. 3 gave 83·7 per cent. at 20 per cent. overload. Thus, although No. 1, the smallest set, has fallen very slightly short of the specified efficiency at nominal full load, it exceeded it when overloaded, and the other three sets have very considerably exceeded it, even at their nominal full loads, *and we consider the results obtained in this matter highly satisfactory.*

In order to obtain the fullest information as to the efficiency of the machines, we indicated them not only at full load but also at various smaller loads, as well as when running excited only. The detailed results of these tests are set forth in the tables.

In all these experiments Crosby indicators were used, with tested springs, and the electrical instruments were read, the indicator diagrams taken and the revolutions noted simultaneously, by separate observers.

In the case of No. 1 machine, indicator diagrams were also taken at several different powers while running on the circuit in the evening. In this case the load was one which had considerable self-induction, in consequence of the number of transformers on the circuit, and it was found that the apparent E.H.P. (corresponding to the product of amperes and volts) exceeded the real E.H.P. by about 13·5 per cent. over a range between 35 E.H.P. and 60 E.H.P., the difference between the apparent and real output being, in fact, very nearly a constant percentage over this range. No doubt the difference will tend to diminish as the total load increases, as we believe that many more lamps can be served from each transformer than are at present connected up.

5. The steam consumption of the engines was measured by weighing the water passing away from their surface condensers. In the case of No. 1 set this amounted to 19·7lb. per I.H.P. hour at full load and 20·2lb. per I.H.P. hour at 17 per cent. above full load. For No. 2 set the figures were 20·8lb. per I.H.P. hour at full load and 20·3lb. at 20 per cent. above full load. For No. 3 set the figures were respectively 19·3lb. and 19·6lb., and for No. 4 set the consumption was 19lb. per I.H.P. hour at full load. These figures are a little above those which have been guaranteed, but as the efficiencies of the machines are also above the guarantees, the consumption of steam per *E.H.P. hour*, which is the really important matter, is practically the same as that corresponding to the specification. *We therefore consider the results as to steam consumption to be quite satisfactory.* We made consumption tests at various loads below full power, and the figures for these tests are given in the tables.

6. The measurements of magnetising energy were made by means of the station instruments in the switch pillar, which have been taken as correct for this purpose. A calibration made in the station after the tests showed that their errors were, at any rate, sufficiently small to be negligible. The percentage of magnetising energy to total output are shown in Tables II., III., IV. and V., from which it will be seen that they are (with the exception of No. II.) somewhat larger than the specified ratio of 2½ per cent.

7. *The temperatures of the alternators at the end of six hours' continuous full-power run appeared to be in every case not only well within the specified limits, but quite exceptionally low. The two larger machines were practically cold after their six hours' full-power run.*

8. We regret that we were unable to make any measurement of the insulation resistance of the machine, as the testing set at the station was found to be out of order, but we have no reason to suppose that the insulation was not quite satisfactory.

9. Instead of measuring the fall of potential directly, we measured the excitation at constant speed and constant E.M.F., which gives the same proportionate result, and is more readily determined. The results are given in Table VI., and show that the variation differs greatly from 7½ per cent. (which corresponds to 150 volts in 2,000) in the different machines. In Nos. 1 and 4 it averages about 12 per cent., in Nos. 2 and 3 about 3·6 per cent. It is to be noted, however, that we could only measure the excitation at the terminals of the field resistances, and not at the terminals of the field windings themselves. This probably accounts for the obvious discrepancy of these figures. Within reasonable limits of variation, however, it does not appear to us that the constancy of excitation is a matter of any practical importance.

† In this case the machine was driving its own exciter, and the exciting watts are added to those of the alternator in computing the output and efficiency.

Table VI.—*Variation of Excitation between half and full load.*

Set.	Exciting energy (kilowatts).		Variation per cent.
	Half load.	Full load.	
1	1·38	1·58	12·6
2	1·39	1·44	3·47
3	2·57	2·67	3·75
4	2·42	2·74	11·7

10. The full power runs of the main engines have already been mentioned. The engines, as well as the alternators, ran well; but it appeared to us that the consumption of lubricating material was somewhat unusually large. It may well be that this matter will rectify itself when the engines have run somewhat longer.

No difficulty was found in running the exciters in parallel. *Alternators Nos. 1, 3 and 4 were run in parallel at different loads in accordance with the terms of the specification, and ran in general satisfactorily.*

11. The circulating and feed-pumping engines were run for much more than the specified period of six hours at as great a load as the conditions of station working allowed us to put on them. The feed pumps ran without the least trouble. The circulating pump engine did not run so satisfactorily; it seemed to be somewhat too small for its work.

We observe that in Nos. 3 and 4 machines a metallic shield has been inserted as a protection of the field winding from the armature coils. *This is a very important improvement in the design of the alternators.*

On the whole matter of the running plant in the station, it gives us pleasure to say generally, in conclusion, that *as to output, efficiency, and economy, as well as in respect to general construction, the results are very satisfactory*, and are substantially in accordance with the conditions of the specification.

STORAGE BATTERY MANIPULATION AT THE BOSTON EDISON STATION*.

How valuable an auxiliary the storage battery may be in central station service has long been recognised in European practice, and the recent success of its application by the Boston Edison Illuminating Company demonstrates that the conditions in this country

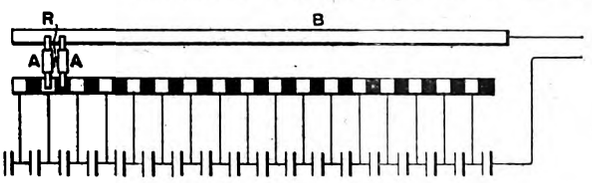

FIG. 1.—Working Circuit.

are no less favourable as to its utilisation in that service. As attention has now been generally directed to the subject, and as the application of electrical storage is likely soon to be widely extended, the method of switchboard manipulation of central station batteries has become a matter of interest.

The switchboards of the Boston Edison Company appear at first sight complicated, but in reality the electro-mechanical devices included are of the simplest nature, though displaying considerable ingenuity in their automatic action. Taking the case of the more recent switchboard, it controls a plant of 144 cells, 72 being on either side of the neutral wire. As the voltage demanded varies it is necessary to switch in more or less cells, and it is also necessary to vary the number in circuit when charging. The switchboard has for its aim the accomplishment of this regulation. The contacts must be very substantial, and therefore do not move easily. The contact shoe must not slip from one plate before it has made contact with the next. To operate a set of sliding contacts of this nature by hand would be impracticable, and hence the automatic devices.

The elementary design of the working circuit is shown in Fig 1. B is the positive bar and feeds the plus mains, while the minus mains find a terminal at the batteries. A A are travellers operated by a mechanism, and cut out more or less cells. The two travellers

* Abstract from the *Electrical World*, of New York.

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are connected by a German silver resistance, R, so that if they bridge two contacts they will not short-circuit the cell, the resistance burning out. The method of moving these travellers along the bars is electro-mechanical, and it is here that the ingenuity of the designer is called into play. This particular board moves its travellers by a reciprocating rack in which pawls on the traveller engage. The rack is reciprocated by an electric motor, which turns, by means of a worm wheel, a gear actuating a crank and connecting rod motion.

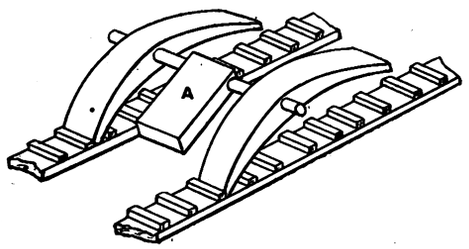

FIG. 2.—Twin Pawl.

A sketch of the double pawl is shown in Fig. 2. There are two crank plates on the axis of the gear wheel, and each of these reciprocates a rack in exact unison, and in the same phase. The iron piece A, rigidly fastened to the pawl axis, is placed between two magnets, one of which can lower and the other can raise it. By this means the pawls are tilted in either one or the other direction and engage with the rack or its journal, or return stroke, according to circumstances. Thus the traveller is drawn along by the rack, and in a single stroke of the latter one cell is cut out. The pawl

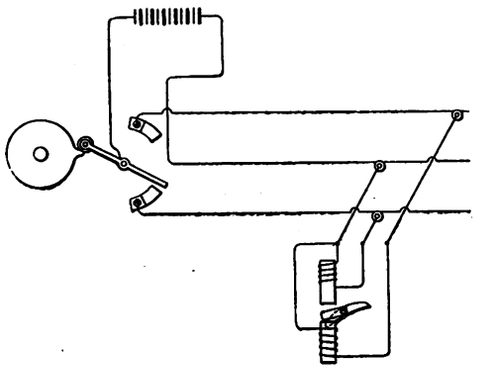

FIG. 3.—Connections of Switch and Pawl Magnets.

magnets receive their current from a system of three little trolley wires. Of course, only one magnet is excited, and according to the direction it is desired to move the traveller. Therefore, the middle trolley wire only is permanently charged, and that is common to both magnets. The other terminals of the magnets go to the upper and lower trolley wires respectively. A switch thrown by a cam on the crank plate completes the circuit through the upper or lower trolley wire, as the case may be.

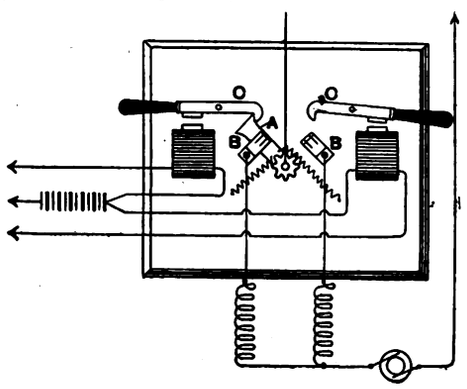

FIG. 4.—Arrangement of Switch.

Fig. 3 shows the connections. The magnets operate at a potential of 12 volts from a circuit around six storage cells. The motors that reciprocate the rack are series motors, and have two field coils, one of which will turn the armature in one direction, and the other in the reverse direction. A single-pole two-point switch is sufficient to reverse the motors. The connections of the latter are shown in Fig. 4. A is a single-pole double-throw switch of special construction. Springs normally maintain it in a vertical position. When turned to the right or left it starts the motor in one or the other direction, as shown by the connections. The latch, C, holds the switch in position, and the motor in turning over its gear wheel cuts the releasing magnet into the 12-volt circuit, and the switch flies back, opening the motor circuit and stopping the mechanism after it has advanced one cell. The levers latching the motor switch also have handles, so that they may be operated by hand in case the releasing magnets should not act. If more than one cell is desired to be cut in or out, it becomes necessary to hold the motor switch until the first click of the releasing gear has taken place, and it will then be held to be released on the second revolution of the crank plate. The motor axles are prolonged beyond their bearings, and are milled square to admit of a crank being placed thereon, in order to operate the traveller, should the motor become disabled.

Of the three wires coming from the cut-out magnets, the middle one passes to the cells, and, emerging from them six cells away from where it entered, passes with the other two terminals to three little brushes hanging over the cylindrical surface of the crank plate. Two insulated pieces of metal are placed on opposite sides of the circumference and connect the middle brush with either side brush in turn. Thus a single release magnet is operated, and then the other, alternately. It remains to be stated that the apparatus is beautifully simple and works with great smoothness and precision, completely controlling the number of cells in circuit.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, January 17th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "More about Argon," by the Right Hon. Lord Rayleigh, F.R.S.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

7:30 p.m. Fourth General Meeting in the Lecture Hall of the Literary and Philosophical Society of Newcastle-on-Tyne. Discussions on the following Papers: (1) "On the Surface Condensing Plant at the Newcastle and District Company's Electric Light Works, Forth Banks, Newcastle-on-Tyne," by W. Cross; (2) "An Investigation into the Forces Tending to Produce Vibration in High-Speed Engines," by J. M. Allan.

MONDAY, January 20th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture I.: "Alternate-Current Transformers," by Dr. J. A. Fleming, F.R.S.

TUESDAY, January 21st.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "The Sanitary Works of Buenos Ayres: Sewage, Drainage and Water Supply," by the Hon. R. C. Parsons.

WEDNESDAY, January 22nd.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Supply of Sea Water to London," by Frank W. Grierson.

THURSDAY, January 23rd.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting.

FRIDAY, January 24th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read: (1) Exhibition of Some Geometrical Instruments," by E. Scott and Signor Monticolo; (2) "On Resultant Tones," by J. D. Everett; (3) "Experiments with Incandescent Lamps," by Sir David Salomons.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Ludwig and Vitalism" by Prof. Burdon Sanderson, F.R.S.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Toynbee Hall.—The philanthropic work of this institution in the East End of London continues to be of the same useful and practical character as hitherto. For the ensuing session, classes and practical instruction in various scientific and other subjects have been arranged.

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With the current number of "The Electrician" is issued as a Supplement (Gratis) a fine Steel-Plate Portrait of Dr. JOHN HOPKINSON, President of the Institution of Electrical Engineers. Complaints of non-receipt should be at once sent to the publisher.

FROM THE CONSUMER'S POINT OF VIEW.

IT is somewhat fortunate both for the Electrical Industry and the British Public that the awe-inspiring discussions as to the exact "current that kills" which crop up from time to time in the electrical and medical journals are beyond the ken of the "average man." The great British Public does not affect electrical and medical literature of the solid order; and if it did, quite 96 per cent. would be more or less unintelligible. It is only when the Edisonian oracle across the Atlantic speaks to us in its well-worn sensational style, or when some unusually gruesome accident occurs to an unfortunate employee, that the general public is troubled by visions of unknown dangers lurking behind the simplest application of electrical energy. Dr. HEDLEY, in a recent number of the *Lancet*, quite soberly and quite rightly draws attention of the medical profession to the undesirably high voltages to which a patient undergoing electrotherapeutic treatment in a bath may be exposed, provided certain simple precautions are not taken, if the current be supplied from the mains of a company with an earthed system. Again, in our last issue, Mr. ALBION T. SNELL described a certain "vile concatenation" of untoward circumstances, which would result in a consumer getting the full pressure between the outers of a three-wire system into his house. It is also thought by some that in admitting a 250-volt current into consumers' houses at all the safety limit has been passed in regard both to life and fire. As regards life, the impossibility of procuring a supply of willing experimental objects, and the difficulty of making accurate measurements even if the supply were forthcoming, added to the widely-varying conditions which obtain in the involuntary experiments made at long intervals, place the expert and the ignoramus much on a level in this matter, and nothing more than a rough approximation to the truth, derived from a much longer experience than we have had as yet, need ever be expected. As regards fire, it would

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be comparatively easy to reproduce with sufficient accuracy the conditions likely to occur in actual practice, and to test by actual trial the behaviour of good, bad, and average wiring under 250 volts as compared with 100 volts. The sooner this is done the better. But dismissing for the moment such grave considerations as the danger to life and the danger from fire, let us try to look at the 250-volt question, and other questions of a similar nature, from the consumer's point of view.

Unless some serious catastrophe occurs to awaken his fears—an eventuality which need not be apprehended—the danger aspect of the matter is not likely to assume prominence in the mind of the consumer. Nevertheless, the introduction of 250 volts into consumer's houses will touch him at many points, and these may prove sore points. If he has to part with his cherished and very useful 8 c.p. lamp, he will scarcely regard the latest step in the march of electrical progress with favour. Fuses, of course, need not be expected to "go" daily in an ordinary well-managed household, but if, when they *do* go (accidents, we know, will happen, even in the best regulated families), they go off with the report of a pistol, the householder may very possibly get nervous. Again, if his lamps also acquire the habit of breaking frequently and at the most awkward moments, it is just possible the consumer may fall into that dangerous frame of mind in which he begins to wonder whether the "new illuminant" is worth all the bother it entails. When in this unjudicial mood it may be doubted whether he will differentiate even with approximate accuracy between the rapid dimming and frequent breakages due to the endeavour to supply the market prematurely with 250-volt lamps, and those due to the advent of cheap and nasty 110-volt lamps; a plague on both your causes, will be his irreverent exclamation. The parallel running of alternators is also a subject of transcending interest to engineers and mathematicians. To the consumer the interest of the game mainly centres on the occasional wild throbbing of the light when two self-willed machines are ordered to get into phase, or on the momentary, but nevertheless alarming, blink noticeable on circuits where the obstinacy of the alternator—or of the engineer—prevents even an attemp at paralleling. *Per contra*, the alternate-current systems are under no necessity to supply the consumer with high-volt lamps, since these may work their feeders at voltages of any degree, while still retaining the 100-volt lamp, which no other system can do without the aid of intermediate moving machinery. Again, a goodly proportion of house fittings, notwithstanding fire-office rules and supply company rules, are at present a source of mild electric shocks. Now it is open to question whether the epithet of mild will be applicable to the language of the *pater familias* who receives the "full force" of 250 volts; at any rate we feel sure the recipient of the shock will not consider it as twice blessed, and bless the company that gave it him, as well as his own good fortune in receiving it. Ultimately, of course, equilibrium will be established. High-pressure steam has given us better boilers, high-pressure current may reasonably be expected to give us better wiring, and possibly a reduced tariff. We trust, however, that the every-day convenience of the consumer will not be entirely overlooked. If it is, he will not fail to do as he is done by.

So much for the matter of the pressure of supply from the consumer's standpoint. On the subject of house wiring no doubt he also has his opinions, inarticulate at present, probably illogical, but possibly worthy of some consideration. To our mind, one of the many merits of iron-barrel and of concentric wiring is that they are calculated to remind the consumer of the familiar gas pipe. The external resemblance between the early railway carriage and the old stage coach induced many a timid conservative to adopt the new mode of locomotion, and if the householder finds that, in lieu of a maze of mysterious-looking wires in ugly wooden troughs, something bearing a striking resemblance to his old familiar friend the gas pipe is all that an installation of the electric light need involve, he may come to regard the adoption of the new mode of illumination less as a bold departure and more as an inevitable matter of course. Apart from the aforesaid graver considerations of safety, the average householder will probably consider the best form of wiring to be that which looks simple, costs little and gives the least trouble. He, at any rate, poor man, does not wish to be for ever drawing wires in or drawing wires out. Once he has paid his bill for the job, he will be inclined to measure the efficiency of his wiring system in much the same way as he measures the efficiency of his digestive system: he will be content to ignore its existence.

REVIEW.

Gleanings from Patent Laws of all Countries. By W. Lloyd Wise, J.P., F.R.G.S. (Cassell and Co., Limited.)

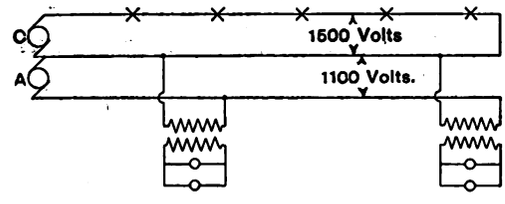
Works on patent law are so frequently either of such a highly legal nature, or deal with the subject in such an elementary fashion, that, as works of reference, they are of little or no value to owners of patents and inventors, requiring, in the one case, a much greater expenditure of time to peruse than is usually at the disposal of business men, and in the other affording but little definite information on points of practical interest.

The first portion of the work we have before us, which deals in alphabetical order with the patent laws of twenty-two countries (ranging from Argentine Republic to Germany), is not open to these objections, for, whilst giving precise particulars as to patent law *and practice* in the several countries, the headings under which these particulars are classified are such as to enable the information with regard to any special point to be readily turned up and digested. The headings include "Who may obtain a Patent," "Subject Matter," "Application, Procedure, Grant," "Term," "Fees (Government)" and "Assignment and Transfer of Patents."

The notes as to the productions, industries, &c., of each country, will no doubt be useful to persons interested in inventions and patents.

AN ECCENTRIC SYSTEM OF ELECTRIC SUPPLY.

Doubt having been expressed as to the possibility of working continuous and alternating currents on the same system of conductors, a writer has sent to the *Electrical World* of New York a description of an instance of this combination having been actually effected. The connections between the two generators, which were a Brush arc machine, C, and a "National" alternator, A, were made as is shown in the following diagram:—



This experiment was made about three years ago, on a three-wire supply system at Brunswick, Me. The pressure of the continuous current was 1,500 volts, for running arcs in series; and the pressure of the alternating current was 1,100 volts, for distribution to transformers in parallel. The experiment was tried under severe conditions, but, it is said, both sets of lights and both machines ran smoothly. It is admitted by the writer that there is some risk of the current from one machine running through the armature of the other.

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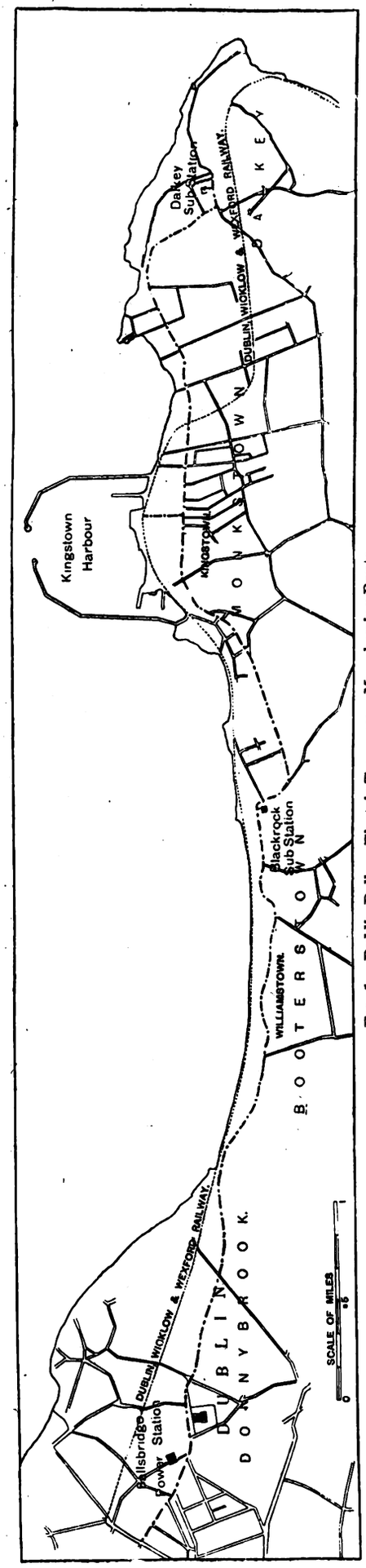

FIG. 1.—Dublin-Dalkey Electric Tramway. Map showing Route.
——·——·—— Electric Tramway. ..... Dublin, Wicklow and Wexford Railway (steam).

THE DUBLIN-DALKEY ELECTRIC TRAMWAY.

The conversion of the original horse tramway between Dublin and Dalkey into an electric line having now been practically completed, and successful trial runs of cars over a portion of the line having already taken place, the interesting event of the inauguration of this line may be expected shortly to occur. The line is owned by the Southern District Tramways Company, of Dublin, the Managing Director of which Company is Mr. George White, whose name has already appeared in these columns in connection with the recently-opened electric line of the Bristol Tramways Company, of which he is also the Managing Director. The extent of the Dublin-Dalkey Electric Tramway is shown by the accompanying map (Fig. 1), and it will be seen that, starting from Dublin at a point about half a mile north of Balls Bridge, where the generating station is situated, the line passes through Donnybrook, Williamstown, Blackrock, Kingstown—where a branch traverses streets leading to the harbour—and thence to Dalkey. Throughout the greater part of its main route the tramway is roughly parallel with the Dublin, Wicklow and Wexford steam railway.

Acting upon the advice of their consulting engineer, Mr. J. Clifton Robinson, the Tramway Company gave the contract for the electrical equipment of the line, the reconstruction of the track and of the buildings for the power-station and substations, and the erection of the generating plant, &c., to the British

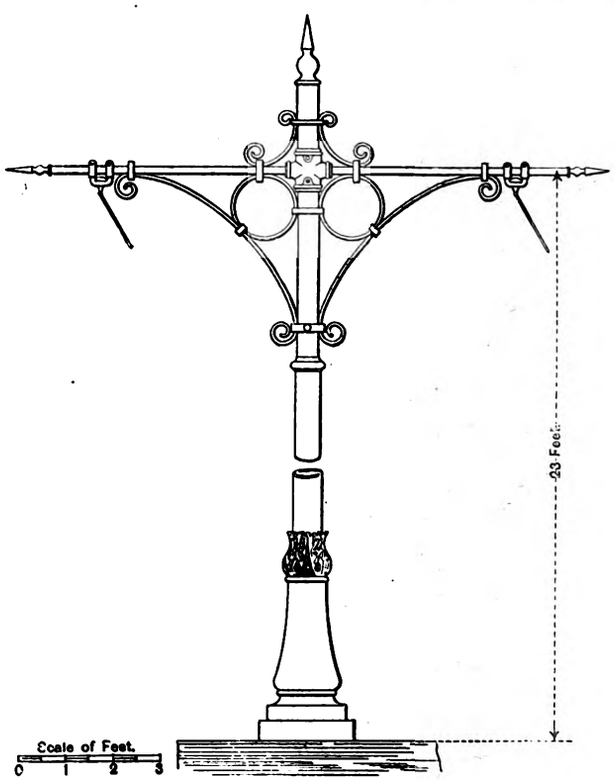

FIG. 2.—Dublin-Dalkey Electric Tramway.
Pattern of Pole used for Bracket Supports in centre of Track.

Thomson-Houston Company, by whom sub-contracts were given to Alderman Meade, of Dublin, for the building construction, to Messrs. Kellners, of London, and Mr. A. Krauss, of Bristol, for the reconstruction of the track, and to Messrs. Callender's Bitumen, Telegraph and Waterproof Company and the British Insulated Wire Company, for cables. The contracts were carried out under the supervision of Mr. A. J. Ireland (chief engineer) and Mr. C. W. G. Little (resident engineer) on behalf of the chief contracting company. The portion of the line between Kingstown and Dalkey was commenced near the end of 1894, and the other portion, extending towards Dublin, early in 1895. Some opposition was at first raised by the ratepayers of Dalkey; but, after a deputation had been received, the matter was satisfactorily cleared up, and the work of construction proceeded.

The track, which is $7\frac{3}{4}$ miles in length, is on the whole fairly level, the principal gradients being 1 in 16, 1 in 23, and 1 in 29. It is double throughout, except for a short distance in two places. The guage is 5ft. $2\frac{3}{16}$in., and the rails, which are of 76lb. size, with massive fish-plates, are laid in concrete. The electrical equipment of the track is upon the overhead trolley system, span wires being principally used, with centre poles in some of the narrower streets, and along the chief road through which the Kingstown branch passes. The style of the centre poles is shown in Fig. 2, from which it will be seen that these are far from

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being inartistic. Indeed, the appearance of the centre poles with double brackets is undoubtedly superior to that of the plainer side poles, with their numerous span wires crossing the streets at right angles. The return current is through the rails, which are bonded on the Chicago plan, single bonding being used throughout, with cross connections at every 120ft. The trolley wires, which are duplicated throughout, are of hard-drawn copper, 320 mils in diameter. The poles, whether for the central or side

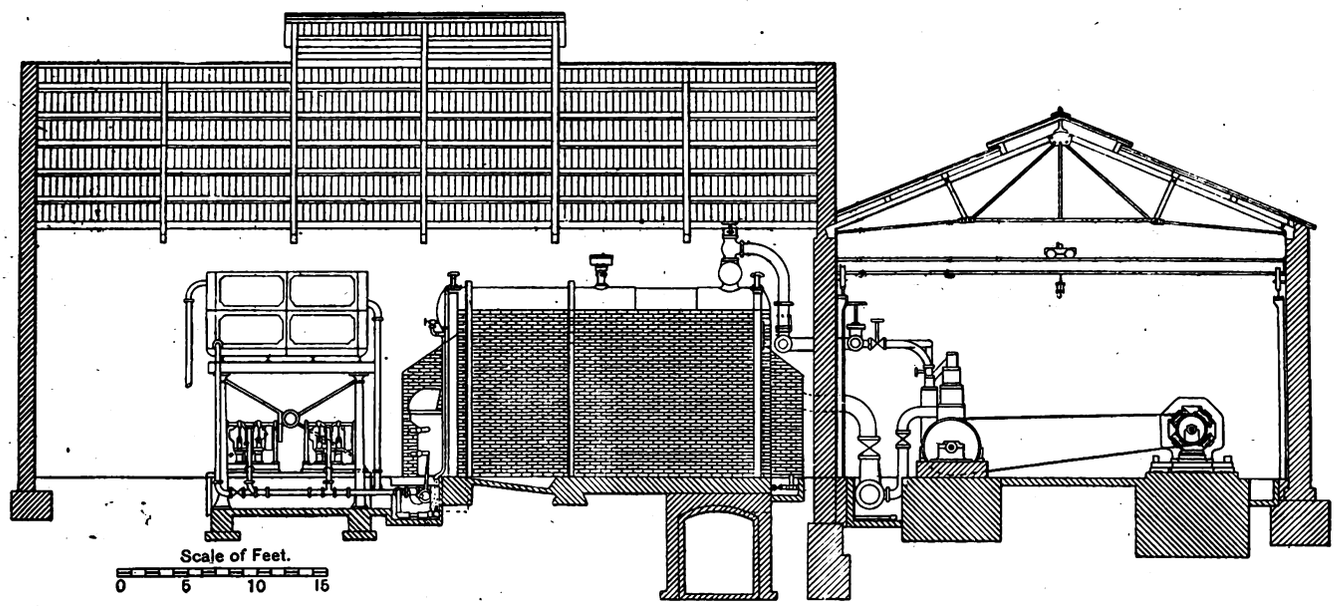

FIG. 3.—Dublin-Dalkey Electric Tramway. Longitudinal Section of the Generating Station.

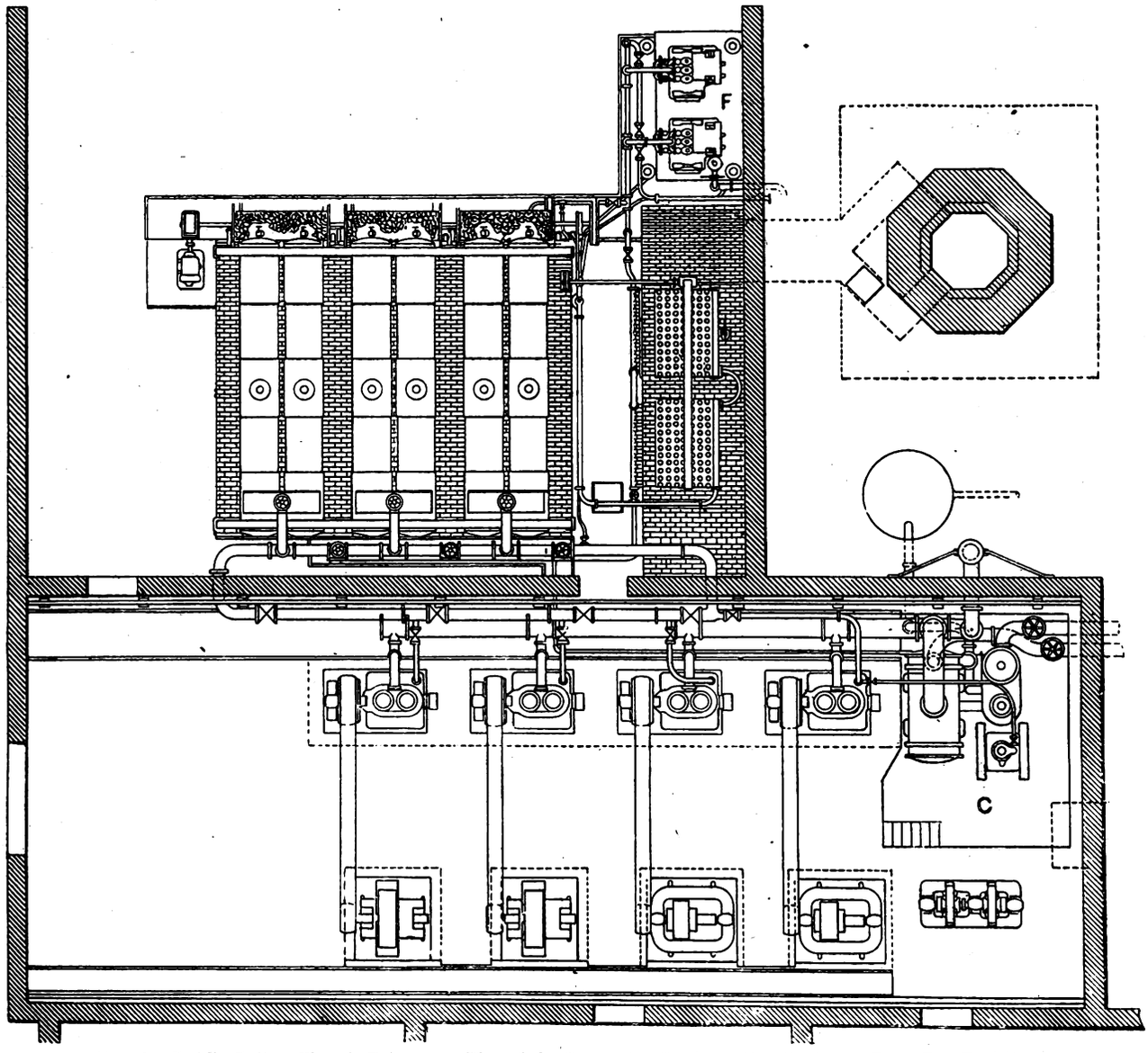

FIG. 4.—Dublin-Dalkey Electric Tramway. Plan of the Generating Station. C = Condenser Pit. F = Feed Pumps.

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construction, are of steel tubes in three sections, with hot-shrunk over-lapping joints. They are grounded to a depth of 6ft. in concrete, a cast-iron base and foot-plate being fitted over the lower end of the pole. In excavating for the pole groundings considerable trouble was occasionally met with, owing to the rocky nature of the foundation; and the pits had in some places to be blasted out. The span wires are of mild-steel cable, $\frac{3}{8}$in. in diameter; they are fastened to the side poles by means of insulated buckles, which are secured to wrought-iron strips, these being clipped around the poles. From the span wires—or from the brackets, where central poles are used—the trolley wires are suspended in the usual manner, by insulators; and, of course, every half-mile is capable of being isolated from the system. At the ends of each half-mile section, section insulators are used; and here the ends are connected to rubber-covered cables leading down the poles to the switch pillar, in which there are switches by which the sections may be connected to the continuous-current feeders. These switch pillars are erected along the route, beside the vehicular way; they are of cast iron, and in general appearance resemble postal pillar boxes, except that they are of a more ornate design. They are 4ft. in height and 18in. in diameter.

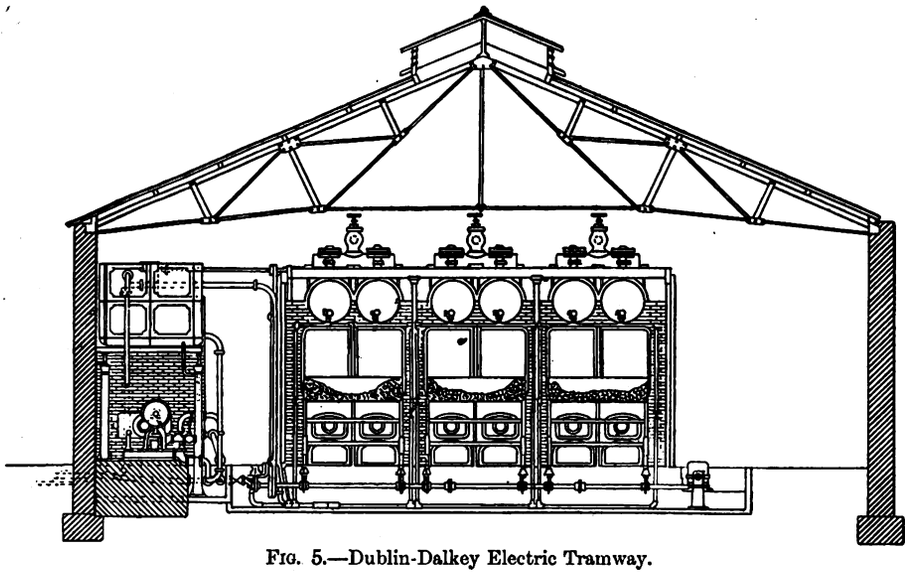

FIG. 5.—Dublin-Dalkey Electric Tramway.

Transverse Section of Boiler House, showing boiler fronts, feed tank, electric pumps, and electrically-driven automatic stokers.

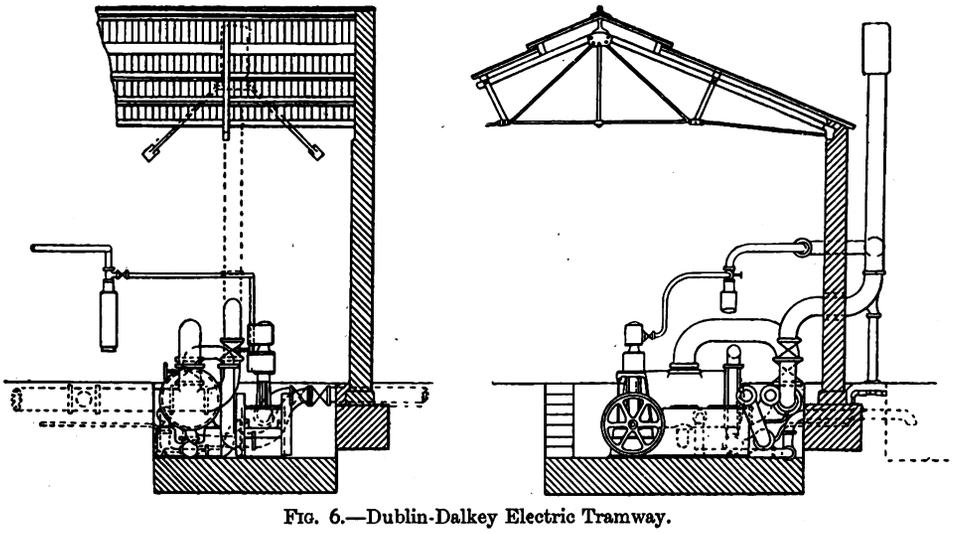

FIG. 6.—Dublin-Dalkey Electric Tramway.

Longitudinal and transverse sections of the Condenser Pit, showing Surface Condensing Plant.

One of the most interesting features of the Dublin-Dalkey tramway system consists in the adoption of power transmission by means of polyphase currents, between the power house and the two sub-stations which feed the line *en route*. A glance at the map will show that the position of the power station would render it difficult to comply with the Board of Trade regulation in regard to the drop of pressure on the return circuit through the rails, except by means of sub-stations at the far end and an intermediate point on the line. This regulation insists that the fall of pressure on the entire length of the return circuit shall not exceed 7 volts. It was therefore considered desirable to adopt polyphase transmission between the power station and the two sub-stations, the one at Dalkey and the other at Blackrock. The sites for the main and secondary stations were fixed by the existence of car sheds and stables, belonging to the original horse tramway system, at these places; and the old buildings on these sites have been partially utilised and reconstructed to suit their present purpose.

The power house is situated on the banks of the River Dodder, which provides water for condensing purposes. The equipment of the power house provides plant for directly feeding the nearer end of the line with continuous current at 500 volts; as well as for transmitting three-phase power, at from 2,300 to 2,500 volts, to the distant sub-stations. The arrangement of the station equipment is shown in Figs. 3 to 6. Figs. 3 and 4 show, on the same scale, a longitudinal section and a plan of the station; Fig. 5 is a transverse section of the boiler house; and Fig. 6 shows a longitudinal and a transverse section of the condenser pit, which is shown in plan at C, in Fig. 4, all these illustrations being on the same scale.

In the boiler house there are some interesting features. There are three Babcock-Wilcox boilers, each provided with double steam drums, of 250 H.P. per boiler. These develop a normal pressure of 140lb. on the gauge. The boilers are fired mechanically, by means of Vicars stokers; and the gear for these stokers is driven by a G.E. shunt motor, which also drives the scrapers in the Green's economiser. The feed water is supplied either by means of an injector, or by two three-throw pumps, made by Messrs. Daniel Thompson and Co., each of which is driven by a G.E. motor, of the same type as those used on the cars, but shunt wound. Fig. 7 shows a longitudinal and transverse elevation of one of these electrically-driven feed pumps. All the motors in the boiler house are worked from the 'bus bars, at 500 volts, through special rheostats and switchboard. The feed pumps are capable of supplying 16,000lb. of water per hour. The feed water is taken from a large storage tank, or from the town supply direct, or from the hot well of the surface condenser, and is passed through a Green's economiser consisting of 192 pipes. An octagonal brick chimney, 111ft. 8in. in height and 6ft. diameter at the top, carries off the furnace gases after they have passed through the economiser flues.

A ring main steam range, shown in Fig. 4, collects the steam from the three boilers, single branch pipes being T'd to each of the boilers as well as to each engine. The main ring is 8in. diameter, of mild steel; the T-pieces and bends are of cast steel; and the branch pipes to the engines are of copper, $4\frac{1}{2}$in. diameter. The stop valves in the main ring and at each branch are of the Hopkinson pattern; they are arranged so that any defective section of the plant can be shut down without interfering with the working of the rest.

In the machinery room there are at present four generating sets, each driven by a 150 B.H.P. Willans (H.H.S.) compound, condensing, two-crank engine, running at 380 revolutions per minute, with steam at 140lb. The engines have been specially strengthened to stand the severe loads which traction work temporarily imposes, and will develop 175 B.H.P. for a short time on occasion. The engines are adapted to belt driving,

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each being provided with a 3ft. 10in. flywheel pulley, and with an outer bearing. Two of the engines drive two "B.T.H." 100-kilowatt four-pole tramway generators at 625 revolutions per minute. These are compound wound for 500 volts at no load and 550 volts at full load. The other two engines are belt coupled to two eight-pole three-phase generators, each capable of developing 120 kilowatts at from 2,300 to 2,500 volts, running at 600 revolutions per minute. These machines were designed by Mr. H. F. Parshall, and were manufactured at Newcastle-on-Tyne by Messrs. Armstrong, Mitchell and Co. In addition to these four generating sets, there is a "B.T.H." four-pole motor generator of 30 kilowatts capacity, consisting of a 500-volt shunt motor direct coupled to a 125 to 140-volt continuous-current generator, for supplying the station lights and charging the storage batteries. This motor-generator is situated at one corner of the machinery room in line with the dynamos, as shown in Fig. 4.

Surface condensing plant is provided in a pit sunk below the level of the machinery room, and the steam plant may be run either condensing or non-condensing. The condenser pumps are driven by a separate small steam engine. The capacity of the condenser is rated at 19,000lb. of steam per hour.

The switchboards are arranged on the panel system, a separate panel being provided for each machine. Those for the 100-kilowatt 500-volt generators are the standard British Thomson-Houston form of K panel, consisting of enamelled slate slabs measuring 19in. by 24in. wide, each carrying an automatic circuit breaker with magnetic blow out, one 300-ampere illuminated dial Weston ammeter, one field rheostat with switch connected to special resistance to take the discharge current on opening the field circuit, one pilot lamp, one voltmeter, single-pole switches, one lightning arrester and Thomson recording wattmeter. There is also a single-pole switch for the series lighting circuits. The 'bus bars and all connections are carried at the back of the board, the positive bus bar is connected to the 500-volt trolley wire-feeder, and the negative 'bus bar to the rails forming the return circuit. The dynamo and 'bus-bar voltmeters, which are the Weston type, are mounted on a bracket, which projects from the end of the switchboard. The equalising switches are mounted on separate pillars, close to the generators. For the three phase plant four separate panels are provided, two being for the generators and two for the feeders, the former each carrying a three-pole high-pressure switch of special design, three high-pressure fuses of the Ferranti oil brake type, three ammeters and one voltmeter, field rheostat, and synchronising gear. The feeder panels each carry a three-pole high-pressure switch and an ammeter. The three-phase generator fields are excited from the 500-volt 'bus bars. The above panels which constitute the main switchboard are bolted to vertical iron supports, there being about 3ft. space between the wall and the back of the board. In addition to the above there are two separate panels, one for controlling the high-pressure side of the motor-generator and the station motor circuits; the other carries the switch gear for the low-pressure side of the motor-generator, the accumulators and the station lighting circuits. This board is so arranged that the secondary side of the motor-generator may be run as a motor when connected to the accumulators, so as to give 500 volts on the high-pressure side for operating the station motors when the main plant is standing idle. This small switchboard is placed beside the motor-generator at one end of the engine room. The cables between the dynamos and switchboard consist of class L rubber-covered cables, laid in trenches and supported by porcelain insulators. The accumulators are of the Epstein type, there being 55 cells of the R 11 pattern having a capacity of 600 ampere-hours.

The repair shops are fitted with a complete set of machine tools, consisting of lathe, shaping machine, drill press, hydraulic press, grindstone, blacksmiths' forge, &c., and a full equipment of small tools. The machine tools are driven by belt from a countershaft operated by a "G.E." shunt-wound motor run off the 500-volt circuit. The testing room contains the usual testing instruments, a battery of 50 small accumulators, and a portable Silvertown set.

The present rolling stock comprises 20 motor cars, each double-decked and capable of seating 24 passengers inside and 30 on top, the length inside being 16ft. 6in., and over platforms 27ft. 2in. These cars were constructed by Messrs. G. T. Milnes and Co., of Birkenhead, and are of handsome design. They are each lighted by means of five 16 c.p. lamps in series from the trolley circuit. Each car is equipped with two "G.E." tramway motors and series-parallel controllers. The trolley is of the usual American pattern, mounted on a cast-iron pedestal 6ft. 6in. in height. This pedestal is bolted to a stout plank running the whole length of the car roof, somewhat on one side of the centre. In addition to the motor cars there are 20 trailers, similar in general design to the motor cars, but without other electrical equipment than the electric bells and glow lamps. Five extra motor cars and 10 extra trailers are being built.

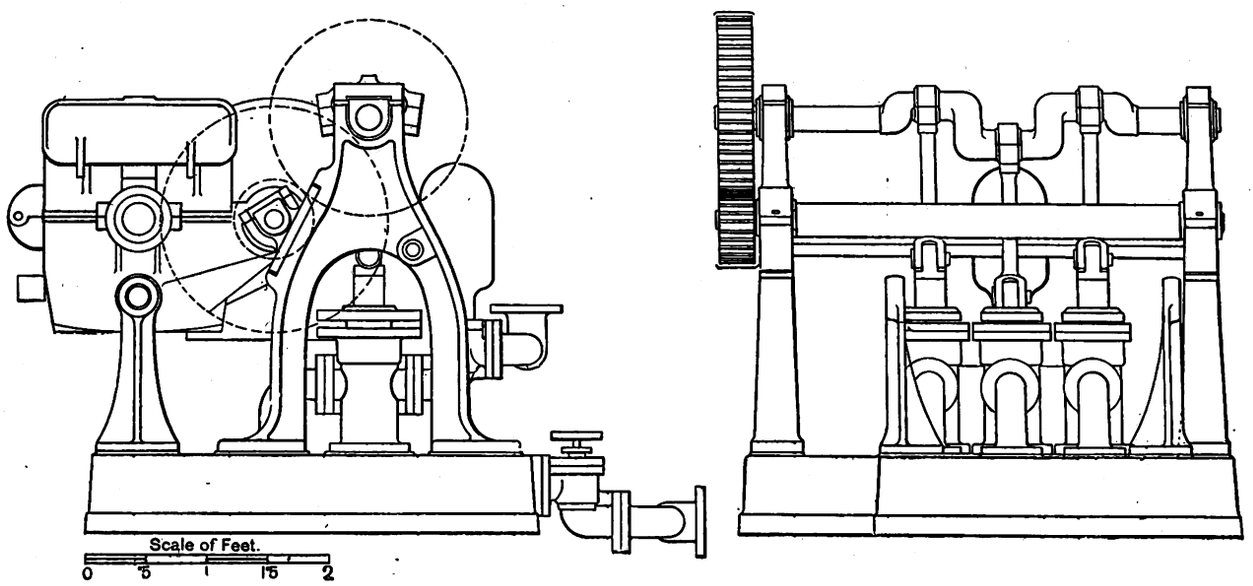

FIG. 7.— Dublin-Dalkey Electric Tramway. Electrically-driven Feed Pump in the Boiler House.

Spacious car sheds have been erected adjoining the power house, and sheds of smaller capacity at the two sub-stations. The position of the sheds at the main station would be represented immediately contiguous to and beneath the plan shown in Fig. 4. There is space for 38 cars in these sheds, arranged on 11 tracks, four of which are provided with pits to enable the cars to be repaired or cleaned from underneath. A traversing table allows of the cars being transferred from any one track to any other. Adjoining the sheds are the repairing shops, the equipment of which has been described above.

At the Blackrock sub-station the plant consists of two direct-coupled units, each consisting of a synchronising motor coupled

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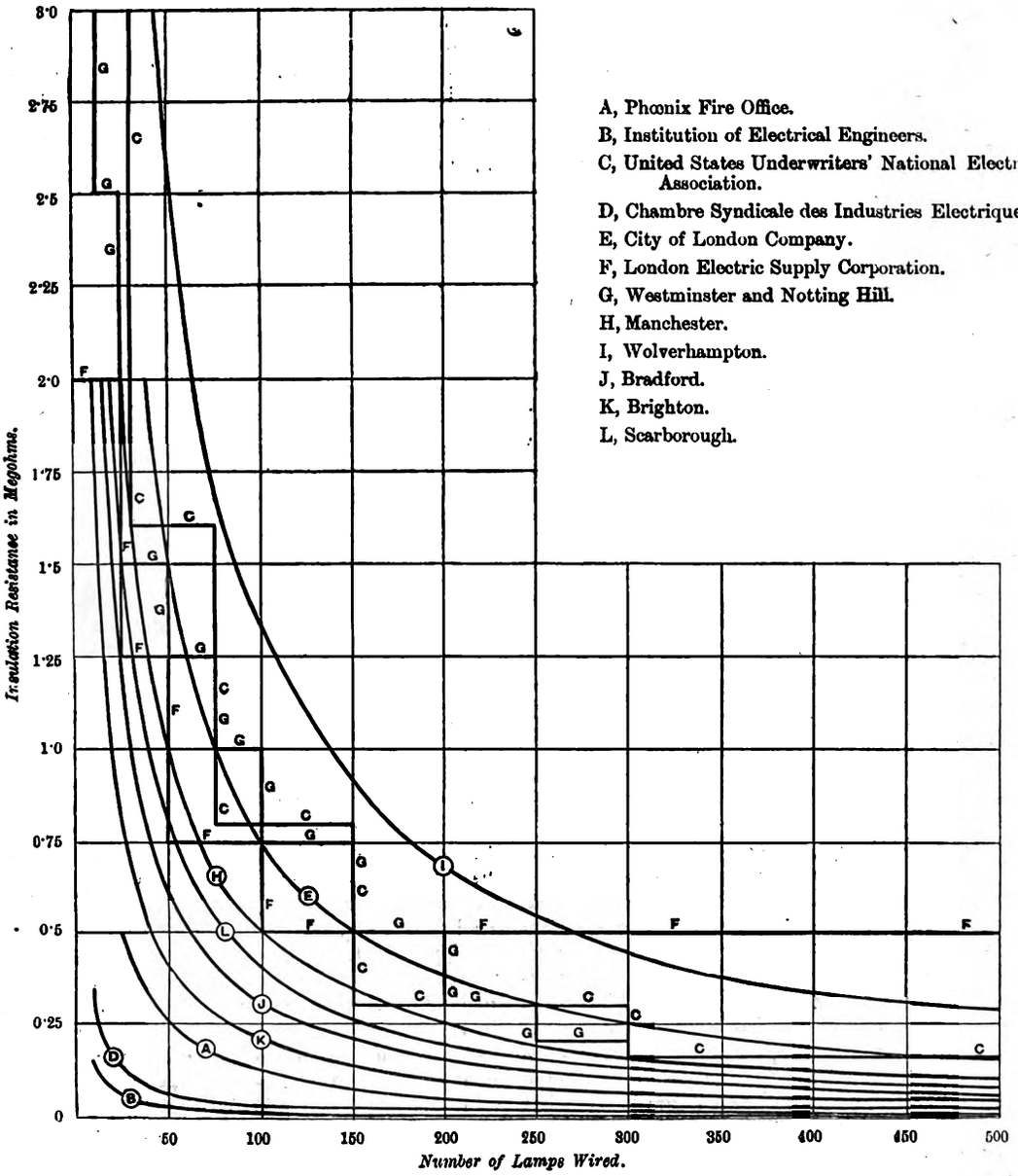
to a 60-kilowatt continuous-current generator. The motor receives the three-phase current at about 2,300 volts pressure, and the generator produces current at a pressure of 500 to 550 volts. Suitable switching gear is provided to enable the generator to be started from the trolley wire feeder to run the motor before throwing it into circuit. There is also a set of switching gear for controlling the direct-current generator, and connecting it to the 500-volt trolley wire feeder. The plant at the Bullock Hill sub-station, at Dalkey, is similar, except that the generators have a capacity of 50 kilowatts each.

Current is carried from the power house by two sets of feeders, one being for the 500-volt direct current and the other for the 2,500-volt three-phase system. The 500-volt feeders, which supply current to the overhead trolley wire, consist of Callender's lead-sheathed armour cables of 0·08 sq. in. and 0·15 sq. in. section. The former cable extends from the power station as far as Blackrock sub-station, but the latter, of course, extends to the Bullock Hill sub-station. The three-phase current is carried from the power station as far as Blackrock sub-station by two triple concentric cables, each of 0·0496 sq. in. section, and from thence to the Bullock Hill sub-station by one triple concentric cable of the same section. These concentric cables are of the British Insulated Wire Company's lead-sheathed and armoured type. In addition to these feeders there is a three-core Callender lead-sheathed and armoured cable, one conductor of which is used as the test wire. The other two conductors are for the telephone system. This cable is led into the feeder switch pillar, and connected to telephone instruments placed at every half mile along the line, and is also carried into the power house and sub-stations, where telephone instruments are fixed.

Our thanks are due to the British Thomson-Houston Company, the contractors, for their kindness in readily supplying us with particulars from which to prepare the foregoing description and illustrations of the Dublin-Dalkey electric tramway.

HOUSE WIRING INSULATION CURVES.

The curves in the accompanying diagram have been drawn upon the basis of the most recently published rules in regard to the insulation resistance of house wiring, which have been issued by the insurance and supply companies and other important bodies. In many respects these rules are the same as those issued on former occasions, but also in many respects they differ from these in important details. We published a similar set of curves in *The Electrician*, Vol. XXXII., p. 265; but since that occasion many of the supply companies have remodelled their regulations in this matter. In the twelve curves selected typical regulations of some of the most important authorities are shown, and many of these represent the rules not only of the authorities whose names are appended, but also of minor provincial supply companies.



Two classes of regulation are apparent in these curves: (1) those which are represented by a regular hyperbolic curve,

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(2) those which are represented by irregular "stepped" curves. Examples of the former class are shown by index letters included in small circles; examples of the latter by index letters at intervals along the line of the curves, but not included in circles. It should be added that a very large number of the provincial supply concerns issue no special regulations, but insist only upon the regulations of the Phœnix Fire Insurance Office.

ON THE MOTIONS OF THE LUMINOUS GLOW IN RAREFIED GASES PRODUCED BY ELECTRIC OSCILLATIONS.*†

BY J. ELSTER AND H. GEITEL.

In the course of some experiments on cathode rays, in which a high-tension transformer was used instead of an induction coil, we observed in a Lenard tube‡ a peculiar discharge phenomenon, the nature of which we endeavoured to elucidate by a series of experiments.

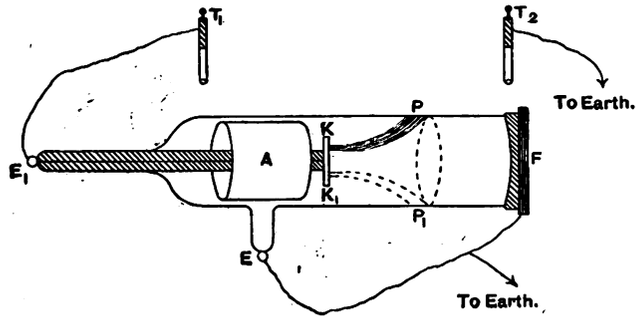

FIG. 1.

For transforming the alternate current of a large induction coil of about 18cm. maximum sparking distance, we employed the arrangement described by Tuma§; the discharge of the attached condenser of large capacity took place between two adjustable zinc terminals, the distance of which in these experiments only amounted to ½mm. to 1mm. (with larger distances the discharge tube ran the risk of percussion). On joining the aluminium disc K (Fig. 1) with the terminal T_1 of the transformer, while putting the other, T_2, as well as the cylindrical electrode A and the metal cap F, to earth, we observed at a pressure of about 1mm. the following phenomenon:—

From the electrode K there proceeded a fine light thread K P, bent upwards, which produced vivid phosphorescence both where it originated on the metallic plate and where it impinged upon the glass wall. The phosphorescent patch on the (oxidised) aluminium disc had a bluish white and on the glass the well-known green

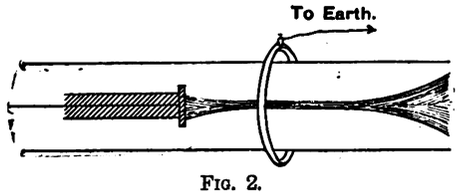

FIG. 2.

colour. Both patches increased in brilliance as rarefaction was carried further, while the luminous thread connecting them steadily decreased in luminosity and almost totally disappeared at the highest attainable rarefactions. Thus the impression was created of a fine cathode ray, bent upwards, proceeding from the plate K. If a conductor put to earth, say the hand, was brought near this ray from above, it jumped into the position $K_1 P_1$ (shown dotted in the figure). On passing the hand slowly round, the patch P passed in succession through the positions indicated by the circle P P'. The luminous thread K P was always urged on to the opposite side of the glass tube away from the conductor—was, in fact, repelled by it. Insulated conductors acted in the same manner, but much less powerfully. Dielectrics had no effect. The bending upwards of the ray was evidently due to the fact that the discharge tube was rather close to the working bench. The effect of this could be eliminated by placing a metal ring put to earth round the tube. The patch then moved into the centre of the plate K, and the luminous ray assumed the shape shown in Fig. 2 without losing its sensibility to conductors approaching from outside.

To follow up the phenomenon further, we now replaced the Lenard tube by a vessel of the shape shown in Fig. 3. In this apparatus the aluminium ring A corresponds to the cylindrical sheet of the Lenard tube, the metal cap bearing the aluminium window having been dispensed with as unnecessary. Exhaustion

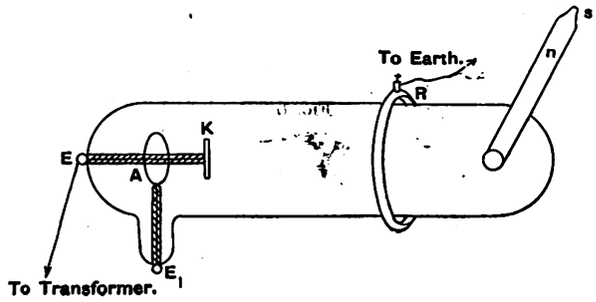

FIG. 3.

was carried on while the induction coil discharges passed through the tube until the sparks began to pass outside between the terminals E and E_1; then the apparatus was fused off the pump at *s*.

The connecting tube *n* served as a handle, being screwed into a wooden clamp. The fusing point *s* is the most endangered piece of the apparatus. On the approach of conductors sparks are easily produced here which puncture the glass. The ring R, which may be replaced by a thin annular wire, is placed at such a distance from K that the movable discharge is formed in the greatest intensity. Its appearance depends upon the distance between the conductors K and R. With high vacua it disappears completely when the ring R is brought very close to the plate, or is placed in such a position that K lies in the plane of R.

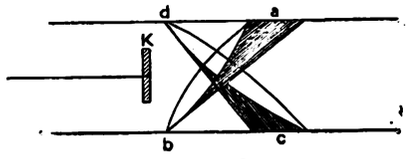

FIG. 4.

After having convinced ourselves that it was possible in this manner to prepare vacuum tubes which would constantly exhibit these phenomena, we next endeavoured to determine the direction of the current in the movable thread of light. For this purpose we introduced such a tube between the poles of an electro-magnet provided with a commutator.

This information would be given by the behaviour of the discharge in the magnetic field. For if K (Fig. 4) is a metallic plate from which cathode rays issue normally to the surface, these are not freely developed in a magnetic field; they are deflected like a current thread fastened at one end, and produce on the cylindrical glass wall a phosphorescent patch, which, according to the position

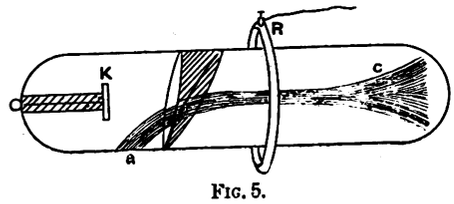

FIG. 5.

of the commutator in the circuit, assumes the position *a b* or *c d*. The tube is supposed to be in an equatorial position.

In the first place, the ring R was placed so that the phenomenon shown in Fig. 2 took place; then the electro-magnet was excited. The result was that while the cathode rays proceeding from R were deflected upwards, the phosphorescent patch produced by the movable light thread shifted from the plate K down to the glass wall, or *vice versâ* (*see* Figs. 5 and 6).

This implies that while the former are due to an electric motion proceeding from K as a cathode, the movable discharge must have its cathode at *c*, and that the two lengths represent the opposite phases of an electric oscillation. The mobility of the latter may

* *Wied. Annalen*, Vol. LVI., No. 12, p. 733.

† Movable light bands and brushes in a vacuum have already been investigated and described by Tesla (*see* Martin, "Tesla's Investigations," &c.), but we have considered the following short description of our experiments to be not superfluous on account of the simplicity of the arrangements, and the conclusion to be drawn from them concerning the nature of the movable discharge.—AUTHORS.

‡ *See* P. Lenard, *Wied. Ann.*, LI., Plate IV., Fig. 1. *See* also *The Electrician*, Vol. XXXIII., May 25, 1894, p. 108.

§ J. Tuma, *Wien. Ber.*, 102, Part 2A, p. 1,352, 1894.

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therefore be due to the fact that the cathode is not a metallic equipotential surface, but a plane in either the glass or the gaseous space whose position may be displaced by approaching conductors.

In the above experiments the discharges were introduced by means of a metallic electrode. Now we endeavoured to simplify matters by using an electrodeless glass cylinder 5cm. wide and 25cm. long, the two ends of which were closed by plate glass. A spherical terminal 1cm. in diameter was in contact with one of these (*see* Figs. 7 to 10), and was connected with the free terminal

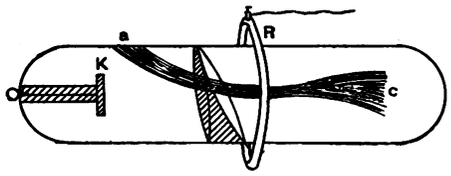

FIG. 6

of the transformer. With a suitable distance of the ring R from the electrode K, and with a sufficiently high vacuum (0·01mm. to 0·001mm. of mercury), there appeared, besides the phosphorescence of g_1, under the influence of the cathode rays proceeding g_2, a bluish pencil of light at c (Fig. 7), which contracted in the centre of the ring M to a narrow band, increasing slightly in diameter from M to a, and producing at a on the glass plate g_1 an intensely green phosphorescent circular patch of about 1cm. diameter. In this case, also, the luminous thread M a was highly sensitive to neighbouring

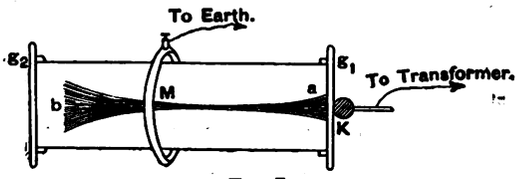

FIG. 7.

conductors. In the magnetic field it assumed, according to the position of the commutator in the circuit of the electro-magnet, the positions shown in Fig. 8 and Fig. 9. The phosphorescent spot is always designated by a.

We made sure, by a direct experiment upon a thin copper wire lightly suspended between the poles of the same electro-magnet, and traversed by a constant current, that this band of light behaves to magnetic forces as if it were traversed by a current from a to b. While, therefore, the cathode rays produced by K are directed from

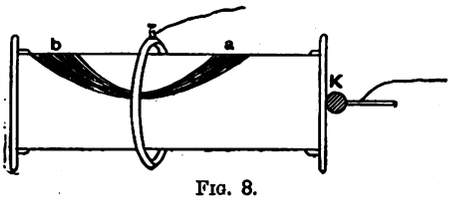

FIG. 8.

g_1 to g_2, as proved by the phosphorescence of g_2 as well as its behaviour in the magnetic field, those produced in the movable band of light follow the reverse direction, from b to a.

Here, then, we obtain the same result as with tubes with flat metallic electrodes.

It might be argued that the movable phosphorescent patch is caused by the cathode rays proceeding from K, and reflected by the opposite wall. Although the behaviour of the phenomenon in the magnetic field contradicts this view (in Figs. 5 and 6 the

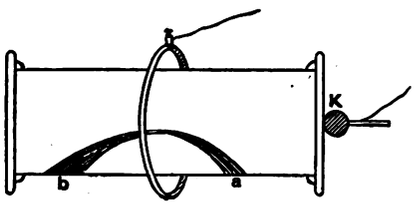

FIG. 9.

cathode rays proceeding from K do not reach the opposite wall at all), we thought better to decide this question definitely. We placed in the electrodeless vessel (Fig. 7), at an angle to the axis of the tube, an elliptical plane mica plate $m n$ (Fig. 10), which would reflect the cathode rays proceeding from g_1 on to the wall of the cylinder. The discharge shown in Fig. 10 shows distinctly that the thread of light $a b$ is *not* at right angles to the reflecting plane. The phosphorescent patch at a can therefore not be explained by the reflection of the cathode rays from g_1 at the mica plate.

Another conclusion also follows from this. Since the cathode rays producing the phosphorescent patch a are not perpendicular to the mica plate $m n$ (as is always the case when such cathode rays are formed at the surface of conductors or dielectrics), it may be assumed that their origin is not at the surface of contact between the mica and the rarefied gas. We are obliged to seek their origin in the gaseous space, and must consider that within the oscillating gas column the (as yet unknown) conditions are fulfilled which determine the genesis of the cathode rays. The gas column which is made luminous by rapid electric oscillations is therefore the origin of the cathode rays, and always produces phosphorescence when it impinges upon the glass wall of the tube. Since its position is entirely dependent upon the capacity conditions of the discharge tube regarded as a condenser—the discharge always going along that side of the tube which has the smallest capacity, and therefore first attains the discharge potential, this column and its cathode rays change with every change of capacity, as produced by the approach of conductors on one side. It always recedes from the conductor, since this increases the capacity on that side of the tube.

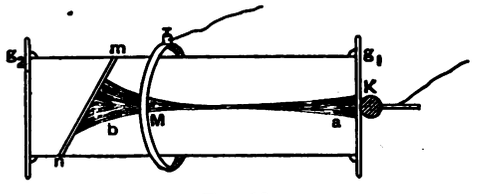

FIG. 10.

If the interpretation of the phenomenon described is correct, it will give a further proof for the view of the nature of cathode rays founded by Hertz, Jaumann,* Lenard, E. Wiedemann, and Ebert, according to which these are not due to projected electrode matter, but to motions in the ether akin to light.

THE DISTRIBUTION OF POWER IN COLLIERIES.†

BY LLEWELYN B. ATKINSON.

The present position of the coal-mining industry in the United Kingdom is one deserving of the most thoughtful consideration by all who are interested in the future of the commerce of the country, and the object of the present Paper is to point out how, possibly, some of the difficulties under which this industry at present labours may be met. The difficulty to be contended with may be briefly stated. The possible output, and, indeed, the output at which a reasonable profit can be earned, is greater than the demand at present prices; and even this demand is threatened by the decreasing price of coal raised in other countries. From whatever point of view it is looked at, this question resolves itself into stimulating demand, which can be effectually done only by lowering the selling price, and this cannot at present be done without extinguishing the profit. To decrease the cost at the collieries, there are broadly three courses: (1) to decrease the payment per ton to the mineral owner; (2) to decrease the wages cost per ton raised; (3) to decrease the fuel expenditure per ton raised. The first of these is a matter outside the scope of this Paper, the second will be briefly touched upon, and the third will be dealt with in some detail.

In the course of the last eight or nine years the author has been in close contact with mining operations in various parts of England and Wales, and the opinion has gradually been forced upon him that there is a very large margin of economy in wages and fuel to be effected. This arises from the fact that economies in labour and fuel which are studied and made use of in engineering and manufacturing industries are hardly considered in coal mining, at all events in the majority of instances. This broad fact must appeal to every mind: that, whereas in almost every manufacturing process or industrial operation the product per man has probably doubled, and the consumption of fuel been halved within the last 15 years, in coal mining the product per man has been practically stationary, and the cost of fuel per ton raised probably nearly so. This is frequently attributed to the stringency of mining legislation; but legislation has also largely affected other industries, and the result cannot be altogether attributed to this cause. It would be a long task to enumerate the causes which, in the author's opinion, contribute to this result; but, broadly, it appears to him that what is required is to do in mining what has been done in every other department of industry—lower the cost of wages and material per ton by increasing the product per man and per pound of fuel by the following means:—(1) Improved organisation, both

* Cp. the Paper, meanwhile published, on "Longitudinal Light," *Wien. Ber.*, 104, Part 2A, p. 747.

† From a Paper read before the South Wales Institute of Engineers.

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scheme of working a colliery, and in the means for doing it; (2) more superintendence and supervision underground by thoroughly well-informed mining and mechanical engineers; (3) the greater use of mechanical power instead of human and horse labour, and more economical production of that power. In short, substitute brains and mechanical power for human labour.

It has been already stated that the immediate object of this Paper is to deal with the question of the economical production of power; but a few remarks on the subject of mechanical power in collieries may be useful. The getting of coal resolves itself into cutting and filling and hauling to the pit bottom. In the great majority of collieries both cutting and filling are done without any use of mechanical power whatever, and the progress made in introducing mechanical coal-cutters is slow, at all events in this country. A considerable experience, extending over some years, with coal-cutting machines in various collieries and various parts of the country justifies the author in saying that there are hardly any seams under 3ft. 6in. in thickness that could not be more cheaply worked by mechanical coal-cutters than by hand labour, and with a better product of round coal, but that in probably not 5 per cent. of the collieries of the country is the existing organisation of the filling and haulage sufficiently good to enable machines to be worked with that regularity which will make them pay. This is the secret of the otherwise unexplained fact that some few collieries have been and are worked by machinery with marked success, whilst the reverse holds good of the majority of cases in which it has been tried. Organisation and superintendence, those are the only secrets of cutting coal by machinery; till they are forthcoming, mechanical assistance in this direction must be postponed. In thin seams much might, no doubt, be done to apply mechanical power to reduce labour and breakage in filling the coal, but the same remark applies as to coal-cutting. The use of machinery in the coal face would so much reduce the length of face under work for a given output that the roads on to the face—being less in total length—could, without increased cost, be kept in a condition enabling mechanical haulage to be used right up to the face, doing away with horses and ponies altogether. These are some of the directions in which mechanical power may be looked for to profitably enable the output per man to be increased. But before this can be done much will have to be done to improve the general organisation both above and below ground. And this may well be commenced by the economical laying-out and conduct of the arrangements for the generation of power above ground. Consider the conditions under which this is at present carried out.

Generally speaking, when sinking operations are completed, a winding engine is put down. Subsequently, as the workings extend, haulage is considered, and some plant—either steam, compressed air, or electrical—is provided for this. Later, perhaps, pumping becomes necessary, and again a plant, perhaps, on another system is put in. There are various engines at the surface for the screening, repairing shop, and other purposes. All these are of uneconomical types; so there ensues, at every point, waste of heat and waste of steam, particularly when, as in some cases, separate boilers are put down for each plant. And the answer to any criticism generally takes the form: "Oh, fuel is so cheap at a colliery that it does not matter." Why is the fuel so cheap—that is, of such low value? Because it is so small—smashed in hewing, smashed in filling, smashed on the screens, due to imperfect methods and appliances at every point. But, at any rate, it is worth at least 2s. 6d. per ton, and it is estimated that from 5 per cent. up to even 10 per cent. of the total output by weight of the collieries is consumed at the surface, and this means, even taking the lower figure, about 9,500,000 tons, worth about £1,190,000 per annum. It has been stated by Mr. Forster Brown that the probable consumption of coal in colliery engines, taking an average, would be not less than 6lb. per horse-power hour. Taking this to refer to indicated horse-power, it is possible to produce the same power with 1½lb. of coal, or even less; hence it may be fairly said that there is a possible saving to be effected of 75 per cent., worth annually nearly £900,000. It would probably be well within the mark to say that the saving to be effected in labour of handling, and in the maintenance of boilers and appliances for consuming this, would be worth, say, 65 per cent. of the above sum, showing a possible economy of, say, £1,500,000 per annum, a sum equal to over 2 per cent. on the total value of the coal raised, or about 3¾ per cent. of the whole wages annually paid in the mining industries; and if the coal were raised unbroken, so that its value was equal to the average value of the coal sold, these figures would rise to 3 per cent. of the value of the total coal raised, or 6 per cent. of the wages paid. It may be stated at once that, to realise these economies, the power required must be produced by compound or triple expansion condensing engines, appliances almost unknown in colliery work, and to do this there is no doubt that the question resolves itself into the production of the whole power required at the colliery in one or at most two engines, and its distribution with as little loss as possible to the points where power is required. There are various methods of distributing power, but some of them are applicable only to particular cases, or in particular circumstances; the only two of general applicability are compressed air and electricity. Of these, while under favourable circumstances compressed air can be made to give a favourable efficiency, its application in mining is discounted by two important considerations of economy. To utilise compressed air with efficiency (1) the pipes must be free from leakage, (2) the air must be heated before being used. These two conditions are practically unrealisable, and hence the efficiency of air transmission in collieries is, and must necessarily be, low. The cost of plant and extended air-mains is also high. There is an advantage in compressed air that to some extent it admits of storage, and therefore the power-producing plant may be fully loaded, producing the average requirement, which, as will be presently shown, is considerably less than the maximum. With this one exception of storage, the advantage in point of view of efficiency as a means of distributing electric-motive power remains with electricity; and the economy of the cables compared with air-mains, and the facility for extension and alterations in the position of the machinery, make electricity an ideal means of distributing power.

There is, however, an objection to which I must refer—viz., the question of safety. This question of safety is one which, from the first introduction of electricity in mining, has been prominently before engineers; but it may be noted that among those who have had practical experience of its use in mines the objection is rarely raised. In a Paper read in 1891 before the Institution of Civil Engineers by the author, in conjunction with Mr. C. W. Atkinson, this question was somewhat fully dealt with, and certain conclusions were arrived at which time and experience have gone to prove the correctness of; but, as this question is to some minds still an open one, and as additional experience has added to the knowledge of the subject, it may be well to deal with it at some length. There are two distinct questions: (1) the safety of an electric motor, which may spark at the commutator; (2) the safety of a system of cables, which may be ruptured while carrying an electric current.

Dealing with the first of these, it has been shown from various considerations and by practical tests that with the amount of sparking which exists with electric motors of good construction it is impossible to ignite fire-damp, owing to the fact that the temperature is never sufficiently high, and it is only therefore in exceptionally abnormal circumstances, such as a brush falling out of its holder, or becoming displaced absolutely on the commutator, that the inflammation of fire-damp can be effected; and it has also been shown conclusively by experiment that there are in the market methods of enclosing either the whole machine, or the armature and commutator, or the commutator alone, which, even under these abnormal circumstances, entirely prevent either the access of fire-damp or the ignition of fire-damp outside the machine. Practical experience is in accord with experiment and with the principles named, and the author knows of no recorded instance where there has been any accident from the use of an electric motor in a coal mine. As regards the second point in the question of safety—viz., the possible breakage of a cable—this may be at once overcome if the cables are buried below the surface; but, as this method has the disadvantage of expense, and frequently of deterioration of the cable, we may consider the case of a cable hung from the walls or timbers. In this case, if the cable does break, the ends are quickly parted; the spark may continue for the fraction of a second, but it has been shown by the experiments of Messrs. Wüllner and Lehmann, at Aix-la-Chapelle, which experiments were accepted by the Prussian Fire-damp Commission, "that even violent sparks from rupture of the current, accompanied with the explosion of fragments of iron in a state of combustion, had no effect on the inflammation of fire-damp."

Considerable light has, in the author's opinion, been thrown on this question by the facts recently stated by Prof. Vivian B. Lewes. It appears that the ignition of fire-damp arises in most cases, not from the raising of the temperature to the ignition point of fire-damp, which is very high, but by the raising of it to the point of its decomposition with evolution of hydrogen, which, becoming ignited, eventually ignites the firedamp. This requires two things: (1) Time (and Prof. V. Lewes states that 10sec. is in some cases necessary); (2) the maintaining of a particular mass of gas in contact with the point where the heat is developed long enough to effect the operation quoted. Neither at the commutator of a motor, or in the case of a ruptured cable, are these conditions fulfilled. In the face of the facts and experiments and experience now at disposal, in the author's opinion, those who raise the objection to electricity in mining on the ground of safety ought to bring some proofs of that danger, if it is to receive consideration. Notwithstanding the extended use of electricity, these accidents do not occur, and, in the opinion of many well qualified to give it, the danger arising from electricity is less than that arising from safety lamps, and enormously less than that arising from almost any explosive agent now in daily use.

Having dealt with this question, it remains to be asked: Is the present position of power distribution by electricity such that we

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in the working and more especially in the original laying-out of the may use it with confidence for the whole of a power required at a colliery? The author's answer to this is, Yes. In support of this may be given the following facts. The largest engine at a colliery is the winding engine, and, supposing this to require to be capable of developing power at full speed of 1,000 H.P., which is an outside figure, this could be well replaced by two motors of 500 H.P., one on each end of the shaft of the drum, without gearing. There are numerous cases of dynamos and motors of this power working with ease and satisfaction and giving no difficulty whatever, and operated by ordinary mechanics with no more trouble than an ordinary steam engine.

Motors of smaller sizes are in use all over the world, and with universal satisfaction as to ease of manipulation and low cost of maintenance. Are the claims made for efficiency of electric distribution of power realised? On this point the author has examined carefully tests made by himself and by others on electric power plants and has arrived at this conclusion: while the efficiency of distributing electric power and its utilisation in the motors come up to that claimed, the efficiency of the production of electricity is not, as a rule, as high as is claimed, or as high as may be realised. The reason is this: sufficient account is not taken of the fact that the average load is considerably less than the maximum requirement. While the efficiency of electric generation—that is, the proportion between the electric power delivered to the cables and the indicated horse power of the engine—is as high as 86 per cent. at full load, it falls to 74 per cent. at half load and to about 58 per cent. at one-quarter load. The reason for this is to be found in the power the engine takes to drive itself. The engine is generally arranged to work with an economical cut-off at the full load or maximum power, and consequently is larger than necessary for all smaller loads. It should be arranged to work with an economical cut-off at the average power; then at a larger power, although the consumption of steam per indicated horse power would be somewhat larger, the mechanical efficiency would be so much better at the average load that considerable economy, and, indeed, the best possible result, would be obtained. The moral is to use engines with automatic expansion valves, permitting the engine, if a simple one, to work with a cut-off as late as one-half or five-eighths of the stroke when developing the maximum power, and working with a more economical grade of expansion at the average load.

To apply the principles advocated in this Paper, the method to be adopted should be as follows: when a colliery is opened, an estimate must be made of the power which will ultimately be required for the whole colliery. It need not be all provided for at once, but the arrangements must be such that what is provided will be worked at an economical load, and that by simple duplication it may be increased. Suppose an example is taken which may be considered to represent an average case, where there is no very heavy pumping.

Table of Power Required at a Colliery.

—	Max. power. H.P.	Aver. power. H.P.	Min. power. H.P.
Winding	700	225	0
Fan engine	60	60	60
Pumps (say)	50	50	50
Haulage	200	100	0
Lighting	20	10	10
Screens	20	20	20
Shops at surface	20	5	5
Capstans for waggon handling.	20	10	10
Total	1,090	480	155

The power required by the winding and haulage engines is what would probably be required in a colliery drawing about 1,500 tons per day, and the maximum power required by the winding engine is reckoned on the assumption that the weight of the ropes is unbalanced, and the average upon the assumption that the winding takes 40sec, and the unloading and loading 25sec. Variations will correspondingly affect these points, and must be made to suit each case. These powers are those required at the separate machines, and, if we take it that the loss in the cables at full load is 5 per cent., which will be ample, as the bulk of the power is not far from the source, and that at the average load and upwards the indicated power is $\frac{100}{86}$ of the power delivered to the cables—we get the following as the indicated power required at each load, which, assuming that the electric motor will transform only as much electric power into mechanical power as a steam engine would convert of indicated power into mechanical power, gives a direct comparison between the actual indicated power required if all the engines were worked direct from the boiler or by the distribution thus to be effected.

Indicated Horse-power of Generating Engines.

Maximum.	Average.	Minimum.
$\frac{100}{86}\times\frac{100}{95}\times 1{,}090$; $=1330$	$\frac{100}{86}\times\frac{100}{97\cdot5}\times 480$; $=572$	$\frac{100}{64}\times\frac{100}{95}\times 155$. $=255$

Now, it will be observed that the average power is 572 I.H.P., as compared with 480 I.H.P. actually required at the engines. But taking for the former Mr. Forster Brown's figure of 6lb., and for the latter 1½lb., the economy resulting is found from the fraction:—

$$\frac{6}{15\times\frac{47\frac{1}{2}}{480}} \text{ or } \frac{6}{1\cdot78} \text{ or } \frac{100}{9\,6}$$

not far differing from the possible economy spoken of early in the Paper. That such figures are realisable in practice is shown by the figures given in a Paper read before the North of England Institute of Mining Engineers by Mr. Alexander Siemens. Tests are there recorded where, with a plant considerably smaller than that here considered, a consumption of 2·62lb. per E.H.P. hour, equivalent to 2·25lb. per I.H.P. hour, was obtained; and in the discussion on the same Paper reference was made by Mr. D. B. Morison to a plant using 2lb. coal per E.H.P. equivalent to 1·72lb. per I.H.P. The use of triple-expansion instead of compound engines would further reduce this to the figures named above.

The writer is aware that in thus advocating the generation of the whole of the power in one engine or pair of engines he is advising a very radical departure from existing and well-tried methods; but the advantage in economy is so great that, in his view, a revision of method must take place, and in any case the subject is well worthy of consideration and discussion.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January 3, 1896.*

Acetylene Gas.—The financial interests which control the Willson patents on the production of carbide of calcium and acetylene gas have apparently been very successful in disposing of local rights. A strong company just formed has purchased rights for New York and neighbouring cities, and the gas magnate of Boston, Mr. J. Edwards Addicks, has acquired the exclusive rights for that city. The parent concern, the Electro-Gas Company, claims that calcic carbide can be produced at the rate of $15 per ton, and acetylene gas itself at $37.50 a ton. This estimate is based upon a cost of $6 per day of 12 hours for 180 electrical horse-power, and otherwise merely included labour and the cost of raw materials. Even the above price is a considerable advance over the claims first made by the original Willson Company, which placed the cost at $5 to $6 per ton. As the validity of the Willson patents is very doubtful, it is considered surprising that those exploiting them have met with such great success.

An Interesting Strike.—The trolley strike which ended in Philadelphia last week developed several features of interest. Owing to the action of the Union Traction Company in ceasing to grant free transfers, as had been the custom of the separate companies of which it was recently formed, the public had become very much incensed against it. As a consequence the strikers had the full sympathy of the people, who even went so far as to refuse to patronise cars run by non-union men. The strikers hired many hundreds of teams for use during the morning and evening hours of travel and transported passengers for five cents, the usual street-car rate, granting transfers from one wagon to another. The result was as might have been foreseen—the street railroad company being compelled to come to terms.

Difficulties in Polyphase Working.—It is reported that some difficulties are being experienced in the operation of some of the polyphase plants recently installed in this country. While no definite information can be obtained, it appears that the trouble arises from the fact that if a close balance is not kept among the several polyphase circuits very unsatisfactory results in working are obtained. There is a rumour that in one large station where polyphase machinery was installed, the original machines will be replaced by simple alternators with shafts rigidly coupled in such a manner as to produce the necessary difference of phase between the currents from the several alternators thus disposed.

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PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *Jan. 14, 1896.*

The Laval Steam Turbine.—At the meeting of the Société Internationale des Electriciens on the 8th inst., M. Fayot read a Paper on the latest results obtained from the trials of the Laval steam turbine. A 50 H.P. turbine was tested at a steam pressure of 5 kilogrammes per square centimetre (71lb. per square inch) and gave a consumption of 10·58 kilogrammes of steam per horse-power hour. Two other trials, made at the Bordeaux Exhibition at full load (100 H.P.) for seven hours at a boiler-pressure of 8 kilogrammes (113lb. per square inch) and a vacuum of 66 centimetres in the condenser, resulted in a consumption of 9·16 kilogrammes of steam per horse-power-hour. With a load of 50 H.P. there was a consumption of 10·8 kilogrammes of steam. A third trial after nine months' use resulted in a consumption of 8·9 kilogrammes per horse-power-hour on a 10 hour trial. A fourth test at Troyes on a 20 H.P. turbine driving shafting which drove four dynamos gave a consumption of 8·9 kilogrammes of steam, the pressure being 5 kilogrammes (71lb. per square inch). In a fifth trial made with a 75 H.P. turbine at the Magasins de la Place Clichy, with a steam pressure of 12 kilogrammes (170lb. per square inch) and a 65-centimetre vacuum in the condenser, the consumption was 10·5 kilogrammes per horse-power-hour. M. Fayot then touched the question of the variation of the steam consumption with the output and the number of nozzles. M. Hillairet asked what the consumption was on starting. M. Fayot replied that it was 30 to 35 per cent. more than the normal amount. M. Arnoux observed that it was quite possible to show why the efficiency was greater with larger turbines: it was due to the fact that the speed of the vanes was greater with large turbines; in turbines of 200 H.P. this speed was 400 metres per second, whilst in 75 H.P. turbines it was only 60 metres per second.

The Blot Accumulator.—At the same meeting of the Société Internationale des Electriciens M. d'Arsonval gave some particulars with regard to the Blot accumulator. He commenced by short-circuiting two 100-ampere cells and reddened a piece of wire, the experiment lasting during the reading of his Paper. These accumulators are of the pure Planté type and present a surface of 1·2 sq. metre for every three kilogrammes of plate. M. d'Arsonval gave the results of his own tests and of some made by Mr. Preece in London in February, 1895, and early this month. An accumulator was short-circuited for 10 minutes, and gave 200 amperes. It was then discharged, charged and discharged at the rate of 1 ampere per kilogramme. It gave a capacity efficiency of 79·2 per cent., and an energy efficiency of 64 per cent. No mud was observable at the bottom of the vessel, and the plates were in a perfect condition. Other tests gave capacity and energy efficiencies of respectively 84 per cent. and 78 per cent. Capacities of from 10 to 12 ampere-hours per kilogramme were obtained. M. d'Arsonval remarked that he was much struck with the way in which these accumulators retained their charge. For instance, a battery which was charged on July 4th was only discharged on October 24th, and next to none of the charge had been lost. Again, two cells were put on short circuit for 24 hours without injury. These qualities, he thought, would make these accumulators valuable for the Concarneaux laboratory, which is on the sea coast, and where wind is used to drive the dynamo to charge the accumulators, and where the cells may therefore be subjected to very trying rates of charge and discharge. In reply to Lieut. Darrieux, M. d'Arsonval gave the following figures:—

Rate of discharge.	Efficiency.
1 ampere per kilogramme.	89% in ampere-hours.
2 ditto.	75% ditto.
3 ditto.	68% ditto.
5 ditto.	50% ditto.
516 ditto.	45% ditto.

Electric and Gas Lighting in Paris.—The Auer burner has proved a serious competitor with the electric light in Paris, though some people find it as expensive as others find it economical. At the present moment there is much talk of the Denayrousse burner, which consists of an ordinary gas burner combined with a small electric air pump, which sucks in the air and forces it through the flame under pressure. The usual candle-power of this burner is about 30 to 40 carcels for a consumption of 10 litres per carcel-hour. In spite of competition, however, the electric light, notwithstanding its high price, continues to progress, and reductions of tariff are in contemplation.

Honours for French Electricians.—At the last meeting of the Société Internationale des Electriciens, M. Hospitalier announced the following "décorés":—Commanders: MM. Loewy, Marey; Officers: MM. d'Arsonval, Joubert, Leaute; Chevaliers: MM. Brylin, Guillaume.

CORRESPONDENCE.

THE AUDIT OF ELECTRIC LIGHT COMPANIES ACCOUNTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: From your Note on this subject commenting on Mr. Morse's very fair letter you seem to assume that under a sensible dispensation either the Board of Trade audit or that by the auditors of a company—you do not say which—could be done away with. May I be permitted to remind you that the expense of a Board of Trade audit (which is absolutely unnecessary and useless for the company) has been imposed upon companies by Act of Parliament, and that the audit of accounts generally is required in the interests of shareholders, and that a Government Department cannot undertake the responsibilities and duties towards shareholders that are expected from the auditors of companies. Naturally I have no objection to the audit by the Board of Trade in the interests of the local authorities being done away with, but this, which is, I fear, quite a work of supererogation so far as the company is concerned, cannot be done, having regard to the condition of the law.—Yours, &c., AUDITOR.

"BAR" AND "TROLLEY" CONTACTS ON ELECTRIC TRAMWAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your editorial remarks on the above subject, with reference to my recent investigations, published in your issue of last week, you say: "From an æsthetic point of view, the demerits of the 'bar' and 'trolley' methods are about equal; the former involves the uglier car, the latter the uglier overhead construction."

I fully agree that no overhead contact system can ever, in the strict acceptation of the term, be æsthetic; but as regards the car, may I, in cheap verse, observe that

A somewhat unæsthetic bar
May surmount a pretty car?

In proof thereof I enclose an illustration of the cars in use at Bale, these cars having, it is true, no outside seats. It is those latter which make the cars so monstrously unsightly, more especially when, in addition, they are roofed for the purpose of protecting passengers against the contingency of a shock from the overhead wire or contact piece. Riding outside is very pleasant as long as the speed does not exceed that of a jog-trot horse-car or omnibus, viz., about eight miles per hour; but when, on electric lines in suburban and country districts, a speed of 15 miles is attained (for several lines in which I am concerned a speed of even 20 miles between stations has been authorised), the effect of outside riding, especially in inclement weather or against a strong head-wind is somewhat too exhilarating, and on such lines cars with only inside seats and end platforms, carrying from 50 to 60 passengers, will not only fully accommodate the traffic but also have a pleasing appearance.—Yours, &c.,

C. S. DU RICHE PRELLER.

18, Margaret-street, Cavendish-square, W.,
January 15, 1896.

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OVER-PRODUCTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your leading article on "Over-production" in last week's issue, I have always maintained that, in the long run, it is conducive to the spread of applied electricity to encourage electrotechnical education as much as possible. The larger the number from which the best men are selected by the inevitable process of competition, the better. The unfit go to the wall, but they carry the light of their knowledge into other professions and callings, and public apathy as regards electrical matters is thus gradually undermined.—Yours, &c.,

W. PERREN MAYCOCK.

Croydon, January 11, 1896.

POLICE INTELLIGENCE.

On Tuesday, before the Common Serjeant, at the Central Criminal Court, James Fenton Whelan, 25, a clerk, late in the employ of Messrs. Nalder Bros. and Co., electrical engineers, of Red Lion-street, Clerkenwell, pleaded guilty to charges of forging and uttering the endorsements to orders for the payment of various sums of money, and also to stealing the money of his employers. Mr. Grain prosecuted, and Mr. Lambert watched the case for the prisoner.

In stating the facts of the case Mr. GRAIN said the prisoner had been in the employ of the prosecutors as a clerk, and it was his duty to disburse small accounts out of the petty cash. Mr. Wm. Henry Haigh, of 15, Wilmington-square, Clerkenwell, had an account owing from the firm in November last, and on November 20th he made an entry, showing that he had paid the account, which was for £2. 5s. 6d. He produced a receipt which turned out to be a forgery. On a further investigation of the accounts it was discovered that a cheque for £2. 14s. 6d., which had been drawn by the firm in payment of an account due to a Mr. Turnbull. This cheque the prisoner endorsed and cashed, as he did also a cheque for £3. 13s. 6d. drawn in October in favour of the same firm. The receipted accounts were forgeries, as were two other accounts for small sums alleged to have been paid the same firm. The prisoner had been in the service of Messrs. Nalder Bros. for about twelve months, and his defalcations extended over a period of three months. When given into custody the prisoner begged that he might not be prosecuted, stating that it was not his fault, and that he had no intention to defraud; but the matter was so serious that the firm could not overlook it.

In reply to the Common Serjeant, Mr. GRAIN said the prisoner's total defalcations amounted to about £35.

The COMMON SERJEANT said he would deal with the case as one of embezzlement, and not as one of forgery; but the prisoner had committed a very serious offence. He seemed hitherto to have been a man of good character, and he appeared also to have been in receipt of what he could not but regard as an adequate salary. The adequacy of a salary, no doubt, depended very much upon what a man had been accustomed to, and persons employing others must be protected from such fraud as the prisoner had been guilty of. He must pass such a sentence as would prevent the prisoner again engaging in such proceedings, and a sentence, also, which would deter others in the same employment from following his example. The prisoner would be sentenced to six months' hard labour

BOOKS RECEIVED.

"Dynamo Electric Machinery." By Silvanus P. Thompson, F.R.S. Fifth Edition, Revised. (London: E. and F. N. Spon.) Price 24s.

"Elektro-Metallurgie." By Dr. W. Borchers. (London: Williams and Norgate.) Vol. II. Price 8s.

"Hazell's Annual for 1896." Edited by W. Palmer, B.A. (London: Hazell, Watson and Viney, Limited.)

"Munro and Jamieson's Pocket Book." By John Munro and Andrew Jamieson. (London: Messrs. Charles Griffin and Co., Limited.) Eleventh Edition. Price 8s. 6d.

"Lockwood's Builder's and Contractor's Price Book for 1896." Edited by Francis T. W. Miller. (London: Messrs. Crosby, Lockwood and Co.) Price 4s.

"The Intellectual Rise in Electricity." By Park Benjamin. (London: Messrs. Longmans, Green and Co.) Price 21s.

"Electricity and Magnetism." By G. C. Foster, F.R.S, and E. Atkinson. (London: Longmans, Green and Co.) Price 7s. 6d.

"Die Spectralanalyse." By Dr. John Landauer. (Brunswick: Friedrich Vieweg and Son. 1896.) Price 4s.

"An Electric Spark." By G. Manville Fenn. Second edition. (London: Methuen and Co.) Price 6s.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is in active preparation, and will be ready at the end of January. Orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. Full particulars post free on application.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES *can be obtained of the Booksellers or direct from the Publishing Offices:—*

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

CORRECTION.—By a slip of the pen in our issue of Jan. 3rd a Trade Note, referring to the bankruptcy of Messrs. Smeaton and Bennett, electrical and general engineers, of 135, Minories, E., was made to read Smeaton and Page. This has, we learn, caused some annoyance to Mr. Page, who trades under the name of Smeeton and Page, electrical engineers, at 163, Queen Victoria-street, London, E.C. We very much regret that such a clerical error should have occurred, and should have caused Mr. Page any annoyance. The announcement should have read: "Mr. W. Izard, 52, Gracechurch-street, E.C., has been appointed trustee in the bankruptcy of Smeaton and Bennett, electrical and general engineers, 135, Minories, London, E." We need scarcely add that the announcement in no way related to the firm of Smeeton and Page, electrical engineers.

TENDERS INVITED.—The Corporation of Birkenhead invite tenders for the wiring of the Town Hall, it having been decided to light the same by electricity. Plans, &c., can be seen, and specifications obtained, at the Town Clerk's Office, Town Hall, Birkenhead, or of Mr. James N. Shoolbred, 47, Victoria-street, S.W. Tenders must be sent in to Mr. Alfred Gill, Town Clerk, Town Hall, Birkenhead, by noon of Thursday, the 23rd inst. Some further particulars are given in our advertisement columns.

——— Tenders are invited until the 22nd inst. by the Roumanian State Railways in Bucharest for the supply of 27½ tons of galvanised iron wire.

——— Tenders are invited until the 30th inst. by the General Direction of French Posts and Telegraphs, 103, Rue de Grenelle, Paris, for the supply of 53,230 prepared telegraph poles.

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TENDERS INVITED.—The municipal authorities of Tuy invite tenders for the concession for the electric lighting of the town during a period of 20 years. Tenders to El Ayuntamiento de Tuy (Pontevedra), Spain.

——— The Hanover Direction of the Prussian State Railways require tenders by the 20th inst. for 191¾ tons of telegraph iron wire, 194 tons insulated wire, 33,000 porcelain insulators, and 1,400 insulator supports. Tenders to Königliche Eisenbahn Direction, Joachimstrasse No. 7, Hanover.

——— The Municipal Authorities of Parma require tenders by February 25th for the electric lighting of the town for a period of 15 years, commencing June, 1897.

——— The District Council of Swadlincote (Burton-on-Trent) invite tenders for the lighting by electricity of the thoroughfares of the township of Stanton. Particulars can be obtained from Mr. R. Cartwright, surveyor. Tenders must be in by the 27th inst.

TENDERS ACCEPTED.—Messrs. F. A. Glover and Co., of Queen Victoria-street, E.C., inform us that their tender for the electric lighting of the Agricultural Hall has been accepted. In addition to the incandescent lighting, 45 arcs, together with large mains for supplying current to the various exhibitions, are to be supplied.

——— The Gas and Electricity Committee of the Bolton Corporation have accepted the tenders of Messrs. S. Z. de Ferranti (Limited), for an additional alternator at the electricity works, and the tender of Messrs. Hick, Hargreaves and Co. for a new engine.

——— The following tenders have been accepted by the Yarmouth Town Council in connection with their electricity works: Additions to the electric lighting station—Mr. Bray, £1,146 (lowest tender); Messrs. W. J. Crampton and Co., a Davey-Paxman engine and 150-kilowatt alternator, £1,593; Crompton and Co., steam pipes, £289 10s; Babcock and Wilcox, pair of 250 H.P. boilers, £1,457 6s.

SALE BY AUCTION.—Wednesday, the 29th, has been fixed for the sale by auction, by Messrs. Wheatley Kirk, Price and Goulty, of the entire contents of the works premises known as the Electrical Works, Acton Hill, London, W. The sale commences at 10 for 11 o'clock prompt, and includes boiler, engines, shafting, fixed plant and machinery, loose tools and utensils, patterns and drawings, stock, stores, office furniture, &c. The boiler is a 50 H.P. loco.-type semi-portable by Davey, Paxman and Co., and the engines includes a Davey-Paxman 40 H.P. and a 17 H.P. "Premier" gas engine.

APPOINTMENTS VACANT.—The Government of Queensland, Australia, require applications for the post of Electrical Engineer to the Government, whose duties will be to advise the Postal Telegraph Department upon all matters connected with the telegraph, telephone and cable systems of the Colony. The salary will be £600 per annum, with travelling allowances. Further information can be obtained from the Agent-General for the Colony, 1, Victoria-street, London, S.W., and applications have to be sent in to the Agent-General by Monday, March 2nd. Some further particulars are given in our advertisement columns.

——— The Lighting Committee of the Wolverhampton Corporation invite applications for the post of assistant and draughtsman to the borough electrical engineer; commencing salary £100 per annum. Applications to Mr. F. Harman Lewis (borough electrical engineer), Town Hall, Wolverhampton, by the 23rd inst. Some further particulars are given in our advertisement columns.

——— The City Engineer's Department of the Liverpool Corporation require a senior assistant in the drawing office. Commencing salary £175 per annum. Applications must be sent in to the City Engineer, Liverpool, by Friday, the 31st inst.

APPOINTMENT.—Mr. E. E. Hoadley has been appointed an assistant electrician to the Islington Vestry Electricity Works.

ENGINE DRIVER WANTED.—The Vestry of St. Mary, Islington, require, for their electric lighting station at Eden-grove, an engine driver with large experience in driving stationary engines, preferably for electric lighting purposes. Some further particulars are given in our advertisement columns.

SALES REPRESENTATIVE.—We are informed that Mr. J. F. Poynter, of 15, Seething-lane, E.C., has been appointed sales representative for the Cruto Incandescent Lamp.

LIQUIDATIONS.—An order has been made, upon the application of Mr. Cecil Mercer, Official Receiver, of 95, Temple-chambers, Temple-avenue, E.C., that Ronald A. Scott, Annie Scott, Herbert K. Reeves, George Heaver, Godfrey Wolley, James Herbert Garrett, T. H. J. Watts and James Damer do attend to be publicly examined at the Town Hall, Brentford, on Friday, the 24th inst., at 2 o'clock.

——— We have received a summary of the liquidator's accounts in the matter of the London Metallurgical Company (Limited), which shows, after payment of Court fees and costs, a credit balance of £748. 18s. Mr. D. J. Stewart Boyle, 91-93, Palmerston-buildings, E.C., is the liquidator, and will furnish any further information required by creditors and contributories.

LIQUIDATION.—A motion came before the High Court on Tuesday for the appointment of a receiver and manager of the business of the Mersey Rubber Company (Limited). After hearing the arguments the judge appointed Mr. Mather, chartered accountant, of Bolton, receiver and manager.

LEGAL.—The case of the Gulcher (New) Electric Light and Power Company *v.* Murray came before Mr. Justice Vaughan-Williams yesterday (Thursday) on an application by the liquidator of the Company for an order of the Court calling upon Mr. James Murray to pay calls upon 300 Preference shares which it was alleged had been duly allotted to him. The respondent admitted that he agreed to take the shares, but only upon condition that at least 10s. was paid up on an issue of Preference shares. His allegation was that the condition precedent had not been carried out, and that therefore he was not liable. Judgment was reserved till this (Friday) morning.

TELEGRAPH MATERIAL FOR AUSTRALIA.—Messrs. Felten and Guilleaume, of Carlswerk, Mulheim-on-Rhine, have secured an order for 60 tons of copper wire, 120 tons of galvanised iron telegraph wire, and 20 miles of insulated copper wire for the New South Wales Posts and Telegraph Department.

TELEGRAPHIC WIRE AND APPARATUS.—There was a revival in the export trade of this country in telegraphic wire and apparatus connected therewith during last month, the exports reaching £296,145, compared to £70,459 in the previous month, and £41,152 in the corresponding month of 1894. The returns for 1895, however, are the smallest for several years past, amounting to £789,810, against £1,386,614 in 1894.

TELEPHONE TRUNK LINES.—The following towns are now connected with telephone trunk lines by means of which communication can be made between Post Office and National Telephone subscribers, or *vice versâ*, on payment of the fees: Belfast, Birmingham, Brighton, Bristol, Cardiff, Chelmsford, Colchester, Dublin, Edinburgh, Exeter, Glasgow, Hexham, Hull, Ipswich, Leeds, Leicester, Liverpool, London, Manchester, Morpeth, Newcastle-on-Tyne, Newport (Mon.), Nottingham, Nuneaton, Plymouth and Sheffield.

TRADE IN 1895.—Messrs. Bennett and Druce, of Preston, report a moderately busy year, with improved trade prospects for 1896. The installations carried out by the firm during 1895 include St. Joseph's Catholic Church, Preston, which has a gas engine plant, with storage batteries, and includes an electric organ blower; 600 incandescents and several arc lights for the new sheds at the Salford Docks, a motor installation at the offices of the *Preston Herald*, an electric heating and ventilating system for the Preston Industrial Co-operative Society, and also a 10 H.P. hoist. This firm's speciality is the installation of the electric light in cotton mills, and nearly 10,000 8 c.p. lamps have now been fixed in these mills by Messrs. Bennett and Druce. The firm complain of a somewhat reckless cutting of prices in the Manchester district, but report that the general tendency seems to be towards better work and fairer prices.

"EXPORT MERCHANT SHIPPERS' DIRECTORY."—We have received from Messrs. Dean and Son (Limited), of 160A, Fleet-street, London, a copy of the above publication, which is in its 31st year. The price of the Directory is 15s., and to all interested in exporting the book should prove of great value. The contents include a list of the consuls of foreign States in London, shipping and forwarding agents, steamship lines and navigation companies, chambers of trade and commerce, very complete information regarding Lloyds' signal stations, agents, &c., excise allowances and drawbacks, tariffs, &c., and an alphabetical list of merchants with their respective trade ports and class of goods shipped. In addition there is an alphabetical list of places of shipment. Nearly 1,400 large 8vo pages are packed with information of service to traders generally.

CALENDARS.—The Calendars for 1896 show a more than usual variety. We have received from the Sandycroft Foundry and Engine Works Company a well-printed hanging sheet calendar, with illustrations showing the special types of mining and electrical machinery made by the Company, including the "Keith" electric locomotive for carrying and hauling, of which a good view is shown.——The Chloride Electrical Storage Syndicate send a neat little watch-pocket calendar and memorandum book, which, being strongly bound, is useful as well as ornamental.

ABERDEEN.—Considerable interest was evinced in the Aberdeen Fish Market last week on the arrival of the "Campania," a Hull trawler, which put into Aberdeen to discharge. The trawler is one of the few fishing boats which may be termed up-to-date. It is fitted throughout for the electric light, and her catch was discharged at Aberdeen under the beams of electricity to the astonishment of a large crowd of on-lookers. The "Campania" has been fitted out by Messrs. Clarke, Chapman and Co., of Gateshead-on-Tyne.

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AMBLESIDE.—The result of the correspondence between the District Council and the Board of Trade on the question of the application of the Windermere and District Electric Supply Company for a Provisional Order to light this district electrically is a notification from the Board that, in order to successfully oppose the Company's application, it will be necessary for the Council themselves to apply for an Order.

ASHTON-UNDER-LYNE.—The Town Council are considering the desirability of erecting a refuse destructor station in conjunction with their proposed electric light works. It has been decided to insert advertisements in the local newspapers inviting tradesmen and ratepayers to state whether they would be prepared to adopt the electric light if produced and supplied by the Corporation at a charge not exceeding 8d. per unit.

BATTERSEA (LONDON).—In response to the invitation of the Battersea Vestry, offering premiums to consulting engineers and contractors for the best schemes, reports, designs, plans and estimates for lighting the district by electricity, 21 such schemes have been received, and are now under examination by Mr. Robert Hammond, who has been appointed by the Vestry their electrical adviser.

BOLTON.—At the last meeting of the Gas and Electricity Committee a number of applications for the extension of the electric light mains were before the Committee.

BRADFORD.—Mr. W. C. Dixon on Tuesday presented the minutes of the Gas and Electricity Supply Committee, which included a resolution to purchase two plots of land, a portion of which is required for the purpose of extending the Corporation's electricity works. Another resolution invited the Council to authorise the provision of additional engines and plant at an estimated cost of £11,000, and to apply to the Local Government Board for the necessary borrowing powers. Mr. Dixon stated that the present supply station was quite inadequate for the requirements of the borough, and the proposed site was the most desirable from every point of view. They would be able to put down plant upon the triple-expansion principle and upon the surface-condensing principle. A beck ran through part of the land that would supply the necessary water for condensing purposes, and would be easy of approach. The Committee had been called upon during the past year for much more electric current than they had been able to supply. They had even had to ask the Corporation to allow them to cut off the supply of current to the Town Hall and the markets. Owing to the sanction for new plant, which the Committee asked for last year, not being granted in time, it was so late before the new engines and boilers could be got to work that it was impossible to cope with the demand. The extensions were estimated to cost a total of about £31,000, of which £22,000 would have to be met during the present financial year. The proposed new machinery consisted of two new 600 H.P. triple-expansion engines and the requisite dynamos. He was glad to be able to report that the electricity plant, so far as it had been established, had returned 9 per cent. upon the outlay, and after paying the interest and sinking fund, left a net profit of 3 per cent. The proposed new plant would nearly double the horse-power output of the works (5,200 H.P. against 2,800). Even if immediate sanction were given to the Committee's proposal, it would take seven months to get the engines and six months to get the dynamos and boilers, and therefore the Committee would have all their work cut out to get the new machinery into working order for next winter. Mr. Speight, who supported the Committee's proposal, complimented them upon looking from 10 to 20 years ahead, although he believed that by the use of electric motors for power purposes the demand would overtake the supply within a much shorter period. Mr. Dixon, in reply to a number of questions, said that when the new plant was erected, they would have a voltage of 500 to deal with, which would enable them to supply the remotest parts of the borough with electric current. The minutes were finally approved.

BRAZIL.—By a telegram dated January 3rd last, Her Majesty's Minister at Rio de Janeiro states that the revised Brazilian Customs tariff raises the duties by one-third, and that there are now no differential duties on British commerce.

BRISTOL.—At the meeting of the Electric Lighting Committee on Friday last extensions of the mains to Small, Quay and Nelson-streets were agreed to. It was also decided to order another alternator from Messrs. Siemens Bros. and Co. Since December 30th, 1,400 lamps have been connected.

BRIGHTON.—Mr. Arthur Wright, borough electrical engineer, presented at last night's meeting of the Council a report in which he recommends extensions of the public electric lighting to a number of additional thoroughfares. Mr. Wright recommends similar sets of 5·7 ampere lamps such as those now being erected in other parts of the town, and for the remaining streets the placing of incandescent lamps in all the street lanterns in proximity to the distributing mains in a similar manner to those in use in St. James's-avenue, where the experiment of electric lighting of side streets has been successfully tried for about 12 months. Mr. Wright sets out the reasons for these recommendations as follows:—

1. The increased illumination of the streets can be more economically effected by using electricity than by increasing the consumption of gas.

2. By electrically lighting these streets a very profitable long hour load would be put on the Corporation distributing mains and plant, which are at present practically idle after eleven o'clock at night.

3. The Lighting Committee would have the immediate control of the lighting of about 20 miles of the most important streets of the town.

4. A profit of about £1,200 per annum would accrue to the Corporation by the electricity undertaking supplying the necessary current on the present tariff.

5. The public will have the fact constantly before them that an electricity supply is available in all the streets electrically lighted.

Mr. Wright has prepared an account of the annual cost, which provides for a 50 per cent. extra candle-power over existing gas lamps, and estimates that the whole of the work can be completed by the middle of September next for a sum of about £8,000. 589 existing street gas standards are affected by the proposal. The Lighting Committee of the Corporation recommend that Mr. Wright's report be approved and acted upon forthwith, and that he be instructed to prepare specifications, upon which tenders are to be invited.

DEWSBURY.—The Corporation have decided to reduce the charge for electric current for motive power, cooking and heating purposes to 4d. per unit.

EDINBURGH.—The Joint Committee of the Cleaning and Lighting and Electric Lighting Committees of the Town Council have decided to recommend extensions of the public lighting by electricity, which will require about 230 additional lamps, the cost of which is estimated at over £4,000.

EXHIBITIONS.—The Foreign Office authorities have notified the Science and Art Department that an international exhibition is to be held at Brussels in 1897. The exhibition will comprise 14 sections, including Industrial and Decorative Arts, Lighting and Heating, Electricity—Traction, and Industrial Manufactures—materials, methods and products.

FACTORY LIGHTING.—The electric light has recently been installed in the Harrington Lace Factory, at Long Eaton. The machinery has been supplied by Messrs. J. H. Holmes and Co.

FAREHAM.—Electric lighting matters progress slowly, and the relations between the Company and the members of the District Council seem to grow more embittered as time goes on. The *Portsmouth Times* makes a very sensible suggestion that some gentleman of light and leading should be invited to mediate between the parties. The Company's offer to compromise the matter is now directly before the Council, who are invited to come to an arrangement promptly.

FIRE ALARMS.—A labourer named Crook was fined £10, with the alternative of six weeks' hard labour, for breaking the glass face of an electric fire alarm. Mr. Corser, the magistrate, described the offence as silly, mischievous and wicked.

GLASGOW TRAMWAYS.—The tramway cars of the Glasgow Corporation, which have been lighted for some time past by electricity, are now lighted with oil lamps, and a small committee has been appointed to consider and report as to the best method of lighting the cars. In commenting upon the subject of the electric lighting Mr. W. Paton, who moved the adoption of the Tramways Committee's minutes at the last meeting of the Corporation, said that there could be now no doubt that the Froggatt Electric Lighting Company (now in liquidation) had taken a contract which it was quite apparent they were unable to carry out. The contract had all through been very unsatisfactory, and the Committee were now in the position that for a time they must discard the electric light. They were extremely sorry to do this. Mr. Primrose strongly advised the Corporation to take over the lighting of the cars themselves, and Mr. Paton replied that this point was receiving attention.

HANLEY.—At the meeting of the Town Council on Tuesday, the Town Clerk reported the effect of the Potteries Extension Tramways Provisional Order, promoted by the North Staffordshire Tramways Company, which empowers the promoters to supply electrical energy for power only, for public and private purposes, and the General Purposes Committee recommend that representation be made to the Board of Trade objecting to the Company obtaining power to supply electrical energy for private purposes within the borough without the consent of the Council. A letter from Mr. Carruthers-Wain was read, stating that he had advised the insertion of a clause in the agreement providing for purchase by arbitration, instead of upon the terms of 5 per cent. reduction on the original cost. The letter also stated that the proposal in the Provisional Order empowering the promoters to supply electrical energy for private purposes did not apply to Hanley, but to the other towns in which the authorities did not provide electrical power. The Committee's recommendation was confirmed. The price of electric current

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has been fixed at 6d. per unit up to a certain consumption; beyond this quantity 3d., and 4d. for places of worship, &c., requiring current on Sunday evenings only. Alterations were also made in the discounts allowed.

HYDE PARK (LONDON).—By order of the First Commissioner of Works, an electric arc light has been placed experimentally opposite the Marble Arch within Hyde Park. This step has been taken after consultation with the police authorities. Should the experiment prove a success, it is proposed to light with similar lamps the footpath between the Marble Arch and Albert Gate, a much-frequented route, and also to place another row round the band-stand, for use during the summer months. The *Daily Telegraph*, in making this announcement, says: "The public will give to this official intimation a cordial welcome. The electric light will not only add to the beauty of the park in the summer twilight, but will also materially alleviate the winter disadvantage of darkness, which often entails inconvenience on those who are compelled to traverse the park."

IPSWICH.—It has been decided by the Town Council to oppose the application of the County of London and Brush Provincial Company for an Electric Lighting Provisional Order, and to consult Prof. A. B. W. Kennedy on the subject generally.

KIRKCALDY.—At the meeting of the Town Council on Tuesday, on the motion of Councillor Hutchison, a Committee was appointed to make the necessary inquiries regarding the installation of the electric light at Kirkcaldy, and to report to the Council.

LAMBETH (LONDON).—Those members of the Vestry who were favourable to the supply of electric current being undertaken by the parish have been defeated, and we understand, the Vestry will now not oppose the application of the County of London and Brush Provincial Company for a Provisional Order, subject to certain conditions being inserted for the satisfaction of the Vestry.

LECTURES.—Prof. J. A. Fleming delivered an interesting lecture at the London Institution, Finsbury-square, E.C., yesterday, on "Experiments with Incandescent Lamps."—At the Polytechnic Society, Liverpool, on Monday, Prof. Hele-Shaw delivered a lecture on "The Hydro-Electric Installations at Niagara." The lecturer pointed out that so far back as 1885 no less than 10,000 H.P. was actually taken from the Falls for motive power purposes in the mills in the neighbourhood. The lecture was fully illustrated, and greatly interested a large gathering of members.

LLANDUDNO.—A discussion arose at the meeting of the District Council on Wednesday on a resolution to rescind a previous resolution of the Council on the subject of electric lighting, and empowering the Electric Lighting Committee to obtain a report on the subject from Messrs. Kincaid, Waller and Manville. It was now resolved that Mr. W. H. Preece be asked to report to the Council on the electric lighting subject generally, or, failing him, Dr. E. Hopkinson, whom failing, Messrs. Kincaid, Waller and Manville be asked to prepare a report.

LURGAN (IRELAND).—The Town Commissioners recently received a proposal from Mr. E. H. Walsh, an electrical engineer of Belfast, to light the main street electrically. It was proposed to erect 16 arcs between William-street and Queen-street. The cost of the plant is put at £478, and the annual cost of maintenance at £90. The matter has been referred to the Gas Committee.

NEWCASTLE-ON-TYNE.—At Wednesday's meeting of the City Council the report of the deputation which recently visited Bristol and Birmingham, in connection with the system to be adopted on the Newcastle tramways, was received. The Committee recommend that in order that the Council may be able, should it be decided to do so, to adopt electricity upon all or any of their tramways, application should be made to Parliament for additional provisions to be inserted in the Bill now before Parliament, which would include those sections of the tramways not now included to be worked by electricity; that in the meantime the matter be referred back to the Town Improvements Committee, to which additional members should be added, in order that the best means of working the entire system of tramways within the district should be considered and reported upon. A meeting of the ratepayers was announced to be held the next evening, and the Mayor recommended that, should it be decided to reject the report of the Committee, he should suggest that the Council's Tramways Bill be withdrawn. Mr. Alderman Winter, a member of the deputation, said they saw the overhead system at Bristol, and he would say at once that there could be nothing better. They were not sufficiently conversant with the working to come to a conclusion. The Tramway Company at Bristol seemed fully alive to their business; but he thought that if anyone would compare the streets of Newcastle with those of Bristol they would not hesitate to condemn the overhead system. On the contrary, Mr. J. Fitzgerald was of opinion that from what he had seen the electric trolley system, as applied at Bristol, would suit Newcastle admirably. Mr. T. Waller said that after his visit to Bristol and Birmingham he was convinced that the electric system was the best; and, more than that, it should be remembered that electrical engineering work was continually improving. Other members announced that they had come back converted, or confirmed in their preference for the cable system. Ultimately the report of the deputation was approved by 31 votes to 16. At the public meeting subsequently held, at which 2,000 were present, a resolution in favour of the Bill before Parliament with the proposed modification was lost, but a poll was demanded by a solicitor present, and this is to be taken. There are 36,647 voters on the municipal roll who will have an opportunity of declaring for or against the Corporation's scheme.

NESTON AND PARKGATE (CHESHIRE).—At the last meeting of the District Council the report of the Electric Lighting Sub-Committee stated that they had sent out 715 circulars, but only 110 had been returned. Seventy-eight were in favour of the electric light and 26 against, while six expressed no opinion. The Manchester, Sheffield and Lincolnshire Railway Company had countermanded the laying of gas mains to their new station at Neston, consenting to use oil lamps until the Council were in a position to supply current. A long discussion took place, but it was decided to postpone the consideration of the matter for six months.

NEWRY.—The Secretary of the Newry Chamber of Commerce announced at the last meeting that the undertaking of the Warrenpoint and Rosstrevor Tramway Company (whose head offices are in Belfast), was about to be taken over by an English company, who intend to extend the line to Kilkeel, to be worked by electric motive power. The name of the Edison-Swan Company was associated with this statement, but neither the London Edison-Swan Company nor the Manchester Company know anything of the matter.

NEWINGTON (LONDON).—A petition to the Board of Trade is being signed in strong opposition to the application made by the Newington Vestry for an Electric Lighting Provisional Order. The moving spirits are a body called the Newington and Walworth Ratepayers' Association. The grounds upon which objections are taken to the scheme are that the district is mainly composed of streets of small houses with few factories or manufacturing premises, and that the shops and business premises are comparatively small, and that, therefore, the demand for current is likely to be so small as to leave the lighting undertaking a charge upon the rates.

NEWPORT (MON.).—At the last meeting of the Town Council the Electric Light Committee recommended the borrowing of an additional sum of £12,000 for electric light extensions, &c. Alderman Moses, in moving the adoption of the report, spoke of the popularity of the light and of the steady increase in the demand for current. The report was adopted.

OLDHAM.—At the meeting of the Electric Lighting Committee of the Town Council last week a report from Prof. A. B. W. Kennedy was read in reference to the proposed extension of plant at the electric supply station. Prof. Kennedy recommends that the station should now be completed according to the original design. It will then be large enough to contain four additional dynamos, each capable of supplying current to 6,000 8 c.p. lamps at one time, bringing up the total to 28,000 8 c.p. lamps. This would enable the Committee to overcome arrears and to supply current for all probable demands for some time to come. The extensions are estimated to cost between £7,500 and £8,000. It was decided to adopt Prof. Kennedy's report, and he is to be asked to prepare a complete scheme.

OSWESTRY.—The General Purposes Committee have decided to ask the local electric light company to submit an estimate for the electric lighting of the Askew Roberts Memorial Clock.

PEMBROKE.—The gas contract for the town lighting terminates on July 1st next, and one ward of the town has asked the sanction of the Distric Council for powers to negotiate for the lighting of the town by electricity. An offer has been received from Mr. J. C. Howell, of Llanelly, to light the town electrically.

PERTH.—A Committee has been appointed to consider the question of lighting the Corporation Buildings, water power being used.

PLYMOUTH.—At Monday's meeting of the Town Council the report of the sub-committee appointed to visit several electrical stations was presented. It will be remembered that some time back Dr. J. A. Fleming presented an exhaustive report dealing with the subject of the lighting of the town by electricity, and this and other reports received by the Council are commended by the Committee. The Committee are unanimously favourable to the introduction of the electric light. Visits were made to Bristol, which gave the Committee an opportunity of inspecting the electric cars of the Tramway Company. The report contains an opinion to the effect that the Committee consider that the overhead system of electric traction, if care and attention be paid to design and form, and if the columns carrying the conductors are used as lamp-posts for arc lights, causes no disfigurement to the thoroughfares, and that the system is safe, convenient, clean and

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economical. The Committee further state on the subject of traction that it is impossible to resist the conclusion that the Plymouth cars should be worked by electricity, for not only is the cost per car per mile less than half that at Plymouth, but the cars are of such size that a far greater number of passengers can be accommodated on every trip. "The saving in our tram lines would be enormous if the propelling power were electricity," say the Committee in their report. The City of London Station, St. Pancras, Brighton, Plymouth and Taunton were also visited. As a result of these visits the report concludes by recommending that the Town Council should itself put into force the powers it has obtained for supplying electricity within the borough; that the electric lighting should be combined with a dust destructor scheme, and that the supply station should be designed and equipped so that current for traction purposes can be supplied. It finally recommends that an engineer be appointed at a salary of £300 per annum, rising to £400, and that the Hoe and the principal places of public resort and the main thoroughfares should be lighted electrically forthwith.

PUBLIC LIGHTING IN THE CITY OF LONDON.—Mr. J. Cecil Bull, Manager and Secretary of the City of London Electric Lighting Company, points out in a letter to a contemporary that the charge by the City of London Electric Lighting Company for lighting the streets by electricity is only £26 per lamp per annum, which figures work out to barely 3d. per Board of Trade unit, "instead of the 5d. obtained by the more fortunate Vestry of St. Pancras."

RAWMARSH (YORKS).—The Sheffield and District Electric Tramway Company have offered the District Council £100 a year for the right of running through their district, and further undertake to keep the road in good repair a certain distance each side of the tramway. At the request of the Council the original terminus point has been extended.

RHYL.—The electric light has just been introduced into the works and premises of Messrs. Charles Jones and Sons, Foryd, Rhyl. The machinery has been supplied by Messrs. P. R. Jackson and Co., of Salford. Twenty-seven 16 c.p. incandescents and two 2,000 arcs are employed, while a special feature of the installation is a number of hand incandescent lamps, which can be used by the workmen at will. A complete telephonic installation has also been erected.

SOUTHAMPTON.—A meeting of the Electric Lighting Sub-committee is to be called for the purpose of taking into consideration the question of the purchase of the Southampton Electric Light and Power Company's undertaking.

SOUTHPORT.—From a statement by the borough accountant it would appear that the working of the electricity works for 1895 resulted in a loss of £210, which will, of course, soon be wiped off. There is a small unexpended balance upon the present borrowing powers of the Corporation, and application is to be made to the Local Government Board for power to borrow a further £4,000 to extend the mains to London-street and Chapel-street.

SOUTH STAFFORDSHIRE TRAMWAYS.—Mr. J. Noake, Mayor of Walsall, has succeeded in bringing about an arrangement between the Electric Construction Company and the South Staffordshire Tramways Company, under which the electric trams will continue running until March 27th next pending further negotiations.

STAFFORD.—Alderman Wormal presented the report of the Gas and Electricity Committee at last week's monthly meeting of the Town Council. The report states that the Committee have decided to modify the charges for electricity meter hire, and certain modifications of the discounts allowed on electric current accounts were also approved.

STAPLETON (BRISTOL).—The District Council have decided to oppose the application of the Great Western Electric Light and Power Company for a Provisional Order for this district.

ST. PANCRAS (LONDON).—On the recommendation of the Electricity Committee the Vestry have decided to supply current to places of worship at 3d. per unit.

SUNDERLAND.—The Highways Committee of the City Council now recommend that the electric supply station and plant be extended in accordance with the report of the Borough Electrical Engineer, and that steps be taken to borrow the necessary amount required for the work. Tenders are to be obtained for the proposed extension, subject to the Local Government Board's sanction. It will be remembered that opinions were divided as to whether steam or gas engines should be selected for the extensions; it has now been finally decided that steam engines shall be used.

SWANSEA.—The scheme prepared by Mr. Manville has now been submitted to Mr. W. H. Preece who will examine and report upon the matter generally to the Corporation. A Local Board enquiry into the Corporation's application to borrow £60,000 for electric lighting and dust destructor purposes is to be held on the 22nd inst., before Mr. W. M. Ducat.

TAUNTON.—The recommendation of the Finance Committee of the Town Council, that certain of the public electric lamps should be extinguished in the narrow thoroughfares of the town, and that no additional electric lamps should be placed in these thoroughfares, has been rejected.

TIGHNABRUAICH (ARGYLLSHIRE).—Mr. S. Millar, proprietor of the Tighnabruaich estate, has offered to put down the necessary plant for lighting the district electrically, on condition that the ratepayers pay the annual cost of maintenance, about £40. Mr. Millar's proposal provides for the erection of 25 lamps for lighting the road from the Post Office to Rhu Ban and the pier. A Committee has been formed to consider the proposal, and negotiate with Mr. Millar in the matter.

THEATRE LIGHTING.—A licence was granted by the Croydon County Council on Tuesday to the new Grand Theatre and Opera House, High-street, Croydon, which is to be lighted throughout by electricity.

TRAFALGAR SQUARE.—At last public attention is being directed to the wretched lighting of this noble space. A correspondent of a leading London daily paper points out that this, one of the finest spots in Europe, is the most wretchedly lighted of any of the metropolitan open spaces; and he suggests that powerful electric arc lights should be placed at convenient spots.

WALSALL.—The report of the Electric Lighting Committee of the Town Council on the subject of the electricity works was presented at the Monday's meeting, and states that the works have been carried out by the several contractors in a very satisfactory manner, and it is believed that the installation will be one of the most complete in the country. The price of current has been fixed at 6d. per unit for lighting and 4d. for motive power, less 2½ per cent. discount for monthly payments. A further £600 for an additional tranformer for the St. George's Hill sub-station was approved.

WATFORD.—It has been decided to appoint a Committee to consider the question of introducing the electric light for the public lighting of Watford and district.

WIGAN.—Some time ago the Town Council invited tenders for electric light plant. The Council have now decided to invite John Fowler and Co. (Leeds), the Corlett Electrical Engineering Co., Mather and Platt, the Brush Co., and Siemens Bros. and Co. to again tender on amended specifications.

"WORTHLESS ELECTRIC LAMPS."—Under this heading a long article appears in the *Daily Telegraph* of the 16th inst., from a correspondent who complains of "a deterioration in the quality of electric lamps, dating from the expiry of certain patents."

DINNER.—The employés of the Exchange Telegraph Company dined at Lake's Restaurant, Gracechurch-street, E.C., on Saturday last. Mr. Higgins presided.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

December 31, 1895.

25,002. R. HEATHFIELD and W. S. RAWSON. London. Improvements in electrolytical apparatus.

25,019. G. ROSSBACH. London. Improvements in apparatus for massage and electro-massage.

25,053. R. T. GLOVER and J. G. GLOVER. London. Improved combined portable electric lamp, switch and battery.

January 1, 1896.

64. F. KRIZIK. London. Improvements in or relating to electric tramways or railways.*

January 2, 1896.

94. H. S. JACQUES. Cheltenham. An improved regulating and feeding mechanism for electric arc lamps.

130. R. J. GLÜCHER. Liverpool. Improvements in and relating to electric accumulators.*

135. V. FABRIS. London. A new or improved method for the adjustment of carbons in electric arc lamps.

January 3, 1896.

156. H. T. PROCTER and R. E. GILL. Glasgow. Improvements in regulating the supply of gas or electric light to railway coach compartments.*

207. W. P. THOMPSON. Liverpool. Improvements in electric arc lamps. (The Electric Arc Light Company, U.S.A.)

234. R. A. MARPLES. Bromley. Cycles electrically driven by means of electricity collected from fixed conductors for track pacing and other purposes.

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January 4, 1896.

265. H. N. Bickerton. Manchester. An improved reflector for electric glow lamps.*

270. S. H. Heywood. Manchester. Improvements in incandescent electric lighting apparatus.

306. J. Chambers. London. Improvements in the manufacture of electrical hot-plates and other electrical apparatus for cooking and heating purposes. [Date applied for under Patents, &c., Act, 1883, Sec. 103, November 8, 1895, being date of application in New Zealand.]

308. C. S. Newman. London. Improvements in electric switches.

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1894.

24,021. Reid. Terminal box and cut-out.

24,285. New and Mayne. Electric lighting of trains, &c.

1895.

297. Claus and Sutton. Electrolytic treatment of tin, &c.

378. Fletcher. Electric generators.

1,317. Hacking and Brand. Electric lamps.

1,731. Faure and King. Secondary batteries.

2,004. Mills (Wirt). Electric recording meters.

3,006. Burnand. Arc lamps.

4,672. Lake (Shea and another). Telegraph and telephone systems.

9,864. Quin and Philpott. Suspending arc lamps, &c.

13,436. Miller. Electric light fittings.

18,038. Leitner and Reicher. Electrodes.

COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Company (Limited).

The following is the report of the Directors of this Company for the half-year ended September 30th last, which will be presented to the forty-seventh half-yearly ordinary general meeting of proprietors to be held at Winchester House, Old Broad-street, London, on the 23rd inst., at one o'clock:—

The revenue for the period amounted to £409,779. 15s. 6d., from which are deducted £96,703. 19s. 7d. for the ordinary expenses and £47,165. 2s. 7d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £3,423. 4s. 7d. for depreciation of spare cable, £821. 2s. 3d. due to revaluation of currency assets, and £5,748. 15s. 5d. for income tax, there remains a balance of £255,917. 11s. 1d., to which is added £1,252. 3s. 9d. brought from the preceding half-year, making a total available balance of £257,169. 14s. 10d. From this balance there have been paid—

Interest on debentures and debenture stock	£27,520	11	8
Dividend on Preference shares	20,296	5	5
Two interim dividends of 2s. 6d. per share each on the Ordinary shares	100,000	0	0
	£147,816	17	1

After carrying £10,000 to the reserve fund for maintenance ships, and £50,000 to the general reserve fund, there remains a balance of £49,352. 17s. 9d., which is carried forward to the next account. The revenue includes £25,447. 14s. 2d., dividends for the half-year upon the Company's shares in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies.

Lord Sackville A. Cecil and Mr. George Garden Nicol retire by rotation, and offer themselves for re-election, as do the auditors, Messrs. Deloitte, Dever, Griffiths and Co., and Messrs. Welton, Jones and Co.

Direct United States Cable Company (Limited).

The report of the Directors of this Company for the six months ended December 31st last, to be presented at the thirty-seventh ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., on Tuesday, the 21st inst., at 2 o'clock, states that the half-year's revenue, after deducting out-payments, amounted to £43,938. 9s. 4d., as compared with £38,342. 8s. 4d. for the corresponding period of 1894, being £5,596. 1s. in favour of the half-year under review. The working and other expenses for the same period, including income tax, but exclusive of cost of repairs of cables, amounted to £19,057. 15s. 9d., leaving a balance of £24,880. 13s. 7d. as the net profit, making, with £1,410. 0s. 9d. brought forward from the previous half-year, a total of £26,290. 14s. 4d. For the corresponding period of 1894 the working expenses and other payments amounted to £19,024. 6s. 3d. Interim dividends of 2s. per share for the quarter ended September 30th, and of 2s. for the December 31st quarter (payable January 24th), amounting to £12,142, have been declared, and, after setting aside £10,000 to the reserve fund account, the balance of £4,148. 14s. 4d. on the revenue account has been carried forward.

During the half-year repairs of the Company's cables, including provision to December 31st for operations not yet fully completed, have cost £6,984. 14s. 6d., which has been debited to the reserve fund account as heretofore, the balance of which, with the addition of interest and the amount set aside from revenue account, now amounts to £306,005. 1s. 4d.

NEW COMPANIES, STATUTORY RETURNS, &c.

In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "The Electrician" Electrical Trades' Directory and Handbook, 1895, pages *304-332, &c., &c.*

WILLIAM SOUTTER AND SONS (LIMITED).—This Company was registered on January 8th, with a nominal capital of £25,000, in 1,750 Ordinary and 750 Preference shares of £10 each, to acquire and take over the business carried on by William Soutter and Edwin Soutter, under the style of "William Soutter and Sons," at Hockley, Birmingham, and Holborn Viaduct, London, and to carry on the business of manufacturers of and dealers in every kind of art metal work, chandeliers, electric light fittings, metal founders, electro-platers, electricians, electrical engineers, &c.

ECONOMIC ELECTRIC SPECIALITY COMPANY (LIMITED).—The annual return to January 3rd has been filed. The whole nominal capital of £50,000, in £1 shares, has been taken up, and 49,993 have been issued as fully paid. The full amount has been called on the remainder, and £4 has been paid.

ELECTRIC FITTINGS, HIRING AND MAINTENANCE COMPANY (LIMITED).—The annual return to December 2nd has been filed. Only seven shares have been subscribed for out of a capital of £200,500, divided into 40,000 shares of £5 each, and 500 shares of £1 each, and no calls have as yet been made.

MORECAMBE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return to December 6th has been filed. The capital of £15,000 is divided into 14,950 Ordinary and 50 Founders' shares of £1 each; 6,709 Ordinary and all the Founders' shares have been taken up, and 761 Ordinary have been issued as fully paid. The full amount has been called upon the remainder, resulting in the receipt of £6,009. 15s.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30⅞d. per oz. (Jan. 16th). Consols (2¾ per cent.) 107⅝—107⅞ for money, 107⅝—107⅞ for account; 2¾ per cent. 104¼—104⅜ (Jan. 16th). Stock Exchange Settling Days: Consols, Feb. 3rd; Stocks and Shares Continuation Day, Jan. 28th; Ticket Day, Jan. 29th; Pay Day, Jan. 30th.

BABCOCK AND WILCOX (LIMITED).—An interim dividend for the six months ended December 31st last at the rate of 6 per cent. per annum on Preference shares and 10 per cent. per annum on Ordinary shares, payable on February 12th, has been declared.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The accounts of this Company for the half-year ended December 31st show a balance, after providing for debenture interest and the full dividend on the Five per Cent. Preference shares, sufficient to allow the payment of a dividend on the Consolidated Ordinary stock at the rate of 1¼ per cent. per annum, carrying forward a balance of £1,220 to the new account. The dividend is the same as for the corresponding period last year, £950 being then carried forward. The traffic returns of the Company for the week ended January 12th were £1,020, against £1,001 in the corresponding period of 1895, an increase of £19. The total receipts for the half-year amount to £2,037, against £2,004 in the corresponding period of 1895, an increase of £33.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company gives notice that the Transvaal Government have notified that they will now accept messages in code language.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 12th inst. amounted to £1,120. The amount for the corresponding week last year was £866; increase, £254.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY (LIMITED).—The Directors of this Company have declared a dividend at the rate of 5 per cent. per annum for the half-year ended December 31st last, making 4½ per cent. for the year. At the eighth ordinary general meeting of the shareholders of the Company on Tuesday the Chairman (Mr. Alderman Gibson), in moving the adoption of the report and accounts, referred to the great increase in the demand for electric current during the past year, and stated that they had sold 48,000 units more than in 1894. The report and accounts were adopted.

STOCK EXCHANGE.—The following shares have been ordered to be quoted in the Official List: City and South London Railway, further issue of 469 Five per Cent. Perpetual Preference Shares, Nos. 7,651 to 8,119.

WATERLOO AND CITY RAILWAY COMPANY.—The fourth half-yearly general meeting of the shareholders of this Company will be held at Waterloo Station, London, on Thursday, February 6th, at two o'clock. A special general meeting will follow for the purpose of considering the provisions of a Bill introduced into Parliament, intituled "A Bill to confer further powers on the Baker-street and Waterloo Railway Company." Extension of time for the completion of the line is asked for. The Bill will be submitted for the approval of the shareholders. The transfer books of shares will be closed from the 23rd inst. until the end of the meetings.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended January 10th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,664.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Jan. 8.	Price Wednesday, Jan. 15.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Jan. 11. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£250,000	£10	..	Amazon Telegraph	8 8½	9½ 10½	..	..	..	..
£1,012,880	Stock	10/0	Anglo-American	41 43	44 46	4 17 0	Jan., Apr., July, Oct.	41½	41
£2,993,560	Stock	20/0	Do. Preferred	79 81	83 85	5 5 11	" "	80½	79½
£2,993,560	Stock	5/0	Do. Deferred	5½ 6½	6 6½	..	.. ..	6½	5½
£178,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	100 104	100 104	3 16 11	January and July ..	103	..
180,000	£10	3/0	Brazilian Submarine	12½ 13½	13 13½	5 7 5	Mar., June, Oct., Dec.	13½	12½
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110 114	110 114	4 7 9	June and December	..	..
10,900,000	$100	$1½	Commercial Cable Capital Stock	160 170	160 170	4 2 7	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	13 14	12½ 13½	5 14 4	February and August	13	..
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 13 0	" "	..	..
12,981	5	2/0	Direct Spanish (fully paid)	3½ 4½	3½ 4½	4 8 11	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 5 3	" "	..	..
£80,000	Stock	4½%	Do. 4½% Debentures of £50 each	102% 105%	102% 105%	4 5 9	.. ..	..	..
60,710	£20	..	Direct United States Cable, 1877	8 8½	8 8½	4 14 2	Jan., Apr., July, Oct.	8⅝	..
400,000	£10	2/0	Eastern	16 16½	16½ 16¾	3 17 7	" "	16¾	16½
70,000	10	6%	Do. 6 per Cent. Preference	17½ 18	17½ 18	3 6 8	" "	17¾	..
£1,297,857	Stock	4%	Eastern Extension	125 128	126 129	3 2 6	May and November	1.7½	126
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 13 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17 17½	17 17½	4 0 0	Jan., Apr., July, Oct.	17½	17
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	127 130	127 130	3 2 5	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900	100 104	100 104	4 16 2	January and July ..	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb.,1900	100 104	100 104	4 6 2	" "	104	103½
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	107 110	107 110	3 18 11	February & August	107	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 115%	3 10 0	May and November	..	..
180,227	10	1/8	Globe Telegraph and Trust	9½ 10	9½ 10	4 5 0	Jan., Apr., July, Oct.	9⅞	9⅝
180,042	10	6%	Do 6 per Cent. Preference	16½ 17	16½ 17	3 10 7	" "	16⅝	16⅞
150,000	10	5/0	Great Northern	21½ 22	21½ 22½	3 16 5	Jan., April, and July	..	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	104 107	104 107	4 15 0	March & September	..	..
17,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	48½	43½
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 110	106 110	5 11 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel.4% Guar. Debs. "Red" 1942xd	108 111	108 111	3 12 1	.. ..	..	..
11,339	8	4/0	Reuter's	4 5	4½ 5½	..	April and October ..	4⅜	..
3,381	£100 Cert.	35/0	*Submarine Cables Trust 6 per Cent.	127 132	127 132	4 11 2	" "	..	..
11,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	..	January and July ..	..	..
£233,300	100	5%	* Do. 5 per Cent. Debentures (red.)	102 105	101 104	4 17 4	March & September	102½	..
30,000	10	2/0	West Coast of America	1 2	1 2	..	January and July ..	..	..
£150,000	100	3%	Do. 3 per Cent. Debentures, 1902	94 99	94 99	3 1 7	June and December	..	..
88,321	10	1/3	West India and Panama	¾ 1¼	¾ 1¼	..	..	1	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10¾	10½ 10¾	5 11 7	May and November	10½	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½ 9½	8½ 9½	6 6 4	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	109 112	108 111	4 10 1	June and December	..	..
64,248	15	3/9	Western and Brazilian	9 9½	9 9½	5 4 0	May and November	..	..
33,129	7½	3/9	Do. 5 per Cent. Cumulative Preferred	6½ 6¾	6½ 6¾	..	" "	6¾	..
33,129	7½	1/6	Do. Deferred Ordinary	2¾ 3¼	2¾ 3¼	..	..	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 14 10	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 14 10	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	113 118	113 118	5 13 8	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	100 103	102 105	5 16 6	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	8½ 8¾	8½ 8¾	..	..	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ¼	⅛ ¼	..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	⅛ ¼	⅛ ¼	..	Yearly	..	..
484,597	5	2/6	National	5½ 6	5½ 6	4 8 4	June and December	6⅛	5⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15½ 16½	15½ 16½	3 12 9	" "	..	..
119,224	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6½ 6¾	6½ 6¾	3 16 11	..	6⅞	6¾
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	104 107	104 107	3 5 5	January and July ..	106	..
58,000	5	3/0	United River Plate	2½ 3	2½ 3	..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	90 95	90 95	5 5 3	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12¾ 13½	12¾ 13½	1 17 9	..	13¾	12⅝
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15½ 16	15½ 16	3 15 0	..	15	..
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	131 135	132 136	3 13 6	June and December	134½	132
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½ 5¾	5½ 5¾	..	..	..	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
22,475	£8	..	County of London & Brush Prov. Ord. (fully paid)	8 9	8 9	..	..	..	..
10,000	£10	9½d.	Do. Pref. (£6 paid)	10½ 11	10½ 11	..	..	..	..
8,822	£5	..	House-to-House Electric	.. ..	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July ..	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7¾ 8½	7¾ 8½	..	..	..	..
111,000	5	..	London Electric Supply	.. ..	.. ..	..	..	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	10 11	10½ 10¾	4 3 9	..	10½	..
150,000	Stock	4½%	* Do. 4½% Debs.	114 117	114 117	3 16 1	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9	8½ 9	..	..	..	..
..	..	..	Rand Electric	¼ ½ prom	¼ ½ prem.	..	..	..	..
19,980	£5	2/0	St. James and Pall Mall	8½ 8¾	8½ 8¾	..	..	8¾	..
20,000	£5	7%	Do. 7 per Cent. Preference	9 9½	9 9½	3 13 8	..	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8½ 8¾	8½ 9	3 1 1	..	8⅞	8¾
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	2	1/6	Brush Electrical Engineering	1⅛ 1⅜	1 1½	12 1 0	..	..	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅜ 2	1⅜ 2	6 0 0	..	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 19 8	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2 2½	2 2½	..	January and July ..	..	..
89,261	5	1/6	Edison and Swan United	1½ 2	1½ 1⅝	..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 4 1	..	..	..
£30,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..	..	..	..
110,000	2	..	Electric Construction	⅜ ½	⅜ ½	..	..	..	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2 2¼	2 2¼	5 11 0	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	¼ ⅜	¼ ⅜	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¼ ⅜	¼ ⅜	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	18 19	19 20	3 18 11	February & August	19	18½
£210,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	101 103	102 104	4 7 10	March & September	..	..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	⅜ ½	⅜ ½	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	41 43	41 43	4 3 9	March and July ..	43	41½
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	102 105	4 15 3	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	13½ 14½	13½ 14½	4 2 9	..	..	..
£80,000	10	7/0	Do. 7 per Cent. Preference	15½ 16½	15⅝ 16⅝	4 4 0	..	..	..
£50,000	Stock	4½%	Do. 4½% Mort ge Debenture Stock	108 111	108 111	4 2 7	..	..	..
			RAILWAYS AND TRAMWAYS.						
£680,000	Stock	1½%	City and South London Railway	40 42	40 42	2 6 6	May and November	40½	40½
7,650	10	5%	Do. 5% Perpetual Preference	14⅜ 15½	14⅜ 15½	3 5 7	..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	128 130	128 130	3 1 11	May and Novem	129½	130
37,500	£10	2½%	Liverpool Overhead Railway	11½ 11⅝	11½ 11⅝	1 18 4	..	..	..
10,000	10	5%	Do. 5% Preference	15½ 15⅝	15½ 15⅝	3 3 6	..	..	..
115,000	Stock	4%	Do. 4% Debenture	112 114	112 114	3 10 2	January and July	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

We publish in the present issue a full translation of Prof. Röntgen's recent communication to the Würzburg Physical Society on "A New Form of Radiation," and a brief abstract of a lengthy and most important Paper by Jaumann, appearing in the current number of *Wiedemann's Annalen* under the striking title of "Longitudinal Light." Röntgen, it will be seen, sums up strongly in favour of the theory that his X-rays are not merely a very ultra-violet radiation, so to speak, but are *longitudinal* vibrations in the ether. Jaumann shows that by assuming μ and k to be variable longitudinal vibrations follow on from Maxwell's equations, and that such vibrations account for many obscure phenomena connected with cathode rays of the Lenard variety and with the discharge by light of electrostatically-charged bodies. In other words, Röntgen, Lenard and others would appear to have discovered what Prof. Silvanus Thompson has, with characteristic preference for the picturesque, termed "ultra-violet *Sound*."

It may not be without interest at the present moment to recall the main points of difference and of similarity between Röntgen rays and Lenard rays—to use two brief and convenient expressions. Röntgen rays are *not* deflected by a magnet; Lenard rays are. Röntgen rays suffer far less absorption and diffusion than Lenard rays. Lenard found that his cathode rays failed to pass through anything but the thinnest soap films, glass, and aluminium foil, &c.; the Röntgen variety will traverse several centimetres of wood and several millimetres of metal or glass. Röntgen was able to take "shadowgraphs" and detect fluorescence 200cm. away from the discharge tube; 6cm. or 8cm. were enough to wipe out Lenard rays in air at atmospheric pressure, and even in hydrogen gas, at only 0·0164mm. pressure, the "radiation length" for cathode rays was only 130cm.; hydrogen at atmospheric pressure behaving as a decidedly turbid medium. These are, however, rather differences in degree than in kind. Lenard rays emanate, of course, from the cathode itself; but Röntgen rays, according to their discoverer, start from the luminescent spot on the glass wall of the discharge tube, at which the cathode rays terminate. The points of similarity between Röntgen and Lenard rays are their photographic activity, their rectilinear propagation (as evidenced by the sharp shadows cast) and the fact that in both cases it would seem the total mass of molecules contained in unit volume of any substance practically determines its transparency. All things tend to show that we are on the verge of a great scientific discovery, which may oblige us, *nolens volens*, to "rearrange our ideas."

The Berrenberg mechanical vacuum pump, described in another column, seems to us to be about as perfect as such a machine can be. How far a first-rate vacuum is necessary for commercial glow lamps, it is difficult to say; but if the exhaustion of an oil-flooded pump will do, we think the Berrenberg will give as good a vacuum as any. It will be inferred from this that we do not think it will give as good a vacuum as the mercury pump, Prof. Ayrton's tests notwithstanding. Such a pump cannot go beyond the vapour pressure of the lighter constituents of the oil used. The tests made were evidently not those of one well acquainted with the very crooked ways of lamp vacua. The McLeod gauge is notoriously untrustworthy, even on a mercury pump, and is also quite useless in dealing with low-pressure oil and water vapours. The method of opening lamps under mercury is generally unreliable, even as a comparison of the vacua of ordinary lamps; as a comparison of a bulb exhausted as Prof. Ayrton exhausted it and a commercial lamp, it is not less so. The principle of flooding an ordinary pump with oil or glycerine to avoid clearance is quite old in sugar works and glow lamp manufacture. So is exhausting with delivery into another exhausted chamber. As a sealing medium for preventing leaks in piping, oil is not to be recommended. Metal is impervious to air, and the vacuum that can be preserved in a system of gas piping is limited only by the pressure of the vapour of the liquids used in the redlead. Greased stopper joints were tried in the early days of lamp making, but were discarded, though their rejection may have been due to too high an ideal. The cost of pumping lamps is not the serious item that many inventors of queer pumps imagine. If a philanthropic inventor came round and exhausted lamps for nothing, it would make little or no perceptible difference in the price of the lamps. To exhaust lamps well is far more important than to do them cheaply.

The spectacle of an electrical industry clamouring for an increase in permissible supply pressures, and then turning shyly from using them when they have been granted, must be a somewhat amusing one for the Board of Trade, presuming, of course, that this much-worried Department is capable of being

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amused. Nevertheless, there may be some practical utility in having the right to use 250 volts, whilst recognising the fact that this use must only be cautiously made. In his recent Presidential Address to the Northern Society of Electrical Engineers, Mr. W. P. J. Fawcus repeats the warning which already has often been made, in regard to the injuries both to the consumer and, ultimately, to the electrical industry, which may arise from the introduction of a pressure of 250 volts into a consumer's premises. "It would be an evil day for the industry," he remarks, "if through the occurrence of fatal accidents to the general public the electric light should again get the name of being dangerous, which fortunately it has now practically lived down." As we recently observed, however, it is not so much fatal accidents that are to be feared, as the minor inconveniences of harmless but unpleasant shocks.

A kindred topic, that of the incandescent lamps for the higher pressure service, is also touched upon by Mr. Fawcus; and it is of interest to compare his remarks with a short communication from a correspondent which we publish this week in our Notes column. Judging by our correspondent's experience, makers do not find it particularly easy to produce lamps, even at 100 volts, which shall comply with specification in regard to efficiency, candle-power, and voltage. What, then, may be expected if a general conversion to 200-volt lamps is to take place? Mr. Fawcus advocates multi-filament lamps in this latter case; but we believe it is generally considered that the compound filament is only a temporary and makeshift contrivance, and that a really successful high-pressure lamp will have to consist of a suitably strong single filament. The cheapening of lamps must inevitably tend to their being run at a higher rate, and therefore at a reduced life. This can only be fairly styled "over-running" when the candle-power of the lamp at the marked voltage is in excess of the marked candle-power. There is no known process by which a carbon filament can be worked at 2½ or 3 watts per candle-power instead of at 4 watts, except it be by running it at a higher temperature; and it ought to be understood by everyone who does so that in our present state of knowledge this will apparently have to be done at a sacrifice of what has up to now been deemed normal lamp-life and normal constancy of candle-power. But, if 200 volt 2½ watt lamps are to replace the old 100 volt 4 watt lamps in practice, it will be all the more necessary that the marked voltage shall not develop more than the correct temperature in the filament, since the lamp, already severely stressed, will be liable to double the fluctuation of pressure that occurs in the present 100-volt systems. Not only, that is to say, will the lamp normally be run much nearer to its fatal point, but it will have to withstand very much greater abnormal encroachments on its slender margin of safety. To meet these more stringent conditions lamp makers will have to subject their stock to much closer supervision and more careful selection than would seem to be the case in this era of cheap lamps.

On Thursday evening last week Dr. John Hopkinson prefaced his Inaugural Address by an appeal to the members of the Institution of Electrical Engineers to do something in their corporate capacity towards the defence of the country. Some people, Bacon tells us, "in all deliberations find ease to be of the negative side and affect a credit to object and foretell difficulties;" and we have no wish to join that noble army. Nevertheless, whilst we are in cordial agreement with the Presidential exhortation to each member to do his duty according to his opportunities, it may be permissible to doubt whether the spectacle of the Institution of Electrical Engineers precipitately converting itself into a submarine-mining or search-light corps will be altogether impressive. It is, as the President truly remarked, the duty of everyone to consider what he can personally contribute towards the nation's defence, and if the Committee appointed by the Council succeed in disabusing members of the Institution of the idea, that in contributing, with the usual quantum of grumbling, to the revenue of the country, they have completely fulfilled their duty towards it, the Committee will not have been called together in vain. Technical training is cheerfully submitted to in order to gain a livelihood; it would be well if a little military training were equally cheerfully submitted to by our young able-bodied electrical engineers, in order that they may prove of at least unit use in time of need.

Men much over 30 who have not taken the trouble to gain the preliminary insight into military technics afforded by a few years volunteering or its equivalent, are not likely, however great their patriotic ardour in a moment of panic, to become "efficient" in time to be of any use. Their patriotism and good sense, it seems to us, would be better evinced by encouraging every young fellow they know to do that which they themselves have left undone. It is only by quiet and *timely* voluntary military training that conscription will in the long run be avoided. Should that dread Continental invention ever reach these shores, together with the many other imported evils "made in Germany," it is some consolation to learn on unimpeachable authority that conscription, even, is not without its compensations. The too-close attention to the fact that it takes the workman away from his work for two or three years at the most economically valuable period of his life has made many overlook both the life-long physical gain derived from spending those very years in healthy outdoor exercise, and the moral gain due to the formation of disciplined habits. Common sense might have divined the existence of this compensation, but, as usual, the dead-weight of authority has been sufficient to prevent most people from thinking the matter out for themselves. The following quotation from the Report of a delegation of employers and employees representing the iron and steel industries of Great Britain, which recently visited the Continent, is a testimony to the compensating influences of a brief period of military training. The italics are our own:—

"One of the most admirable features of the administration and operation of the iron and steel works that we visited on the Continent, almost without exception, was *the splendid discipline maintained. The workmen generally discharged their duties as if they were acting under military commands. There was no slovenliness, no undue haste, no noise, no idling about, and the foremen, in a quiet and unobtrusive manner, appeared to*

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control everything without commotion. Each man worked as if he were a piece of machinery fitted into its proper place, which did exactly the right thing at the right moment, because it could not do otherwise. The operations, as a rule, were carried on with the regularity of clockwork. We are also bound to acknowledge that we were greatly struck with *the splendid physique* of the men employed in the works that were visited in Germany, and not less so with their sobriety, their steadiness, and their readiness to act on instructions. These qualities are manifestly of much value alike to employers and employed. The workman who is regularly and steadily engaged at work is not only earning better wages for himself, but is in a better position to do good work, while the effect of such a state of matters on the employer is that he gets the maximum production out of his plant, no heats being lost through broken time, &c. *The early military training of the workman has probably a good deal to do with this system of working;* but, whatever its cause, its effect on the industry of the country is very important."

Owing to the great extension of the metropolitan electric light mains during 1895 we have been obliged to correspondingly increase the area covered by our annual map, the 1896 edition of which is published with the present issue. St. Pancras has sent a long bifurcating feeler northwards; the streets of Hampstead have become green, not with grass, but with mains; a similar fate has befallen Clerkenwell, and the Islington station has sent a long, lonely line to the north and another to the south. Next year, when we hope to include the Wandsworth district of the County of London and Brush Provincial Electric Lighting Company, the size of the map will be still more portentous. We have to thank the engineers of the various electric supply concerns for their kind assistance in bringing our map accurately up to date.

The Institution of Junior Engineers.—The eleventh anniversary dinner of this Institution takes place on Saturday at the Westminster Palace Hotel, the President (Mr. Archibald Denny) in the chair.

Appointment.—The appointment of Scientific Adviser to the Trinity House, which has been in abeyance since the resignation of Prof. Tyndall, and which was formerly held by Faraday, has been revived, and has been accepted by Lord Rayleigh.

Northern Society of Electrical Engineers.—Mr. W. P. J. Fawcus, Managing Director of the Manchester Edison-Swan Company, has been elected to the office of President of this Society for 1896, the Vice-Presidents being Messrs. S. Z. de Ferranti and C. M. Dorman (of Dorman and Smith). The hon. treasurer is Mr. Eckstein, of the Manchester branch of the General Electric Company, and Mr. J. Vincent Swindells remains hon. secretary.

The Smithsonian Institution.—In the last number of *Nature* there is commenced an interesting series of articles on the Smithsonian Institution, of Washington, with a historical sketch of the Institution and its founder. The first article is illustrated with a picture of the Smithsonian buildings and portraits of Joseph Henry, S. P. Langley, Chief Justice Fuller and S. F. Baird, who are, or have been at one time, officially connected with the Institution.

Cable Interruptions and Repairs :—

	Date of Interruption.	Date of Repair.
Puerto Plata—Martinique ...	December 19, 1895 ...	—
Perim—Obock	January 2, 1896 ...	—
Bathurst—Sierra Leone	January 14, 1896 ...	January 14, 1896
Konakry—Sierra Leone	January 14, 1896 ...	January 18, 1896
St. Thome—Loanda	January 15, 1896	—
Odessa—Constantinople	January 17, 1896 ...	—
Durban—Lourenco Marques..	January 19, 1896 ...	January 22, 1896

A Contradiction.—We are given to understand that nothing is known at the General Post Office of the proposed telephone trunk line between London and Berlin, which the papers state Dr. Stephan alluded to a day or two ago in the Reichstag in connection with the German Post Office estimates. Dr. Stephan was probably alluding to the proposed new Anglo-German *telegraph* cable.

An Old Friend in a New Office.—"It is rather amusing to gas engineers," says the *Journal of Gas Lighting*, "to observe that their good friends the electric lighting engineers are just now having their turn at towns' refuse utilisation. Time was when this same rubbish, with and without the admixture of sewage or sewage sludge, was highly recommended as good stuff for making illuminating gas from. Indeed, it is hard to say what the same kind of material has not been said to be good for, at one time or another, by various perfervid individuals who fancied it ought to be made useful somehow."

Coventry.—A serious accident took place in Bishop-street, which is a very steep decline, on Wednesday afternoon. One of the electric cars was proceeding from Foleshill to Coventry, when, at the top of Bishop-street, the brake refused to act, and in consequence the tram attained a speed of about 25 miles an hour. Near the bottom of the street, on the line, stood a lorry with a stage on top used in connection with the repair of the trolley wire, on the top of which, 20ft. above the ground, a man was working. The car collided with the trolley, and the man was pitched into the roadway and severely injured.

Cable Communication with South Africa.—In explanation of the recent rapid repair of the Delagoa Bay—Durban cable, it may be mentioned that the Eastern and South African Company, in view of the exceptional importance at the present time of maintaining communication with South Africa, ordered the cable steamer "Great Northern," then stationed at Cape Town, to proceed to the East Coast, calling on the way at each port where the lines connect. The day after the ship's arrival at Delagoa Bay the cable thence to Durban broke, and, as the fault was only 27 miles distant, the ship was able promptly to effect the repair.

Dundee.—On Tuesday an unfortunate breakdown occurred in connection with the Dundee electric light supply, as a result of which a number of shops in the city had to be closed. It seems that the steam feed pipe of the pumping engines fractured, and recourse had to be had to an injector. This arrangement worked smoothly till the afternoon, when a valve gave way, and as the supply of water to the boilers could not be kept up the fires had to be drawn. From the fact that there were 10,000 lamps in circuit at the time, recourse could not be had to the batteries, which are only capable of supplying about 1,500 lamps.

Obituary.—On January 1st Mr. Alfred E. Beach, proprietor and editor of the *Scientific American*, died of pneumonia. He was born in 1826 in Springfield, Mass. In 1846 he and his former schoolmate, Mr. Orson D. Munn, founded the firm of Munn and Co., and became the proprietors of the *Scientific American*, which at that time was the only weekly journal of its kind published in America. For nearly 50 years Mr. Beach was active in the editorship of the paper and in the direction of the extensive patent business of the firm. Mr. Beach has made several inventions.——We regret to record the death on Wednesday of Sir Henry Calcraft, K.C.B., Permanent Secretary to the Board of Trade from 1886 to 1893.

Waterfalls and Aluminium Works.—A Reuter telegram from Christiania states: The estate of Hafslund, near the great waterfall known as the Sarpsfos, between here and Göteborg, has been acquired by a syndicate, consisting chiefly of German and American capitalists, for the sum of 800,000 kroner. The purchasers intend to form a large company to electrically utilise the power of the falls and establish aluminium works. The Sarpsfos is one of the finest falls in south-eastern Norway, being 74ft. in height and 116ft. in width. The water is, however, already utilised by numerous saw mills and cellulose factories, and the railway crosses the fall, so that the proposed new works will probably not interfere to any great extent with the picturesque aspect of the place.

Expiring Patents.—Next Sunday, the 26th inst., will expire Patent No. 386 of 1882, granted to W. T. Henley for "Improvements in the Construction of Cores for Sending Electric Currents for Telephone, Telegraph and other Purposes, and in Apparatus connected therewith." One of the two claims is for: "The construction and employment of cores for cables

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with multiplec onductors substantially as set forth."——On Friday next, the 31st inst., will expire patent No. 489 of 1882, granted to G. Skrivanoff for "Improvements in Electrical Batteries for Telegraphic, Telephonic and other Purposes." There are four claims, dealing with a battery composed of a Zn C couple, with electrolytes and depolarisers of chloromercurate of ammonium and chloride of sodium, and with interposed layers of filtering paper or asbestos soaked in chloride of zinc and chloride of sodium, with or without glycerine.

Fatal Accident at the Hampstead Electric Supply Station.—On Tuesday evening last Edward Clarkson, a jointer in the service of Messrs. Siemens Bros., proceeded without anyone's orders to the back of the switchboard at the Hampstead Vestry's electric supply station to disconnect an alternator, which had just been tested, from a water resistance and reconnect it up to the station "bus" bars. A heavy fall was heard, and on going into the spacious well-lighted alley at the back of the board one of the assistant-engineers at the station found Clarkson dead on the floor. He had evidently come in contact with a minute piece of bare wire belonging to a voltmeter connected to the "bus" bars with one hand, and not knowing this, proceeded to connect up the alternator, and the insulation of the connection being faulty, and the man unprovided with gloves, he short-circuited the station "bus" bars from one hand to the other.

Anderson Closed-Conduit System at Leeds.—A short experimental line on the Anderson closed-conduit system has been laid down at Hunslet, near Leeds. In this system the motors in the cars are fed from an underground conduit. Along the track, 21ft. apart from each other, are iron boxes, the lids of which are level with the road. In each box are three pins, about 1in. in diameter. These pins are made to rise about 3in. above the road as the car passes along the track. These small projections convey the current from the conduit to a collecting bar at the bottom of the car. At the end of the collecting bar is a ramp, and as the car passes over, the ramp knocks down the pins to the level of the road, and the current from that particular box is at once automatically switched off. The knocking down of these pins sends up the pins in the next box, which is then under the collecting bar right in front of the car. The estimated cost of constructing this conduit system is £1,200 per mile.

Röntgen Rays.—Prof. Röntgen's discovery with regard to radiations from a Geissler tube has been put to practical use in Vienna by Prof. Mosetig, whose experiments on two patients on whom operations were to be performed were attended with complete success. The "shadowgraphs" taken showed with the greatest clearness and precision the injuries caused by a revolver shot in the left hand of a man, and the position of the small projectile. In the other case, that of a girl, the position and nature of a malformation in the left foot were ascertained. The experiments are regarded as affording a means of determining the exact spot where an operation may be necessary. Mr. A. A. C. Campbell Swinton, whose "shadowgraphs" caused much interest at the Camera Club and at the Institution of Electrical Engineers last Thursday week, finds that no effects are evident when an induction coil is employed in the ordinary manner. He used an alternating current to work a coil, the secondary of which charged a battery of Leyden jars, the discharge from these being passed into a second Tesla induction coil. Prof. Silvanus Thompson has, we believe, discovered that Röntgen rays are also generated in the electric arc, and has succeeded in getting an excellent "shadowgraph."

Street Lighting at Munich.—On Sunday, December 22nd, 1895, the new street-lighting plant was handed over for ordinary working. Up to the present there have been two generating stations, with water and steam power, supplying 66 5-ampere and 210 10-ampere arc lamps, the distribution being on the three-wire system, 6 lamps being always in series between outer and middle wire. The arrangement was such that the lamps on one side of the three-wire system were switched off at midnight, while the others burned through the whole night. The extension was carried out on the lines proposed by the municipal electrical engineer, Herr Uppenborn, by which 12 lamps are put in series across the outers of the former three-wire system, the middle wire being omitted altogether. The extension plant consists of two 250 H.P. turbines, each driving two Schuckert dynamos. A steam plant of two 350 H.P. engines has also been provided for further extension and as a stand-by. Provisions are also made for an additional 700 H.P. and a 1,000 H.P. engine. The work in connection with the underground mains has been enormous; 95 miles of cables have been laid in 25 miles of trench, Munich, it must be remembered, being a town which covers a large area. The extension comprises 480 10-ampere and 48 5-ampere arc lamps. The lamp-posts are of various designs, from very ornamental patterns for the principal streets and squares to plain posts in side streets. Switch pillars are erected about the town, from which the different circuits can be cut in and cut out. The whole plant now comprises 690 10-ampere and 114 5-ampere arc lamps.

Association of Technical Institutions.—The report of the Council of this Institution, which is to be presented at the annual meeting, to be held at the Goldsmiths' Hall, to-day, states that since the issue of the last report a number of additional institutions have been admitted to the Association during the year. Suggestions have been made to the Committee of Her Majesty's Privy Council on Education with the view to modification of the basis for the calculation of the Government grant for technical education purposes. A Committee was appointed to consider the question of examinations in practical chemistry, the result of whose labour was the submission of resolutions to the Department of Science and Art in regard to certain modifications of the technical education code. The Council recommend the meeting to authorise them to make representations to the Science and Art Department on the inadequacy of the present grants to science and art classes, and to make urgent representations to the Privy Council Committee on Education requesting that clauses may be inserted in any Bill which is based on the report of the Royal Commission on Secondary Education recently issued in order to secure that the continued efficiency of technical institutions shall not be impaired by any diminution in the amount of aid which they at present receive from votes available under existing Acts of Parliament and in the form of grants from the Science and Art Department. The President for 1896, and vacancies in the Council, are to be elected at the meeting. The Right Hon. A. J. Mundella, M.P., is the Council's recommendation for the presidency.

The Cheltenham Fatality.—The Board of Trade inquiry into the circumstances attending the recent death of John Pugh, employed as jointer in the Electric Light Department of the Cheltenham Corporation, was held at the Municipal Offices on Wednesday last week, before Major Cardew.—Mr. M. Hamilton Kilgour, Borough Electrical Engineer, gave it as his opinion that no protective covering to metal traversed by high-pressure currents would really reduce the danger. In most cases covering would reduce the danger at the start, but it might ultimately increase it, owing to the freedom in handling which it would cause.—The Inspector thought that the question in this and other cases is whether there has not been a tendency to leave too much of this highly-charged metal exposed, instead of having insulating covering for it.—Replying to the Town Clerk, Major Cardew said the carelessness of workmen in handling charged metal, and particularly in touching instruments in connection with the high-pressure system, was incredible.—Mr. R. Cresswell, surgeon, who attended the deceased in the transforming chamber, adhered to his statement before the coroner that the position in which the deceased was working was a very dangerous one.—Mr. Kilgour was re-called, and asked by Major Cardew whether he considered it absolutely necessary that the high pressure should have been kept on during the time the men were working in the sub-station. He replied: It would have meant switching off the supply from a part of the town if the high pressure had been taken off. There was no work being done on the high-pressure side on this occasion.—This accident occurred shortly after eleven o'clock in the morning, and in the middle of the day no great inconvenience would be caused by switching off. There were one or two customers who used the light all day.

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Glow-Lamps.—A Correspondent, who has had much commercial experience of cheap glow-lamps in this country, writes to the following effect in answer to an inquiry we made:—The tests of incandescent lamps which I began some time ago were carried out to find which was the best 3-watts-per-candle-power lamp in the market, as I consider a lamp of that efficiency to be the best all-round lamp for general use, especially where some consumers wish to make an economy over their previous consumption of current with the usual 4—5 watt lamp. *There was great difficulty in getting lamps anywhere near the right efficiency even when the makers were paid an extra price per lamp for specially picked lamps.* Following this I give some of the readings taken on lamps submitted for trial. They are of both English and Continental manufacture:—

	Nominal c.p.	Actual c.p.	Watts per c.p.
Ediswan	16	21	2·3
	16	18·5	2·6
	16	19·75	2·45
	8	7·6	3·1
These lamps were much over-run at the marked voltage (=100 volts).			
Robertson	32	23·8	3·95
	32	23·6	3·12
	32	26·6	3·57
Sunbeam	32	29·0	3·9
	16	12·7	4·3
	10	8·5	4·7
Daylight	16	21·7	2·88
	16	21·0	2·72
	32	36·3	2·95
	32	30·8	3·38
	50	65·1	2·7
	50	60·4	2·86
Cruto	16	17·2	3·16
	16	14·8	3·8
Venus	16	12·2	3·3
	16	4·8	7·2
(After 100 hours burning.)			
Quanonne	8	8·0	4·1
	16	16·2	3·25
	25	20·5	3·0
	32	32·7	3·0

The above figures have been selected out of numbers of tests made on each type of lamp, and represent the average results obtained. I found that the makers generally selected the lamps by the total watts consumed, as, for instance, 48-50 watts for a 16 c.p. lamp, but regardless of the candle-power given by the lamp, and that most so-called high-efficiency lamps were simply ordinary lamps over-run at the marked voltage, and these lamps, if run at the nominal candle-power by reducing the voltage, were not better than an ordinary 4-5 watt lamp.

The Alternate-Current Transformer.—On Monday evening last Dr. Fleming delivered the first of his course of four Cantor lectures on this subject. The transformer, he said, existed in a three-fold character—there was the mathematician's transformer, clothed in an elaborate mathematical raiment; the contractor's transformer, of exceedingly high efficiency; and the real transformer, having its vices as well as virtues. The importance of considering how to reduce transformer-core loss was evident when one remembered that the energy consumed annually in the cores of all the transformers connected to the mains of the 47 alternating electric supply concerns operating 1,100,000 8 c.p. lamps in the United Kingdom amounted at least to about 1,600,000 kilowatt-hours, costing quite £6,000 per annum for coal alone. Transformers, the lecturer said, could be broadly classified as follows: (*a*) Iron core, (*b*) air core, (*c*) closed circuit, (*d*) open circuit, (*e*) constant current, (*f*) constant potential, (*g*) step up, (*h*) step down. Various methods of delineating alternating-current curves were then described, and, amongst others, the method fully described by the lecturer in *The Electrician* of February 15, 1895. The uses of polar curves and the meaning and significance of the "form factor" of the wave of an alternator (see *The Electrician*, May 10, 1895, and January 10, 1896) were then discussed. Reproductions in the form of lantern slides of alternating-current curves taken at Bankside station (see *The Electrician*, February 22, 1895) were then thrown on the screen, and the comparative stability of the P.D. wave form of the Mordey alternator strikingly shown, as well as the extreme peakiness of the Thomson-Houston curve (maximum value 3,500 volts) when the alternator is running on an inductive load. The harmonic analysis of alternator curves was then gone into, and it was stated that in practice it was found that every alternating-current curve could be synthesised by means of three simple sine curves suitably placed having frequencies of 1, 3 and 5 respectively. Dr. Fleming stated that it was an entire misconception to talk of transformers as "wiping out ripples" in the curve of primary E.M.F.—the secondary P.D. wave was an exact copy to a reduced scale of the primary. The interesting question of the influence of wave from on core losses was then gone into at some length, also the algebraical and geometrical construction of hysteresis curves from the P.D. curves. The lecture concluded with a reference to the essential connection of the "secondary drop" with wave form; with peaky P.D. curves drop is greater than with flat P.D. curves. At the end of the lecture an instructive exhibition was given of the capabilities of Dr. Fleming's wave-tracing motor in analysing the fluctuations in the light and temperature of an alternating-current arc (see *The Electrician*, December 20, 1895), the perfect synchronism of the motor with the fluctuations of current being made evident by the absolute steadiness of the image of the alternating arc in one particular phase projected on to the screen when the light of the arc was sent through a slot cut in an aluminium disc attached to motor axle.

The Pacific Cable Scheme.—Under date Sydney, January 19th, Reuter cables as follows:—An intercolonial conference of Postmasters-General concerning the appointment of Australasian representatives on the Pacific Cable Commission to be held in London, and for other matters, met here on Friday and yesterday. The Postmasters present were Mr. Joseph Cook, New South Wales; Mr. J. G. Duffy, Victoria; Mr. A. J. Thynne, Queensland; Dr. Cockburn, South Australia; and Mr. W. P. Reeves, the new Agent-General in London for New Zealand. Dr. Cockburn also represented West Australia and Tasmania. Mr. Cook took the chair. The following resolutions were adopted, subject to the approval of the various colonial Governments, and recommended to the Australasian Commissioners: "(1) That the Pacific cable should be constructed and owned jointly by the various Governments interested. (2) That the landing places of such cable should be only upon territory belonging to or under the control of the British Empire. (3) That the construction, working and maintenance be borne by Great Britain, the Dominion of Canada, and the contributing Australasian colonies, in the proportion of one-third. (4) That the route from Fiji to Australia be to Norfolk Island, and thence bifurcating to the nearest convenient landing places in North New Zealand and Moreton Bay respectively. (5) That it is highly desirable that South Australia should join the other colonies in the Pacific cable project, and, having regard to their vested interests in the trans-continental line, Dr. Cockburn be invited to move a proposition embodying the terms upon which the South Australian Government would be prepared to join the other colonies." Upon this Dr. Cockburn submitted the following offer: "South Australia is willing to join in the project provided that a guarantee, either from the contributing colonies, or jointly with the Imperial Government, be given that the financial position of South Australia as regards the Port Darwin line be maintained on the basis of the average for the last five years." (6) That the colonies joining should contribute equally to the undertaking. (7) That in consideration of South Australia joining with the other contributing colonies in the project they would be willing jointly with Great Britain to guarantee that colony against a further loss in connection with their trans-continental line in consequence of the construction of the cable. (8) That Sir Saul Samuel and Mr. Duncan Gillies should be nominated as representatives of the Australasian colonies on the Commission in connection with the Pacific cable, and that they should be requested to consult on all important points with the Agents-General of the Australasian colonies." Under the same date the Melbourne correspondent of *The Times* cables: "Mr. Reeves and Dr. Cockburn strongly protested at Sydney against equal payments by the colonies for the cost of the maintenance of the Pacific cable. They declined voting on the question and wished the payments to be on the basis of population."

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ELECTROMAGNETIC THEORY.—LXXXII.*

BY OLIVER HEAVISIDE.

(*Continued from page 352.*)

The characteristic of the whole combination, whose vanishing settles the admissible rates of subsidence, may be taken to be the conductance operator at any point, specialised by regarding p as a constant, all other forms being derivable from it. The normal functions are always entirely real when electric energy alone is concerned, and also when magnetic energy alone is concerned, though the latter does not occur in the above diffusive applications. In intermediate cases, the p's may be either real or complex. There is more to be said about these things in other electrical applications, but the present remarks are sufficient for the immediate purpose.

There is no material alteration when, by means of cross connections, we convert the above arrangement of cables entirely in sequence into a network of cables, of any degree of complication. To make the normal system complete, it must be continued over all the branches. We may use different symbols to indicate position, or we may use the same symbol with a different range. These things are immaterial. We still have to regard the normal system, though made up of many parts, as a single system, self-contained. At the same time, as before, any parts thereof may be left out, provided the proper operators are employed to sum up their reaction upon the retained parts.

§ 327. We should now point out how a normal solution, as above specified, differs from what I have usually called the operational solution. There are likenesses and differences. Let the electrical arrangement be the same, either a single circuit of cables or a network; but now consider how to find the operational solution expressing the effect all over the combination due to impressed force at any point therein. It may be impressed voltage e, or impressed gaussage h. The former will create a discontinuity in the potential, the latter in the current, and these constitute the effective sources of disturbance, whereby energy is brought into the combination. We have here a difference from the self-sufficiency of a normal system.

We have to find V (and C) all over due to e or h; say $V = Xe$, for example. The form of X is wanted. Since e is at a definite point, whilst V is anywhere, X is a function of x, specifying position in the combination. It is not the same function (in its expression) in different branches, but since all the different forms have to be harmonised, we may still regard X as a whole, changing its form of expression as we pass over the combination. In this respect it is like the normal function. But at the same time, it is a function of p, the time differentiator, and varies in form as concerns p as well as x, because p enters along with the electrical constants.

To find X fully, we proceed as in the case of a normal function, to divide the combination into sections involving only one characteristic. But we do not assume that p is constant in the characteristic. It remains what it is fundamentally, a differentiator. So, in the general solution of any section, say $V = av + bw$, the a and b are not now constants, but time functions, and v, w are not merely algebraical functions, but differential operators. We may write $V = va + wb$, if we wish to explicitly indicate that a and b are operated upon by u and w. But this is a matter of convention. A cart may be pulled or pushed. Another form is $V = (v + jw)\,a$. Here there is but one time function explicitly. The other is ja, where j is an operator.

Now supposing we have found the general solutions of V for every one of the sections, we have next to harmonise them by the conditions at the junctions. This process is, up to a certain point, formally like that of harmonising the different parts of a normal function. The difference comes in when, say finally (though it may be done initially) we treat the section containing the impressed force. There is nothing special there in a normal solution. But in the operational case we have an additional split. The section is made two sections, and there are two auxiliary conditions, as, continuity in C, and a jump in V produced by e. The result is that all the time functions in all the branches become known in terms of e. Or, in another form, in $V = Xe$, we know the operator X completely throughout the combination, and there is nothing left over to be fixed by extra data. In the case of the normal system, on the other hand, its size is left quite indefinite. Apart from this, the normal system constitutes a succession of values making it be a numerical function of x. It is one of a set, for the constant p in it may have any one of a particular series of values. It is different in an operational solution. The operand e is any function of the time, and X by itself is not numerical. But the determinantal equation is implicitly involved. For if we put $e = 0$, producing $0 = X^{-1}V$, the latter is the general characteristic of the solutions when free from impressed force. If it is, as in most of our applications, a rational equation, then $X^{-1} = 0$ finds special solutions, of the type $\epsilon^{pt} \times f(x)$. This brings us to the normal functions again. I have shown how to expand $V = e/X^{-1}$ in normal functions when they are appropriate. From the examples given, it will be seen that the operator X itself may be regarded as expressing the type of the normal function (apart from size), viz., by making p in it become constant and assume one of the critical values. It then also simplifies in form, in virtue of the determinantal equation. The greater generality of the form of X is essential. The normal system cannot be more than it is. The other has to cover all possible cases, and is constructed to do it.

Similar remarks apply when the source is h, impressed gaussage, equivalent to an external source of current. This brings us to the normal functions again from another point of view, viz., when there are no impressed forces given whose effect is required, but the data consist in the specification of an initial state of V and C, from which the subsequent states arise. We convert this general problem to a special case of the former by the use of impulses. There are two sorts. Let $e = p\mathrm{P}$ and $h = p\mathrm{Q}$, where P and Q are constants, or, more strictly, constant functions of the time when t is positive, and zero when t is negative. Then e is merely the impressed voltage in an impulse at the moment $t = 0$, the total of the impulse being P. Similarly, h is the impressed gaussage in an impulse of total Q. That is, as before explained, the charge Q is instantly introduced, and then left to itself. Similarly as regards P. It represents magnetic momentum. The analogue of $\mathrm{Q} = \mathrm{SV}$, where S is the concrete permittance connecting the charge Q and the voltage V, is $\mathrm{P} = \mathrm{LC}$, where L is the concrete inductance connecting the momentum P and the current C. But in the case of a cable, if S and L belong to unit length, Q and P are the length integrals of SV and LC. Now the initial state is fully specified by V and C. That is, P and Q are given, or which is the same thing, e and h. In our diffusion problems, we do not require to know C at all, that is, e equivalently, because the assumption $\mathrm{L} = 0$ destroys the momentum. That is why only $h = p\mathrm{Q}$ has been employed in discussing initial states, and the expansions required to represent them. But, in general, when L is included, we must use both e and h to obtain the proper expansions. The addition of the impulsive e is important because it enables us to treat the electromagnetic problems with generality as regards initial states, and from the operational standpoint.

§ 328. The object of the mathematical investigation of physical matters being to ascertain what happens under given circumstances, and map out the field of knowledge, so to speak, the method of normal functions, or modes of vibration, or of subsidence, or of time variation in more mixed manners, is one of the most important ways of working to the desired end. But whether it should be used, and if so, how it should be used, depends upon circumstances. There are other methods. It may be that only very partial knowledge is wanted—*e.g.*, the general nature of normal modes—and then it may be quite unnecessary to resort to operational methods, though their use will often settle matters which are obscure without them. On the other hand, operational ways are much the best in dealing with the effects of localised impressed

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forces, and the study of such cases is often most instructive. The most serious drawback to the method of analysis into normal systems is that, beyond a certain point, the numerical examination of general results becomes impossible in any reasonable time. This is of no consequence in theory, but is a great practical objection. We should go to the operational solutions for information. We may turn them to normal systems if we want to, and if we do not, we can apply other methods to them. The most important is usually the simply periodic, from the wide application possible, involving the reduction of $V=Xe$ to $V=(X_0+X_1 i)e$, where e is simply periodic and i is the differentiator $d/d(nt)$. Some other special ways of working have been given, and I will give more later on. The discovery of practical methods of manipulating operators is a matter of importance to the future of physical analysis. Objections founded upon want of rigour seem to be narrow-minded, and are not important, unless passive indifference should be replaced by active obstructiveness. In making them rigorists make confession of ignorance. It would be more useful for them to try to extend the matter, and remove the want of rigour, if they want to. But this is merely parenthetical.

Returning to the simply periodic solution just mentioned, it may be worth while to point out two ways of connecting it with solutions in series of normal functions. Suppose we have a telegraph line of any sort, and desire to express the current C at the distant end (or anywhere else) in terms of e at its beginning. We may do this operationally, of course. Say we come to $C=Ye$. Now, given that e is impulsive, we can convert the result to a series of normal functions. Next, observing that if e is given variable in any way with the time, it may be regarded as made up of a succession of infinitesimal impulses, we see that the last solution in normal functions, by being used as the element of a time integral, enables us to express C when e is variable. Lastly, by choosing e to be simply periodic, the result must be equivalent to that which may be obtained directly from $C=Ye$, by the transformation $p=ni$. The method described is a very complicated way of getting the simply periodic solution, but its execution and verification is quite feasible in some cases.

The process is reversible, if we are in possession of all the steps. But if not, if we only know the simply periodic solution, obtained directly from the operational, there is another and much shorter way of passing to the solution when e varies anyhow—namely, by analysing an impulse into simply periodic variations. Thus, the impulsive voltage $e=p\mathrm{E}$ is equivalent to

$$p\mathrm{E}=\frac{\mathrm{E}}{\pi}\int_0^\infty \cos nt\,dn, \tag{113}$$

by (54) § 271. The simply periodic solution for the element $(\mathrm{E}/\pi)\cos nt\,dn$ is obtained by operating on it by Y. So

$$\mathrm{C}=\frac{\mathrm{E}}{\pi}\int_0^\infty \mathrm{Y}\cos nt\,dn=\frac{\mathrm{E}}{\pi}\int_0^\infty\left(\mathrm{Y}_0+\mathrm{Y}_1\frac{d}{d\,nt}\right)\cos nt\,dn \tag{114}$$

expresses C due to an impulsive voltage, and therefore, by a time integration, as before, we express C due to any varying e by the second method. This process can also be practically carried out, in some cases, by the evaluation of the integral. But I am afraid that, in general, the evaluation of the definite integral will present much difficulty. Considering the extreme complication introduced into normal systems by the inclusion of gradual propagation into the wires as well as along them, the process (114) seems at first sight rather enticing. It looks so simple. So it is, in idea; but if we cannot effect the integration, the integral does not tell us any more than the operational solution itself. So I found it some years ago, when I desired to trace the progress of an elastic wave along a resisting wire. The integral was unmanageable. But the operational solution itself was amenable to treatment by a specially-invented process, which had its foundation in the physical ideas involved, and which proved to be relatively simple in execution. In connection with this matter, the converse process should be noticed, viz., the transformation of definite integrals to operational form, with a view to their evaluation by any means that may then present itself. This is often a very useful practice.

But the transformation from $C=Yp\mathrm{E}$ to (114) requires to be done with caution. It may be the case that the physics is such as to show that the process is legitimate. But the legitimacy cannot be asserted when Y is an arbitrary operator, of unknown meaning. The resulting integral may not be equivalent, or may be equivalent only within a certain range. That there should be failures in this application of (113) will be understood, at least partly, by considering the application or misapplication of Fourier's theorem in the definite integral form (55), § 271, to a function which does not vanish at infinity, particularly if it is infinite itself there.

§ 329. There is little more to be said about the submarine cable without self-induction, which has been principally useful as a convenient basis upon which to rest the theory of diffusion. The application, however, of the zeroth Bessel function may be continued in a generalised form, since the Bessel functions are of great importance in mathematical physics, and have many applications in electromagnetism.

Take the problem of § 324, but now put a terminal arrangement Z_1 at $x=\lambda$, instead of having a short-circuit there. The resistance operator at the point λ is now

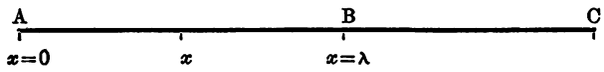
$$Z=Z_1+\frac{R_0}{q_0\lambda}\frac{I_0(q_0\lambda)}{I_1(q_0\lambda)}, \tag{115}$$

by (101), using the same notation, and it follows that if the initial state is Q at the point y, the resulting potential is

$$V=\sum\frac{QI_0(q_0x)\,I_0(q_0y)e^{pt}}{-\left(\frac{q_0}{R}I_1(q_0\lambda)\right)^2\frac{dZ}{dp}} \tag{116}$$

by the formula (83), § 322, applied to the present case, Z being given by (115), and $Z=0$ being the determinantal equation.

Now choose Z_1 to be another Bessel cable exactly like the first, but turned the other way, so that the zero conductance is at the far end. Then we make a single cable A B C, whose



conductance and permittance are greatest at B, and fall off linearly to zero at A and C. The solution (16) relates to the left one, the right one being uncharged. The resistance operator at B is twice that of either cable, or

$$Z=\frac{2R_0}{q_0\lambda}\frac{I_0(q_0\lambda)}{I_1(q_0\lambda)}. \tag{117}$$

This is such that e/Z is the current produced by e at the point B.

But it is clear on consideration that if this Z be used in (116), that result is erroneous, if limited to the roots of $I_0(q_0\lambda)=0$. For every normal system then has a node at B. This is perfectly right as regards the normal systems concerned when e is at B, because it charges the two cables symmetrically but oppositely, so that $V=0$ at B when e is removed. But it cannot be right in general, for the cables may be charged symmetrically so as to produce no current at B. Besides $I_0(q_0\lambda)=0$, we require another condition giving nodes to the current at B in a set of normal systems.

In fact, if in (115) we let Z_1 be nearly, but not quite, the same as the other term, say by the length of the right cable being slightly different from that of the left one, it will be found that the roots of Z divide into two sets, approximately those of the sum of the operators and of their difference. In the limit, the first lot lead to $I_0(q_0\lambda)=0$, with potential nodes at B, and the second lot to $I_1(q_0\lambda)=0$, with current nodes at B, the I_1 function being the derivative of I_0. The first set of normal systems are solely concerned when the initial state is such as to produce no potential at B, and the second set when such as to produce no current there.

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I have introduced this example to illustrate the need of caution in the treatment of normal systems in peculiar cases. It is a necessity for the validity of the expansion of an arbitrary initial state in normal systems that every possible normal system should be included. But it usually happens in these peculiar cases that the peculiar results can be foreseen. It may be noticed that in the denominator in (116), representing $-c^2Z'$, the quantity c vanishes at the point B for all the missing normal functions. The reader has already been cautioned not to choose a point where v vanishes in the alternative form v^2Y'. If we chose Z at some other point, between B and A or C, there would be no failure.

In the treatment of this problem by the operational solution, there is no room for hesitation. Put Q at y in the left cable, and find the resulting V in the usual way. We require, of course, to use the second solution, $K_0(qx)$, along with $I_0(qx)$. The result is, writing q instead of q_0, for convenience, and R instead of R_0,

$$V_2 = I_0(qy)\left\{\frac{\pi}{2}K_0(qx) - \frac{I_0(qx)}{2q\lambda I_0(q\lambda)I_1(q\lambda)}\right\}RpQ, \qquad (118)$$

at x, on the right side of y; and the same expression with x, y interchanged serves when x is on the left side. This result is explicit in making

$$I_0(q\lambda)I_1(q\lambda) = 0 \qquad (119)$$

be the determinantal equation when (118) is expanded in a series of the normal functions $I_0(qx)$, and shows the two sets. The $K_0(qx)$ function, though required in general, then disappears altogether. Developing (118) by the expansion theorem, we get

$$V_2 = V_0 - \Sigma\frac{RpQI_0(qx)\epsilon^{pt}}{\{q\lambda I_1(q\lambda)\}^2} - \Sigma\frac{RpQI_0(qx)\epsilon^{pt}}{(q\lambda)^2 I_0(q\lambda)I_1'(q\lambda)}, \qquad (120)$$

where the first summation is subject to $I_0(q\lambda) = 0$, and the second to $I_1(q\lambda) = 0$. The accent means differentiation to $q\lambda$. There is a steady term V_0 because there is no earth connection. It is obtained as usual by making $p = 0$ in the operational solution (118). The result is

$$V_0 = \frac{Q}{S\lambda^2} = \frac{Q}{\text{total permittance}}, \qquad (121)$$

if the permittance per unit length is Sx in the first cable, and symmetrically in the second. The change to the oscillating functions $J_0(sx)$ and $J_1(sx)$ by means of $q^2 = -s^2$ is obvious. But this is a special case of the next investigation, so it is only needful to record the results as above.

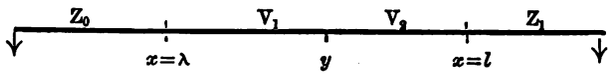
§ 330. Passing now to the general case involving the zeroth Bessel functions of both kinds we can obtain our results very shortly and symmetrically by the operational method. Let terminal arrangements Z_0 and Z_1 be put on at the points $x = \lambda$ and l, in a cable subject to the circuital laws

$$-\frac{dV}{dx} = \frac{Z}{x}C, \qquad -\frac{dC}{dx} = Yx V, \qquad (1)$$

V and C being the voltage (transverse) and current at x, where the resistance and leakance operators per unit length are Z/x and Yx. Here Z and Y are independent of x, and are preferentially of the forms

$$Y = K + Sp, \qquad Z = R + Lp, \qquad (2)$$

R, L, K, and S being constants, being the values at the point $x = 1$ of the resistance, inductance, leakance and permittance per unit length. It is merely the introduction of variation



with x in the manner specified that introduces Bessel functions.

The characteristic of V, obtained by eliminating C from (1), is

$$\frac{1}{x}\frac{d}{dx}x\frac{dV}{dx} = YZV = q^2V. \qquad (3)$$

Later on, we can give different meanings to q, according to those assumed for Y and Z.

The two solutions of the characteristic are

$$I_0(qx) = 1 + \frac{(qx)^2}{2^2} + \frac{(qx)^4}{2^2 4^2} + \frac{(qx)^6}{2^2 4^2 6^2} + \ldots$$

$$K_0(qx) = \frac{2}{\pi}\left\{-I_0(qx)\left(\log\frac{qx}{2} + \gamma\right) + \frac{q^2x^2}{2^2} + (1+\tfrac{1}{2})\frac{q^4x^6}{2^2 4^2} + (1+\tfrac{1}{2}+\tfrac{1}{3})\frac{q^6x^6}{2^2 4^2 6^2} + \ldots\right\}, \qquad (4)$$

where $\gamma = 0{\cdot}5772$ is a certain constant introduced to make $K_0(qx)$ vanish at infinity. That these are solutions of the characteristic is easily verified; and since they are not in constant ratio, it follows that they are sufficient to express all solutions directly or indirectly. That is,

$$V = \{I_0(qx) - jK_0(qx)\}A, \qquad (5)$$

where A and jA are any time functions, is the general solution of the characteristic, j being any operator.

When qx is numerical and positively real the I_0 function is like ϵ^{qx}, finite at the origin and increasing continuously to infinity at infinity. The K_0 function, on the other hand, is like ϵ^{-qx}, in falling continuously to zero at infinity. It is, however, not finite, but infinite at the origin. Both I_0 and K_0 are always positive when qx is positive.

Now construct the operational solutions for e and h at the point y. The characteristic fails at that point, so we have two forms, say

$$V_1 = \{I_0(qx) - \alpha K_0(qx)\}A, \qquad (6)$$

$$V_2 = \{I_0(qx) - \beta K_0(qx)\}B, \qquad (7)$$

where V_1 holds when x is on the left, and V_2 when on the right side of y.

In the case of e, we have

$$e = V_2 - V_1, \qquad C_1 = C_2, \qquad (8)$$

at the point y. These conditions, applied to (6), (7) determine A and B, and produce

$$V_1 = \frac{\pi qy}{2}e\frac{(I_{0x} - \alpha K_{0x})(I_{1y} - \beta K_{1y})}{\alpha - \beta}, \qquad (9)$$

$$V_2 = \frac{\pi qy}{2}e\frac{(I_{0x} - \beta K_{0x})(I_{1y} - \alpha K_{1y})}{\alpha - \beta}, \qquad (10)$$

which are quite general, as due to the source e. The operators α and β enable us to introduce terminal conditions. Say

$$V = Z_1C \text{ at } x = l, \quad V = -Z_0C \text{ at } x = 0, \qquad (11)$$

These determine α and β, thus,

$$\alpha = \frac{I_{0\lambda} - (q\lambda Z_0/Z)K_{0\lambda}}{K_{0\lambda} - (q\lambda Z_0/Z)K_{1\lambda}}, \qquad \beta = \frac{I_{0l} + (qlZ_1/Z)I_{1}e}{K_{0l} + (qlZ_1/Z)K_1 l}. \qquad (12)$$

Equations (9), (10) are now made fully explicit in terms of the terminal operators, and may be developed in Bessel series.

As regards the notation, I_1 and K_1 are the derivatives of I_0 and K_0; and, to ease matters, $I_0(qx)$ is denoted by I_{0x}, and similarly for the rest.

When h is the source, we still use (6), (7), but instead of (8) we have the conditions

$$V_1 = V_2, \qquad C_2 - C_1 = h, \qquad (13)$$

at y. These find A and B, and make

$$V_1 = \tfrac{1}{2}\pi Zh\frac{(I_{0x} - \alpha K_{0x})(I_{0y} - \beta K_{0y})}{\alpha - \beta}, \qquad (14)$$

$$V_2 = \tfrac{1}{2}\pi Zh\frac{(I_{0x} - \beta K_{0x})(I_{0y} - \alpha K_{0y})}{\alpha - \beta}. \qquad (15)$$

The expressions for α and β are the same as before. The determinantal equation of normal systems is

$$\alpha = \beta. \qquad (16)$$

The h solutions are required to represent initial states of potential, and the e solutions those of current. In obtaining them use was made of the identity

$$I_0(z)K_1(z) - I_1(z)K_0(z) = -\frac{2}{\pi z}, \qquad (17)$$

which often turns up in these investigations.

(To be continued.)

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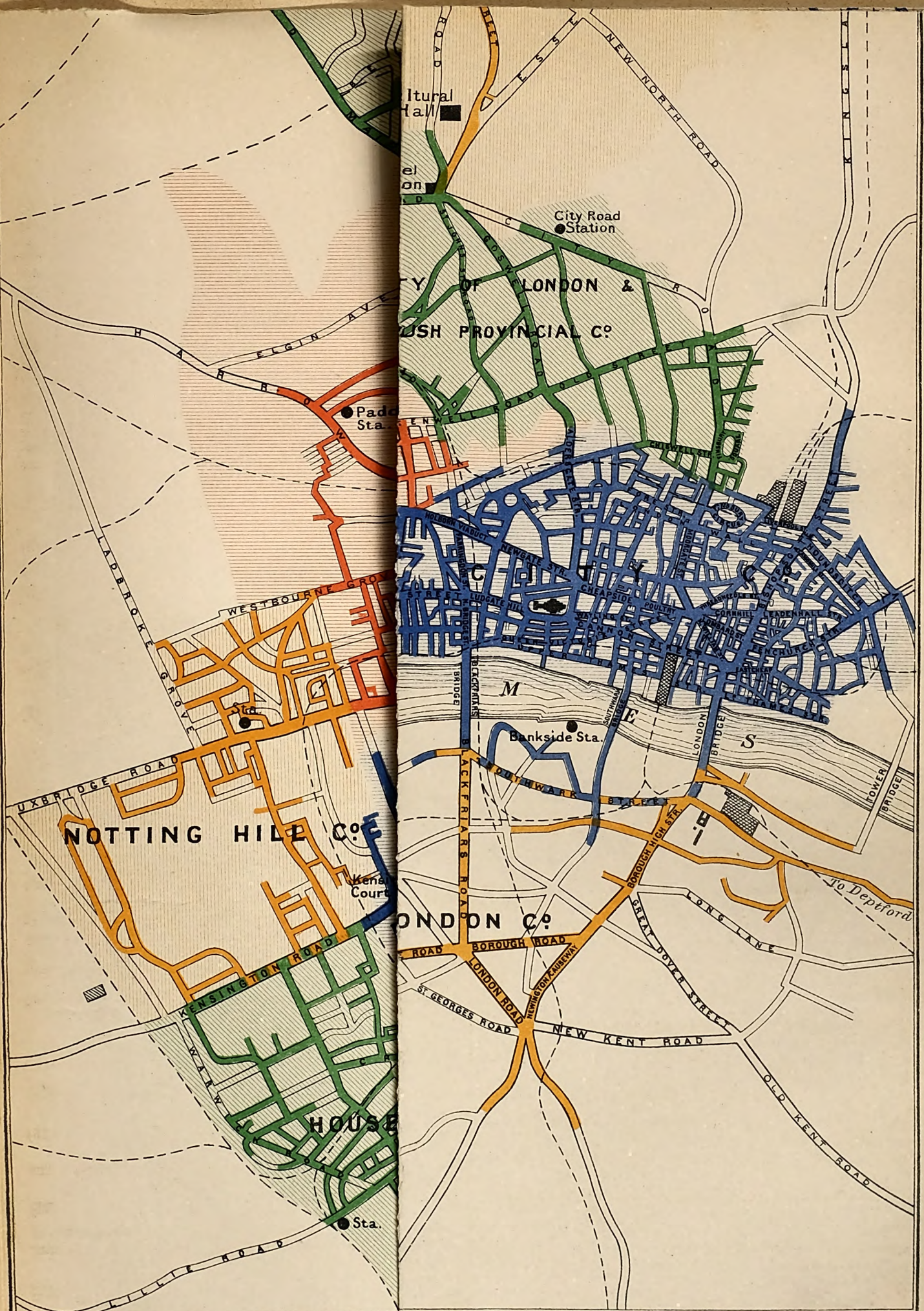

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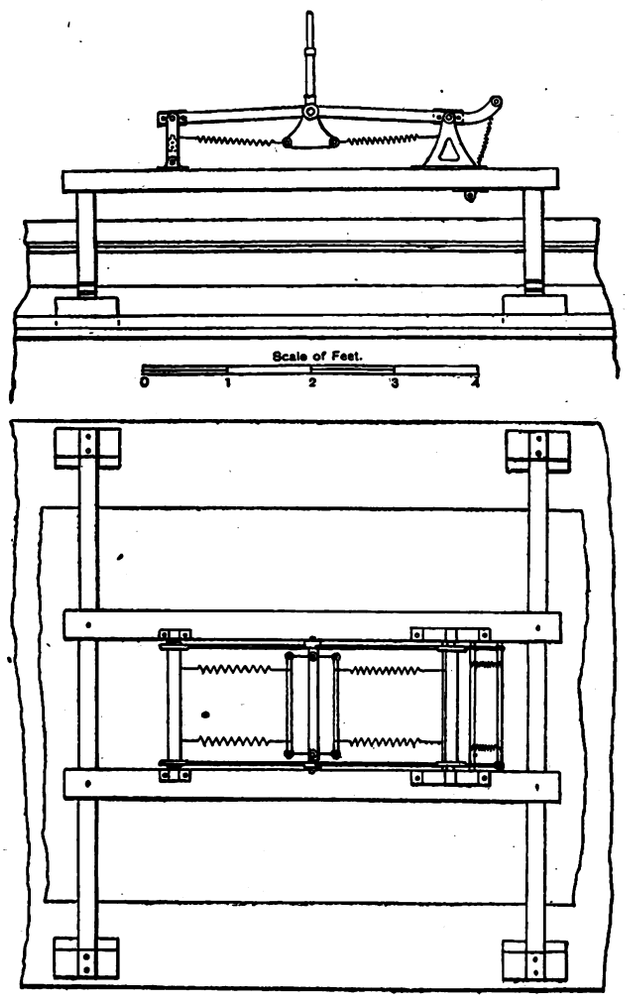
THE SIEMENS AND HALSKE SLIDING CONTACT SYSTEM FOR ELECTRIC TRAMWAYS.

The accompanying illustrations show in some detail the well-known sliding contact collector of Messrs. Siemens and Halske. This apparatus, which is intended to perform the same function as its American congener, the trolley, in overhead wire electric traction, consists of a metal frame, pivoted and spring-supported on the deck of the car; the upper part of the frame carries a horizontal contact bar extending for a transversal length of 4ft. or 5ft., and made of special metal. This bar slides with constant pressure on the line wire.

As compared with the ordinary trolley, or rolling contact collector, the Siemens apparatus offers the great advantage of ensuring permanent communication with the supply line under all conditions. It entirely does away with the frequent



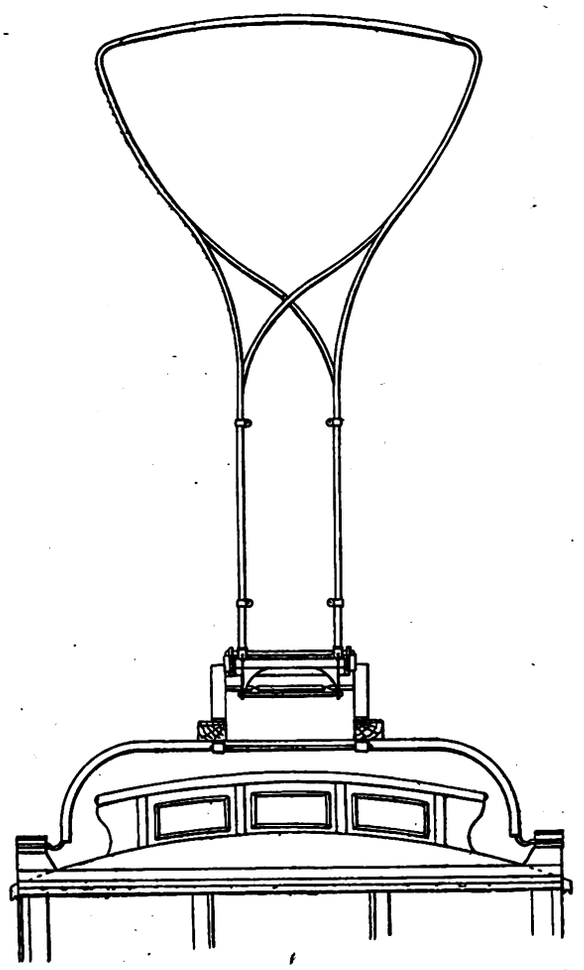
Siemens and Halske Sliding Contact System. Longitudinal Elevation and Plan of Mounting.

interruptions of contact due to the jumping of the trolley, especially on curves or passing under frogs, wire hangers, &c., when the speed is not kept within a low limit.

Objection has been raised against the use of the sliding contact on account of the considerable friction and the consequent noise and wear of the working parts. Messrs. Siemens and Halske claim, however, that the noise with the sliding collector is not greater than that experienced with the trolley, and, as regards the wear, by constituting the contact bar of a special soft alloy the line wire is not only protected from any deterioration, but its lower surface becomes gradually covered with a layer of particles from the softer metal, the contact thus becoming improved. All the wear is taken by the contact bar, which is interchangeable, and may be easily replaced. In order not to concentrate the wear on a single point of the bar, the line wire is stretched with slight deviations from the axis of the track, making a kind of zigzag.

A recent improvement introduced by Messrs. Siemens into this system consists in the substitution of a soft alloy contact bar with an aluminium channel, of U-shape and filled with grease, so as to ensure a certain lubrication of the contact. It is stated that by this contrivance all noise is practically avoided, and less power is lost in friction, beside which the renewal of the slider bar need not be so frequent.

If the latter claims should be confirmed after long practical experience, the Siemens apparatus may be expected to replace the trolley in most applications of electricity to traction, and



Siemens and Halske Sliding Contact System. Transverse Elevation.

especially where the speeds are greater than usual. The Siemens and Halske collector has been working successfully at Hanover, Dresden, Bucharest, Lemberg, Bochum, Barmen, Basle, Vienna, Berlin, Pankow, &c.

THE "HORNSBY" WATER-TUBE BOILER.

Messrs. Hornsby and Sons, of Grantham, have for some time past been conducting trials and making experiments with a view to perfecting a type of steam generator which is most commonly used in electric supply stations—namely, the water-tube boiler. The result of their inventions has attained the form shown in the accompanying vertical section of the boiler, and two boilers of this type and pattern have been erected at the Woking electric supply station, where, we understand, they have given satisfaction.

It will be seen that the "Hornsby" boiler possesses several features which will distinguish it from the class of water-tube boiler commonly met with. One of the most striking features is the arrangement for giving efficient circulation through the lower tubes, the vertical return tube delivering the water to the header opposite to the lowermost layer of tubes. This must tend to increase the evaporative efficiency and steaming capacity of the boiler, while obviating the risk of breakdown

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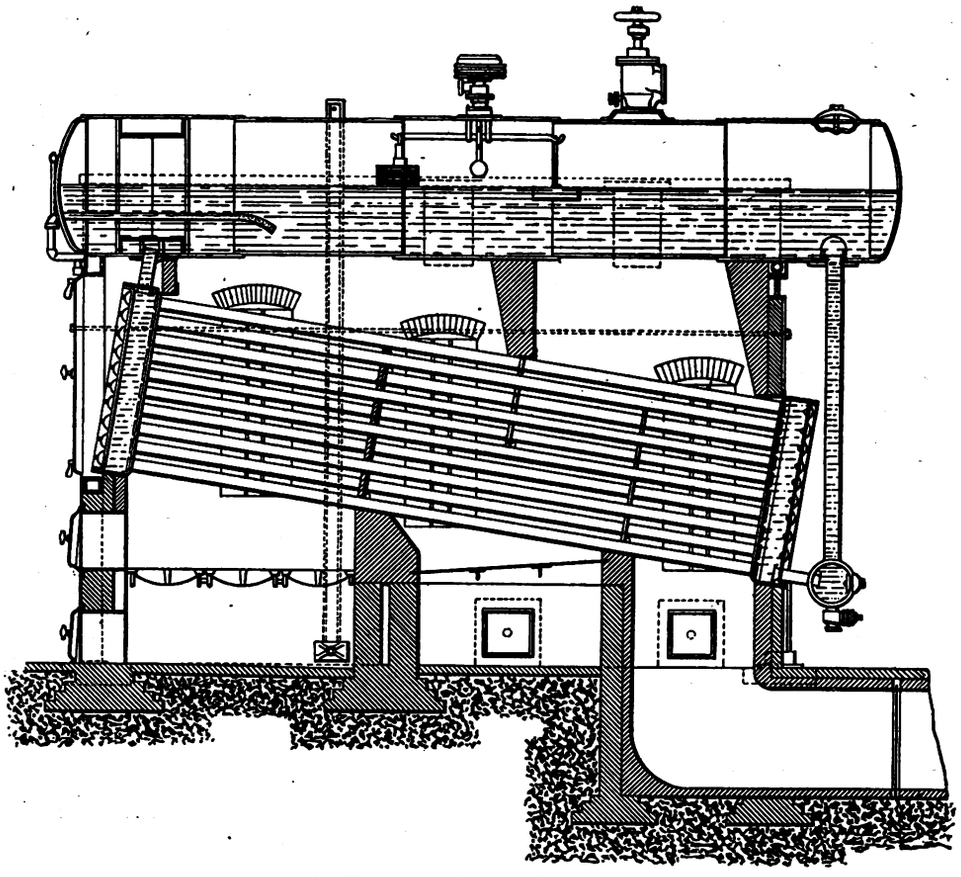
due to the choking of the lower tubes with steam. Another valuable feature is the provision of a water separator at the top of the up-take tube, this separator consisting of an annular chamber inside the steam drum. By its action the steam passes into the steam space in a much drier condition than if compelled to bubble up through the water.

has a separate header, is said to be beneficial in preventing the entry of cold air between the tube ends. It should be stated that the front ends of the tubes are expanded to facilitate the drawing out and replacement of tubes. The illustration shows that the rear tube ends and header are carried beyond the brick setting, thereby enabling any defect in the tubes at this



Hornsby Water-tube Boiler. Longitudinal Section.

The tube headers both at the front and back ends of the tube stack are each made in one piece, an arrangement which is found to be conducive both to strength and to economical steaming. The absence of gaps between the headers at each end, such as will occur where each vertical column of tubes

part to be readily detected, and any repair to be easily carried out. The boiler can be adapted for burning either dry or bituminous coals, and, as we have already stated, is said to give very satisfactory results. Results of actual trials are not yet, however, forthcoming.

GERMAN WIRING RULES.*

The Special Committee of the Verband Deutscher Elektrotechniker, which was appointed during the Annual Meeting at Munich last year, has now (January, 1896) revised and approved of the proposed wiring rules (*see* also *The Electrician* of May 24, 1895, page 116, and of August 2, 1895, page 443). The Verband has now published the full text of the rules, and hopes that electrical engineers and manufacturers in Germany will speedily adopt the rules, though the Verband has, of course, no legal right to enforce them.

Much discussion arose as to whether the sizes of fuses should be determined by the current intended to traverse them or by the section of the conductor to be protected. A second much-discussed question was the amount of insulation required. It was argued that whilst from a purely theoretical point of view it was correct to proportion fuses to the current, but difficulties were experienced in the practical application of this principle. In many cases to keep the fall of potential within certain limits the section of the conductor has to be taken considerably larger than required by the current, which would necessitate specially-constructed terminals between the conductors and fuses. Standards for fuse blocks and fuses having been already adopted at Munich, it was further argued that these standards must be adhered to, as they had been already accepted by the German electrical industry. If the size of the fuse were to be determined by the current, changes would be required every time that lamps were added. In consideration of these circumstances the Committee adopted the principle that the sizes of fuses were to be determined by the section of the wire intended to be protected.

With regard to the right amount of insulation for installations, two formulæ have, so far, been in use. One was $R=K\frac{E}{I}$, where E represents the potential, I the maximum current, and K is a coefficient. No mention is made of the number of lamps, and, as every electrician knows, the difficulty to obtain a good insulation lies not in the long run of wires, but in the joints, fuses and switches, so that a disregard of the number of lamps cannot be technically justified. In the so-called Vienna formula the coefficient K is equal to 5,000. Accordingly, a 100-volt installation for 2,000 50-watt lamps would require an insulation resistance of 500 ohms. The same resistance would suffice for a 100-kilowatt motor plant, together with its supply conductors. It is, of course, at once clear that in this latter case a higher resistance not only can, but must be obtained, if both installations are to offer the same degree of safety against fire. One can see that the formula in question does not suit both cases, and to rectify this state different insurance companies have adopted formulæ in which the number of lamps is brought into consideration. In general $R=Kn$ is the formula, in which n represents the number of lamps, and K is a coefficient which depends upon the potential, the kind of current, and the more or less severe conditions required by the insurance companies.

In the Phœnix formula, the coefficient for potentials up to 220 volts continuous current is $12{\cdot}5\times10^6$, and in alternating current 25×10^6. According to this, a continuous-current installation of 2,000 lamps would require 6,250 ohms, and the same installation with alternating current 12,500 ohms insulation resistance. This is

* Abstract from the *Elektrotechnischc Zeitschrift.*

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12½ and 25 times larger than is required by the Vienna formula. Such a high insulation can of course be easily obtained under favourable conditions, but it cannot be relied upon in all cases, and for this reason the Phœnix formula must be considered as too severe for general practice. Even the Phœnix office itself has declared it so, as in addition to the paragraph on insulation resistance, it is stated the representative of the Company is empowered to allow smaller insulation resistance in certain cases. Under these circumstances it will be scarcely otherwise than that the exception will become the rule, and for this reason the Committee of the Verband has reduced the coefficient from 12,500,000 to 1,000,000. An insulation resistance of $\frac{1,000,000}{n}$ for the whole installation would, however, offer no guarantee of fire safety. In fairly good work 10 megohms per lamp can easily be reached. Suppose that, in an installation of 2,000 lamps, all lamps are fitted well except 10. The insulation of the 1,990 lamps at 10 megohms each is about 5,000 ohms, while the insulation of the 10 badly-fitted lamps may be together only 1,000 ohms. The reduction of the resistance to 1,000 ohms is likely to be dangerous, but in spite of this a test of the whole installation would show an insulation resistance of 830 ohms, which is considerably more than the 500 ohms required by the Verband's rule. The instance just mentioned shows that even if the number of lamps is regarded, the formula does not always offer a guarantee for safety. To minimise this evil the Committee of the Verband has made it a rule that not only must the whole installation comply with the formula $R = \frac{10^6}{n}$, but no part of the installation must have a smaller insulation resistance than $10,000 + \frac{10^6}{n}$. The introduction of the constant factor of 10,000 ohms is for the purpose of avoiding the danger indicated above, which could arise in an otherwise good installation through a few badly-installed lamps. In tests the wiring may be subdivided to suit convenience, and the smaller the divisions the easier it will be to comply with the formula, as the influence of the constant factor of 10,000 ohms becomes smaller, the smaller the number of lamps.

The following is an abstract of the more important rules. These rules apply to electrical installations with potentials up to 250 volts between any two conductors or one conductor and earth, with the exception of underground networks and electro-chemical plants :—

Copper conductors must possess such a conductivity that 55 metres of wire of 1 sq.mm. section have at 15°C. a resistance of not more than 1 ohm. The maximum permissible current for copper wires and cables is as given in the following table :—

Nearest S.W.G.	Section in sq. mm.	Current in amperes.	Nearest S.W.G.	Section in sq. mm.	Current in amperes.
19	0·75	3	19/17	35	80
18	1·0	4	19/15	50	100
17	1·5	6	19/13	70	130
15	2·5	10	19/12	95	160
13	4·	15	37/14	120	200
12	6·	20	37/13	150	230
9	10·	30	37/12	210	300
7/16	16·	40	61/13	300	400
19/18	25·	60	91/12	500	600

The smallest permissible cross-section for conductors is 1 sq. mm. (about No. 18 S.W.G.), for fittings ¾ sq.mm. (about No. 19 S.W.G.), and for flexible conductors 1 sq. mm. These latter must not be fixed permanently along ceilings or walls. For fixing conductors, porcelain insulators, cleats and tubes can be used ; *wood casings are not permitted*. The size of fuses is conditioned by the section of the smallest of the conductors to be protected, and the highest permissible fusing current is to be taken from the following table :—

Nearest S.W.G.	Section of conductor wire in sq. mm.	Working current for conductor in amperes.	Fusing current in amperes.
19	0·75	3	6
18	1	4	8
17	1·5	6	12
15	2·5	10	20
13	4	15	30
12	6	20	40
9	10	30	60
7/16	16	40	80
19/18	25	60	120
19/17	35	80	160
19/15	50	100	200
19/13	70	130	260
19/12	95	160	320
37/14	120	200	400
37/13	150	230	460
37/12	210	300	600
61/13	300	400	800
91/12	500	600	1,200

In installations on the three-wire system the fuses of the middle wire must be 1½ times the size of the fuses of the outer wires. When the middle wire, however, is permanently earthed, no fuse is required. The insulation resistance of the whole conductor network to earth must be at least $\frac{1,000,000}{n}$ ohms, and, in addition, each main branch must have an insulation of at least $10,000 + \frac{1,000,000}{n}$ ohms. In these formulæ n is the total number of 50-watt glow lamps connected ; one arc lamp, motors, or other energy-consuming apparatus being reckoned as equal to 10 glow lamps.

In making insulation tests to earth with continuous current the negative pole of the generator should, if possible, be connected to the conductor which is to be tested. The readings must only be taken after one minute's electrification. All insulation tests must be made with the working pressure. In multi-wire systems the pressure at the lamps is to be taken as the working pressure. In all the insulation tests all glow lamps, arc lamps, motors and other apparatus must be disconnected, but all fittings, fuses and switches must be in the circuit.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, January 24th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read : (1) "Exhibition of Some Geometrical Instruments," by E. Scott and Signor Monticolo ; (2) "On Resultant Tones," by J. D. Everett ; (3) "Experiments with Incandescent Lamps," by Sir David Salomons.

SATURDAY, January 25th.

THE INSTITUTION OF JUNIOR ENGINEERS.

7 p.m. Anniversary Dinner at the Westminster Palace Hotel Victoria-street.

MONDAY, January 27th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture II. : "Alternate-Current Transformers," by Dr. J. A. Fleming, F.R.S.

TUESDAY, January 28th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read : "Recent Developments in Gas Engines," by Dugald Clerk.

WEDNESDAY, January 29th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read : "Standards of Light," by W. J. Dibdin.

THURSDAY, January 30th.

INSTITUTION OF MECHANICAL ENGINEERS.

7:30 p.m. Annual General Meeting at 25, Great George-street, Westminster. Papers to be read : (1) "Telemeters and Range-Finders for Naval and Other Purposes," by Profs. Barr and Stroud ; (2) "Calculation of Horse-Power for Marine Propulsion," by Lieut. Col. Thomas English.

FRIDAY, January 31st.

INSTITUTION OF MECHANICAL ENGINEERS.

7:30 p.m. Annual General Meeting at 25, Great George-street, Westminster. Paper to be read : "Notes on Steam Super-heating," by William H. Patchell.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at the St. James's Hall Restaurant (Banquet Room), Regent-street, W.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Geneva Exhibition.—The Swiss National Exhibition begins at Geneva on May 1st and terminates October 15th. Colonel Turrettini, Mayor of Geneva, the distinguished electrical engineer, is president of the exhibition, and it is expected that the electrical exhibit will be a fine one. There will be a travelling footpath, operated by electricity, traversing the great machinery hall ; horseless cabs driven by electricity, &c, and Prof. Pictet will display his inventions for producing intense cold.

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The Electrician.

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NOTICE.

With the current number of "The Electrician" is issued as a Supplement (Gratis) a Coloured Map of London Mains and Districts. Complaints of non-receipt should be at once sent to the publisher.

THE ARRANGEMENT OF OUR IDEAS.

Apparently the President of the Institution of Electrical Engineers has been for the past ten years so deeply immersed in the toils of his professional career as to be unfamiliar both with the methods of the technical colleges and with the views of Mr. OLIVER HEAVISIDE. Perhaps we ought to rejoice at the circumstance, because when we read his Presidential Address it is the more delightful to find him independently arriving at the same ideas and expounding them with all the freshness of original discovery. For apart from the perplexities of a mathematical intermezzo, and the scherzo of an ether-less theory of waves in space, the composition to which he treated his audience combined sundry familiar themes. The opening (after a military fanfare by way of prelude) was in the allegro manner, a cheerful progression of chords—not by any means all common. Then a modern *motif*. Why not abandon all the century-old stale methods of working out a theme? Nothing easier. Throw aside the old fundamental starting point. Remodel your ideas in the new manner. And the concluding coda of the performance repeating the introductory movement brought down hearty cheers.

What, then, did Dr. HOPKINSON imply in his suggestion that we should remodel our ideas as to electric actions, and treat them from the standpoint of modern discoveries? How far does he wish us to go? Clearly the exposition of a science in which all the phenomena are interlinked might begin with any one of them. One might start with the fundamental fact of thermo-electric transmission of heat, or of ARAGO's rotations, or of the electric motor, and work out thence all the other electric phenomena. The historic method, as Dr. HOPKINSON pointed out, begins with electrostatics and the attractive properties of rubbed amber. But now we are invited to a step forward, and start, not from the phenomenon of *charge*, but but from that of *current*—of current as generated by chemical

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means. About this phenomenon, rather than the older phenomenon of charge we are to arrange, or rather re-arrange, our ideas; and following up this plan we are shown that many of the more complex notions, even that of the electromagnetic theory of light, can readily be brought into line and modernised.

But it is not quite clear from the address how far the PRESIDENT is willing to go in re-arranging our ideas on the fundamental basis of the electric current as a simple phenomenon. If he goes no further than this: that for a man studying the science for the purpose of making himself useful in the industrial applications of electricity, it is best to take the so-called "current" as a simple directed quantity, and to build up a knowledge of the facts about it without first having recourse to a glass rod or a piece of sealing-wax, Dr. HOPKINSON will have the support of every one conversant with the subject. For in all our technical colleges that method of approaching the subject is successfully employed; and in modern books, such as Prof. AYRTON'S "Practical Electricity," it is carried out just as Dr. HOPKINSON would wish. If it is suggested, however, as the wording of the Address would lead us to suppose, that the electric current should be taken as the fundamental notion upon which all other notions in electricity and magnetism are to be built, there will be raised many dissentient voices. It is true that we may begin with the current or the group of facts which are called the phenomena of the current, and arrange our ideas in a way which will give a consistent account of everything that we observe in electrostatics and magnetism (as indeed is illustrated by the very neat example relating to electrostatic attraction in the Address), but it by no means follows that such a course is desirable. If the whole science were built up rigidly upon this solitary basis, there would be no place in it for the inquiry as to what an electric current may be, or why we have the heating effect, the magnetic field and the electrolysis accompanying each other. We cannot take Dr. HOPKINSON to mean that we are to be content with the experimental facts.

When during the temporary absence of the ordinary attendant the stoker is left in charge of the dynamo and switchboard, there is some resemblance between the way in which he regards the machine and the way in which a scientific man regards a voltaic cell. To the man whose only experience of a dynamo has been gained by observing the running of it from day to day it is merely an entity which lights the lamps when run up to speed, and connected with which are various little tricks and requirements which a more pedantic spirit might call "the phenomena of the dynamo." For instance, if the pointer in that instrument called "voltmeter" points to 95, it can be restored to its proper place, 100, by turning this handle to the right, or if there is sparking at the brushes it can be cured by moving the rocker. These are facts which are established in his mind by indisputable experimental evidence, just as the phenomena of the voltaic cell are familiar to the man of science. Each is in his own case ignorant of the exact connection between cause and effect. It would be possible to build up a fairly useful science, beginning with the stoker's fundamental notion of a dynamo, and proceeding with such facts as might be found out by experiments on it. Improvements in dynamo design would, of course, be difficult, but it is conceivable that central stations might be built and great deal of money made by the application of a science so restricted. Our present knowledge is, of course, far more extended and far more elastic because it is built up of simpler elements; and so will our present knowledge be further extended and made pliable when we know as much about the interior actions in a voltaic cell as we know about the interior working of a dynamo.

When we seek to obtain a complete view of that which is known of electricity and magnetism, the question arises: What shall we take as our starting point? From what pole shall we proceed on our investigation? But the question is really as futile as in an electric circuit to hunt for the place where the electricity starts. The motion is essentially circuital, one may begin anywhere and trace round to the place whence we began the quest. We may discover a definite point where energy enters or energy leaves, but the cycle is necessarily re-entrant. You may begin at any point, and track the phenomena in either direction; but to your starting point you are bound to return. So is it with the mutually inter-connected phenomena of electricity, galvanism, and magnetism. Consider the general case presented by a simple electric circuit interlinked with a simple magnetic circuit. There are six important quantities, each of which depends on the others. In the electric circuit there are three things to be considered:—The (electromotive) force E, the displacement D (depending on E and on k the inductivity), and the current C (which is equivalent to the rate of change of displacement $\dot{D}$). In the magnetic circuit there are also three things to be considered—the (magnetic) force $\mathbf{H}$ (which depends on C), the displacement $\mathbf{B}$ (depending on $\mathbf{H}$ and on μ the permeability) and the rate of change of displacement $\dot{\mathbf{B}}$, on which E in the electric circuit depend. Without being very precise as to the units, and merely for the purpose of giving a general view of the dependence of these quantities, we might group them in a circle in their order, omitting C as a separate symbol, since it is the same thing as $\dot{D}$ or $\mathbf{H}$. For typographical reasons we print them here in one line:

$$E;\ Ek=D;\ \dot{D}=H;\ H\mu=B;\ \dot{B}=E.$$

The series ends with the term with which it began. Had we begun with D (the electrostatic displacement), or with $\mathbf{B}$ (the magnetic flux per unit of area), we should still have had a re-entrant series. Grouped thus in a natural cycle, there is a strict symmetry about the relations between the quantities which makes it impossible to say that any one of them is the necessary or natural starting point. They are all necessary. The true answer to the question—What shall we take as our fundamental quantity?—depends entirely upon what problem we have in hand. If we are dealing with the supply of electric current, let us by all means adopt Dr. HOPKINSON'S suggestion and take the current as our fundamental quantity and everything else as a function of the current. And if we do so in the logical way that Dr. HOPKINSON has set out we shall, along with other benefits, obtain, as he has shown, a rational system of units such as OLIVER HEAVISIDE has advocated in our columns for years past. Irrationality cannot have long to live when it is attacked by two such opponents, and from both the practical and theoretical sides at once. If, however, we are dealing with a magnetic problem, it will be convenient to take $\mathbf{H}$ or $\mathbf{B}$ as fundamentals; if we are dealing with electrostatics, E or D. HERTZ would not have made much progress with his experiments upon electromagnetic waves if he had not had a simpler mental picture of an electric displacement than is conveyed by the expression $\int C\,dt$. The important point is that all the different methods must go hand in hand and not be set in opposition to each other. For instance, if the man who looks from the electrostatic point of view can show that the energy is transmitted through the dielectric, the man

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who looks only from the current point of view must not say "It is not known how the energy is transmitted" merely because his particular method does not make the matter clear. We think that herein Dr. HOPKINSON failed to do justice to the far-reaching discovery by Prof. POYNTING of the energy paths in space. Neither must he say "There is no ether" because in his limited presentation of the subject he has, by a metaphysical stretch of ideas, managed to dispense with a medium.

The true student of electricity will be prepared to take any one of the six quantities as a starting point, and deduce the others; then finding, as he must do in the nature of things, that they lead him round in a re-entrant cycle, he will look out for some entity outside the ring of phenomena which shall, on due investigation, prove a key to their real and inner nature, and to the ultimate cause of their interdependence.

DR. HOPKINSON'S PRESIDENTIAL ADDRESS TO THE INSTITUTION OF ELECTRICAL ENGINEERS.

When it was suddenly proposed to me that I should a second time be your President, I felt considerable reluctance to accept the duty. This reluctance arose from two causes. Of the first I am ashamed—pure laziness—and of it the less I say the better. The second was a *bonâ-fide* doubt as to whether I was specially suitable for the post. But it soon struck me that that was a matter for which those who proposed me were responsible, and not I who accepted, but had not sought the office. But if I felt a temporary reluctance, do not suppose that I for a moment failed to appreciate the honour which had been done me. To be called by his fellow professional men to fill the chair which has been occupied by men of such distinction as Kelvin, Siemens, Abel, Crookes, not to mention others, is an honour of which anyone may confess himself proud. After once having occupied this chair, to be called to it a second time is a greater honour, for it shows that one's efforts, however imperfect, have been generously appreciated by those for whom they were made. I thank you for the honour, and assure you I will do my best to verify, if I can, the judgment of those who proposed and you who elected me, rather than my own misgivings.

The century which is now just drawing to a close has been a time remarkable above all other times for the extraordinary development of our knowledge of the physical sciences, and in particular of experimental physics and chemistry, and for the extent of the practical application of this knowledge to useful purposes. The century has seen the discovery of the mechanical nature of heat, of the spectroscope, and of the whole of the science of organic chemistry; it has seen the enormous development of the application of the steam engine, the construction of our railway system, and the supersession of sailing vessels by steamboats. But perhaps the most remarkable illustration of this development is to be found in the science, and its application, with which this Institution has to deal. Consider what was known of the sciences of electricity and magnetism at the end of the last century. The two sciences were then quite unconnected. In magnetism the properties of permanent magnets were known—that is to say, it was known that steel needles could be rendered magnetic by rubbing with a loadstone, and that when so rendered magnetic they would tend to remain in that condition; it was known that if a magnet were broken in parts that each part would exhibit North and South poles like the magnet from which it was broken; it was also known that the earth exhibited properties of magnetism, inasmuch as a magnetic needle free to move would point, on the whole, to the North; broadly speaking, what we know to-day about permanent magnets was known, and that was about all. The practical applications were limited to the use of a magnetic needle in the mariner's compass. The knowledge of electricity was confined to what is now known as electrostatics. That certain bodies when rubbed exhibited peculiar properties, attracting and repelling each other, had long been observed; and the facts expressed by the hypothesis of positive and negative electricity were known—namely, that two pieces of amber which had been rubbed repelled each other, two pieces of glass which had been rubbed repelled each other, but a piece of rubbed glass and a piece of rubbed amber attracted each other. In a general way the proprieties of conductors, as distinguished from insulators, were also known in their relation to charges of frictional electricity. Cavendish had made elaborate investigations into the capacity of condensers, the condensers being usually of glass, and being charged by the old-fashioned frictional means. Franklin had proved the identity of the cause of lightning with the cause of the sparks produced by frictional electricity. Just one hundred years ago Galvani had made his celebrated experiments showing that the muscles of the limb of a frog were disturbed by contact with a piece of copper and a piece of zinc which touched each other; and that was the only fact which up to that time had ever been observed in the enormous group of facts which now constitute our knowledge of the production of electricity by chemical action. Shortly stated, that was the extent of our theoretical and experimental knowledge of electricity. The practical applications of this knowledge were almost *nil*. I can recall nothing excepting the provision of lightning conductors as a protection to buildings.

It is worth insisting that the additions to our knowledge of the properties of permanent magnets and of frictional electricity during the century have not been of great importance, and the practical applications of these limited branches of knowledge have been few. If one is asked what uses can be made of our knowledge of frictional electricity apart from the phenomena of currents, it is hard to name anything of importance. In like manner, in regard to our knowledge of permanent magnets, it may almost be said that the advances in practical applications have been confined to improvements in the use of the mariner's compass, which, most important although they are, have had comparatively little share in the changes in our conditions which the last hundred years have witnessed. Almost everything in the way of practical applications of electrical science has been the outcome of subsequent discoveries—the voltaic cell, discovered by Volta in the year 1800; Davy's discoveries in electrolysis, Oersted's discovery of the action of currents upon magnets, Ampère's discoveries of the mechanical action of currents upon currents, and Faraday's discoveries in electro-magnetism, not to mention the names of eminent men still living. Now, the remarkable thing is that none of these phenomena had ever been witnessed by mortal man. It was not that they were constantly occurring around us, and that the explanation had not been seen; it is the fact that the phenomena had never been experienced. It would seem that the phenomena of electric currents as Volta discovered them do not occur in nature on any substantial scale. Electro-magnets may be regarded as purely a creation of the human mind; so far as we know at present, no example of an electro-magnet is found in the natural world. The great currents produced by the action of electro-magnets have, so far as we know, no counterpart in nature—not only no counterpart in degree, but none in kind. In this respect our science differs much from many others. In mechanics and in heat we may find the phenomenon of which we make use occurring without our aid on an enormously greater scale than we are accustomed to use; changes are constantly occurring around us, and it is conceivable that we might have obtained much of our present knowledge by the aid of observation without experiments. But it is not so with electricity and magnetism. We should be puzzled even now to adequately illustrate the facts we know by observation alone without experiment.

Let us consider for a moment the practical applications which have been made of electrical knowledge during the last 60 years. The first, of course, is the telegraph. What are the scientific facts which have been used in the development of telegraphy? The currents are generated either by chemical means or electro-magnetic means. The receiving instruments either depend for their action on the action of currents upon magnets, or, in a limited number of cases, on electro-chemical

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decomposition. We might put it broadly thus—that, with the exception of the distinction between conductors and non-conductors and certain properties of condensers, the telegraph could do without anything that was known up to the end of the last century, and that it wholly depends upon more recent discoveries. Much the same may be said with regard to the more recent applications; the electric light, electric transmission of power, and the rapidly-growing department of electro chemistry may all be said to be quite independent of any facts which were known before the year 1800, and entirely based upon discoveries made since. Suppose it were a fact that electricity could not be produced by friction, that we knew nothing concerning the attraction which oppositely-electrified bodies have for each other, that permanent magnets did not exist—or, in other words, that iron had no hysteresis—would it make any material difference, so far as we know, in the practical applications of electrical science to telegraphy, telephony, electric light, electric transmission of power, or electro-chemistry? The permanent magnets, which are practically used only in instruments, would be at once replaced by electro-magnets, and the apparatus would work just as it does now.

Enough has been said, I think, to show that the knowledge of electricity and magnetism which was possessed by men at the end of the last century, intensely interesting though it was, has not been the parent of the great applications of later days; that the knowledge of the last century has not grown in any great degree upon the lines which existed at its commencement, but that our advances in science, as in practice, were the result of the discoveries which were made since the beginning of the present century.

It has been a frequent practice with presidents of societies devoted to promoting some department of science, theoretic or applied, to deal with the history of the science in their presidential addresses—to show how one idea has led up to another, and how marked have been the advances made. This evening I propose to adopt a different course. What I wish to consider is, how would the theory of electricity have been arranged if the order of discovery of the facts of the science had been other than it has been? Here I owe you some words of apology. You are a practical body more immediately interested in the application of science to the service of man than in the promotion of abstract knowledge. The justification I would offer for my subject is that the science of electricity, whether viewed from the practical or theoretical side, is in a state of extraordinarily rapid advance. The rules of practice of yesterday are of little use to-day, hence more discussion is needed, more publication is needed, than in departments which are in a more stable state. Furthermore, there is no department of applied science in which the connection with theory is so close and intimate. The practical electrical engineer reads eagerly the results of those who, careless whether their work finds application or not, labour to advance knowledge; he attacks these results whether they be expressed in the ordinary speech of men or in mathematical symbols. On the other hand, much of our knowledge of electricity, viewed from the scientific side, has come from those who are concerned with practical application. Nowhere else do we find a closer interdependence of pure science and practice. In what I have to say there will be much that is trite and obvious to the merest tyro in electricity. What I wish to do is to show how the facts of electrostatics can be explained by the facts of current electricity* without hypothesis; and it is necessary to rehearse elementary principles. In a complicated subject like electricity, in which the appeals to our senses are indirect, there are open to us many ways of arranging our ideas, any one of which will give us a consistent account of that which we observe. We may take as our fundamental basis one or other of various groups of facts, and deduce others therefrom. The actual arrangement of ideas on the subject depends in a measure upon the accident of the historical order of discovery. Thus, the fact that actions at a distance between electrified bodies were known many years before the phenomena of current electricity and electro-magnetism is the reason why that part of the science which treats of such actions is to-day treated first and made the basis of the rest. The time has, I think, come when we may with advantage reconsider our position, and see whether or not our ideas may be more conveniently arranged. The arrangement which is most convenient may no doubt depend upon the phenomena which occupy the most prominent place in the practical use we wish to make of the science. Those facts are best treated as fundamental which are most frequently used, provided they are sufficiently simple. To the practical electrician, are the facts of current electricity, or of the attractions and repulsions of electrified bodies, more familiar? Surely the transference of energy by current is the agent by which almost every operation he purposes is effected, whilst the phenomena of electrostatics touch him only at points in the theory of electrometers and so forth. I propose, then, this evening to sketch out very briefly, *ab initio*, how we may base the science of electrostatics upon the theory of current electricity taken as fundamental. We might, if we pleased, drop the word "current" altogether, and substitute another. It seems hardly worth while, but I shall ask you to bear in mind that, if used to-night, it does not connote the idea of anything flowing along the conductor. It is a name for a directed magnitude, and nothing more. I shall have occasion to refer to some elementary experiments, but you will bear with me, I trust, for we are concerned with arranging the subject on as small a basis of facts as is consistent with rigid deduction. Please, then, to banish from your minds all theory on the subject, and let us imagine that the facts of current electricity are first discovered, and that it is only when these are well developed that electrostatic attractions and repulsions are found out.

In a vessel of dilute sulphuric acid is placed a piece of pure zinc, or of zinc carefully amalgamated, and also a piece of copper, platinum, silver, or carbon, the two plates not being in contact with each other. It is observed that no change takes place; the acid does not attack either plate. The two plates are now touched with the two ends of a wire of copper or other metal; immediately the zinc begins to dissolve in the sulphuric acid, and gas—which, if collected, proves to be hydrogen—is found on the copper or platinum plate. If the plates are large and near together, and the wire is not too long or thick, it becomes very sensibly heated. On separating the wire from either plate, the chemical reaction and the heating of the wire cease. When the wire touches both plates there is then development of chemical energy in the vessel of acid; but a part of this energy appears as heat, not where it is developed, but in the wire connecting the plates. Whether this energy goes across the space of air between the zinc plate and the wire, or whether it goes along the wire, we do not know; but that the two plates should be rendered continuous with each other by a wire or some equivalent is a condition precedent to the chemical reaction and to the heating of the wire.

Let two such vessels of dilute acid, with plates of zinc and copper, be provided, and let the copper in one vessel be connected metallically to the zinc in the other: nothing happens until the copper in the second vessel is connected to the zinc of the first; then both zincs are dissolved, hydrogen is liberated on both copper plates, and the connecting wires are more or less heated.

Again, varying the experiment, let the coppers in the two vessels be connected together and the zincs be connected together: no reaction or heating occurs.

The combination of a piece of zinc and a piece of copper dipping separately into a vessel of dilute acid is called a "galvanic cell" or element; a series of elements connected together copper to zinc is called a "galvanic battery." Galvanic elements and batteries take a multitude of forms; the zinc may be replaced by another metal—for example, cadmium—and the copper by platinum; many other liquids than dilute sulphuric acid may be used; but all galvanic batteries have this in common—to cause them to work, the chain or circuit must be completed by a wire touching the zinc at one end of the series and the copper at the other, and then chemical reactions occur in the cells, and heat is liberated in the metal

*I am informed by Prof. S. P. Thompson that he has for some time past in his lectures began the subject of Electricity with the consideration of currents. My attention has also been called to Prof. Ayrton's excellent book on "Practical Electricity," with the contents of which I ought to have been, but was not, acquainted, in which a similar arrangement of the subject was adopted no less than nine years ago.—J. H.

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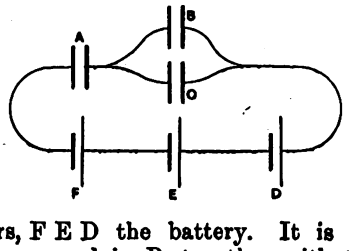
connections. The zinc and copper plates, or their equivalents, at the ends of a galvanic battery are called "poles."

Let two plates of platinum dip into dilute sulphuric acid; connect one plate by means of a wire to the zinc pole of a battery, the other plate to the copper pole. So soon as the connections are made, chemical reactions occur in the cells of the battery, the connecting wires are more or less heated, and, further, a reaction occurs in the vessel in which the platinum plates dip, the water is decomposed, gases are liberated on the two plates; if these are collected, it is found that the gas from the plate connected to the zinc pole is hydrogen, that from the plate connected to the copper is oxygen. The effects cease on detaching either wire from the platinum plate or the pole of the battery, or otherwise interrupting the continuity of the circuit. In this experiment is seen a chemical reaction liberating energy in the cells of the battery, and another chemical reaction absorbing energy in the vessel containing the platinum plates; how the energy passes from one vessel to the other we do not know.

The experiment may be varied. Let two plates of zinc or other metal dip into a solution of salt of zinc or other metal, and let the plates be connected to the poles of a galvanic battery for a time. If the plates be weighed before and after the operation, it is found that the plate which was connected to the zinc pole has gained in weight, and that the plate which has been connected to the copper has lost an equal amount. By weighing such plates, and noting the time the experiment was allowed to continue, it is practicable to examine quantitatively the phenomena of a galvanic circuit. Such pair of plates and solution of salt is called a "voltameter."

Suppose now a series of voltmeters, having in each the same metal, are connected together in a chain, a plate of one to a plate of the next, and the two ends of the chain connected to the two poles of a battery, it is found that, no matter what be the size and form of the voltameters, their position, or the arrangement of the connecting wires, there is the same gain and loss of weight of the plates in all the voltameters; it is further found that, if the zincs of the cells of the battery are weighed before and after the experiment, and if the metal used in the voltameter be zinc, the quantity of zinc dissolved is the same in all the cells, and is the same as that transferred in each voltameter. The rate of dissolution and deposit is the same in the several voltameters and cells. In a closed galvanic circuit we have, then, a measurable something the same for all cross-sections of the circuit, measurable by the quantity of zinc or other selected metal which is transferred from one plate to the other of a voltameter in a unit of time. This something has direction as well as magnitude, and as the magnitude may be represented in terms of any unit chosen by a numerical quantity C, so the direction may be represented by the sign + or −. It is arbitrarily chosen to take as + the direction from the plate which loses weight to that which gains weight through the liquid in the voltameter. The quantity C taken, with its sign, is called the galvanic or electric current round the circuit, but it must not be supposed that it is known that there is anything flowing round the circuit.

Suppose that, instead of a simple galvanic circuit, the circuit divides or branches as indicated in the sketch, in which A, B, C,



are voltameters, F E D the battery. It is found that the quantity of zinc moved in B, together with the quantity of zinc moved in C, is equal to the quantity moved in A. This gives us the idea of current in the branch B or C, and we may say that the current in A is the algebraic sum of the currents in B and C.

Not all bodies are competent to complete a galvanic circuit. Thus, if the copper wires which serve to connect the poles of the cells of the batteries and the voltameter are any of them replaced by thread, the phenomena of galvanism do not occur; if one of the wires be severed and a piece of paraffined paper interposed, the phenomena do not occur.

Thus we have a distinction of substances into those which are capable of forming continuously part of a galvanic circuit and those which are not; the former are called "conductors," the latter "non-conductors." The distinction will be found to be really one of degree.

Consider a wire forming part of the galvanic circuit: after a short time no change occurs in the wire; it is heated by the current, and it loses heat by heat conduction, convection, or radiation. It is possible by the methods of calorimetry to measure the total quantity of energy leaving the wire as heat by these agencies; it must be equal to the quantity of energy brought into the wire by galvanic agency.

Again, consider the battery itself. A certain chemical reaction is going on; zinc is being oxidised, and other reactions are occurring. Of the net amount of energy liberated per second by these, some goes to heat the battery, but some also appears in parts of the circuit external to the battery—that is, leaves the battery by galvanic agency. Thus a galvanic current is an instrument which takes energy from certain parts of the circuit and takes it into other parts of the circuit; and when the current is steady the algebraic sum of the quantity of energy taken into all parts of the circuit is *nil*. Denote by E C the quantity of energy per unit of time taken into any section, A, B, of the galvanic circuit, the positive direction of the current being from A to B. If the whole of the circuit be broken into sections, the algebraic sum of the values of E C is *nil*, but the value of C is the same for all sections; hence the algebraic sum of the values of E is *nil*. Let there be any quantity, V_a, referred to each point of the circuit, such that $V_a - V_b = E$, the condition that the sums of the values of E shall be *nil* is fulfilled. E is therefore properly described as the difference of two quantities, one peculiar to A, the other to B; it is called the difference of potential between A and B, and V_a is called the potential at A, though it is only with differences of potential that we are concerned.

Suppose now the circuit divides at A into two or more branches, joining again at B, by our definition the difference of potential between A and B is the sum of the energies taken per unit of time into the conductors A, B, divided by the sum of the currents in the conductors A, B. We have now to show that the energy taken into each of the conductors A, B, is equal to the difference of potential between A and B multiplied by the current in that conductor. This is by no means obvious, but depends on an assumption of an experimental truth, viz., that in a given conductor the energy taken into it by the current is a function of the current only, and is independent of other conditions external to the conductor. Granted this, it easily follows that, if two or more conductors be joined at A and B, the potential difference between A and B deduced from each will be the same.

As we have defined difference of potential by means of work done in a conductor when a given current exists in it, the laws of resistance must have the same basis. In the case of a homogeneous metallic conductor under given constant physical conditions of temperature, stress, and magnetic field carrying a constant galvanic current C, Joule found that the heat liberated per unit of time varies as the square of C = R C^2 when R is a constant relative to C for the conductor, Whence follows that E = R C R is called the electrical resistance of the conductor. For metallic conductors R is constant, but the constant R does not exist for all conductors; for the electric arc, for example the heat generated varies more nearly as C than as C^2, and therefore E is more nearly constant than varying as C.

We have now gained two fundamental ideas—that of galvanic current, and difference of potential. In terms of what units are we to measure them? We have only one unit to choose, because E C must be expressed in terms of our mechanical unit of power. If a unit were to be fixed at this stage, it would be natural to define either a unit of current or of resistance the ratio of $\frac{E}{C}$; for example, we might say the unit of current shall be that current whereby a unit weight of distilled water if decomposed per second; or we might say, let the resistance of

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a piece of wire of defined shape and material at a definite temperature be the unit of resistance. The units in general use have an electromagnetic basis, but be it observed that all rational systems must be such that EC is expressed in some ordinary mechanical units.

(*To be concluded*)

ON A NEW FORM OF RADIATION.*

BY PROF. WILHELM KONRAD RÖNTGEN.

1. If we pass the discharge from a large Rühmkorff coil through a Hittorf or a sufficiently exhausted Lenard, Crookes, or similar apparatus, and cover the tube with a somewhat closely-fitting mantel of thin black cardboard, we observe in a completely-darkened room that a paper screen washed with barium-platino-cyanide lights up brilliantly and fluoresces equally well whether the treated side or the other be turned towards the discharge tube. Fluorescence is still observable 2 metres away from the apparatus. It is easy to convince oneself that the cause of the fluorescence is the discharge apparatus and nothing else.

2. The most striking feature of this phenomenon is that an influence (*Agens*) capable of exciting brilliant fluorescence is able to pass through the black cardboard cover, which transmits none of the ultra-violet rays of th sun or of the electric arc, and one immediately inquires whether other bodies possess this property. It is soon discovered that all bodies are transparent to this influence, but in very different degrees. A few examples will suffice. Paper is very transparent;† the fluorescent screen held behind a bound volume of 1,000 pages still lighted up brightly; the printer's ink offered no perceptible obstacle. Fluorescence was also noted behind two packs of cards; a few cards held between apparatus and screen made no perceptible difference. A single sheet of tinfoil is scarcely noticeable; only after several layers have been laid one the top of each other is a shadow clearly visible on the screen. Thick blocks of wood are also transparent; fir planks 2cm. to 3cm. thick are but very slightly opaque. A film of aluminium about 15mm. thick weakens the effect very considerably, though it does not entirely destroy the fluorescence. Several centimetres of vulcanised india-rubber let the rays through.‡ Glass plates of the same thickness behave in a different way, according as they contain lead (flint glass) or not; the former are much less transparent than the latter. If the hand is held between the discharge tube and the screen, the dark shadow of the bones is visible within the slightly dark shadow of the hand. Water, bisulphide of carbon, and various other liquids behave in this respect as if they were very transparent. I was not able to determine whether water was more transparent than air. Behind plates of copper, silver, lead, gold, platinum, fluorescence is still clearly visible, but only when the plates are not too thick. Platinum 0·2mm. thick is transparent; silver and copper sheets may be decidedly thicker. Lead 1·5mm. thick is as good as opaque, and was on this account often made use of. A wooden rod of 20 × 20mm. cross-section, painted white, with lead paint on one side, behaves in a peculiar manner. When it is interposed between apparatus and screen it has almost no effect when the X-rays go through the rod parallel to the painted side, but it throws a dark shadow if the rays have to traverse the paint. Very similar to the metals themselves are their salts, whether solid or in solution.

3. These experimental results and others lead to the conclusion that the transparency of different substances of the same thickness is mainly conditioned by their density; no other property is in the least comparable with this.

The following experiments, however, show that density is not altogether alone in its influence. I experimented on the transparency of nearly the same thickness of glass, aluminium, calcspar and quartz. The density of these substances is nearly the same, and yet it was quite evident that the spar was decidedly less transparent than the other bodies, which were very much like each other in their behaviour. I have not observed calcspar fluoresce in a manner comparable with glass.

4. With increasing thickness all bodies become less transparent. In order to find a law connecting transparency with thickness, I made some photographic observations, the photographic plate being partly covered with an increasing number of sheets of tinfoil. Photometric measurements will be undertaken when I am in possession of a suitable photometer.

5. Sheets of platinum, lead, zinc and aluminium were rolled until they appeared to be of almost equal transparency. The following table gives the thicknesses in millimetres, the thicknesses relative to the platinum sheet, and the density:—

Thickness.	Relative thickness.	Density.
Pt. 0·018	1	21·5
Pb. 0·05	3	11·3
Zn. 0·10	6	7·1
Al. 3·5	200	2·6

It is to be observed in connection with these figures that although the product of the thickness into the density may be the same, it does not in any way follow that the transparency of the different metals is the same. The transparency increases at a greater rate than this product decreases.

6. The fluorescence of barium-platino-cyanide is not the only recognisable phenomenon due to X-rays. It may be observed, first of all, that other bodies fluoresce—for example, phosphorus, calcium compounds, uranium glass, ordinary glass, calcspar, rock salt, &c.

Of especial interest in many ways is the fact that photographic dry plates show themselves susceptible to X-rays. We are thus in a position to corroborate many phenomena in which mistakes are easy, and I have, whenever possible, controlled each important ocular observation on fluorescence by means of photography. Owing to the property possessed by the rays of passing almost without any absorption through thin sheets of wood, paper, or tinfoil, we can take the impressions on the photographic plate inside the camera or paper cover whilst in a well-lit room. In former days this property of the ray only showed itself in the necessity under which we lay of not keeping undeveloped plates, wrapped in the usual paper and board, for any length of time, in the vicinity of discharge tubes. It is still open to question whether the chemical effect on the silver salts of photographic plates is exercised directly by the X-rays. It is possible that this effect is due to the fluorescent light which, as mentioned above, may be generated on the glass plate or perhaps on the layer of gelatin. "Films" may be used just as well as glass plates.

I have not as yet experimentally proved that the X-rays are able to cause thermal effects, but we may very well take their existence as probable, since it is proved that the fluorescent phenomenon alters the properties of X-rays, and it is certain that all the incident X-rays do not leave the bodies as such.

The retina of the eye is not susceptible to these rays. An eye brought close up to the discharge apparatus perceives nothing, although, according to experiments made, the media contained in the eye are fairly transparent.

7. As soon as I had determined the transparency of different substances of various thicknesses I hastened to ascertain how the X-rays behaved when passed through a prism—whether they were refracted or no. Water and carbon disulphide in prisms of about 30deg. refractive angle showed neither with the fluorescing screen nor with the photographic plate any sign of refraction. For purposes of comparison the refraction of light rays was observed under the same conditions; the refracted images on the plate were respectively about 10mm. and 20mm. from the non-refracted one. With an aluminium and a vulcanised-rubber prism of 30deg. angle I have obtained images on photographic plates in which one may perhaps see refraction. But the matter is very uncertain, and even if refraction exist it is so small that the refractive index of the X-ray for the above materials can only be, at the highest, 1·05. Using the

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† By the "transparency" of a body I denote the ratio of the brightness of a fluorescent screen held right behind the body in question to the brightness of the same screen under exactly the same conditions, but without the interposing body.

‡ For brevity's sake I should like to use the expression "rays," and to distinguish these from other rays I will call them "X-rays."

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fluorescent screen, I was unable to discover any refraction at all in the case of the aluminium and the rubber prism.

Researches with prisms of denser metals have yielded up to now no certain results, on account of the small transparency and consequently lessened intensity of the transmitted ray.

In view of this state of things, and the importance of the question whether X-rays are refracted on passing from one medium to another, it is very satisfactory that this question can be attacked in another way than by means of prisms. Finely-powdered substances in sufficient thicknesses only allow a very little of the incident light to pass through, and that is dispersed by refraction and reflection. Now, powdered substances are quite as transparent to X-rays as are solid bodies of equal mass. Hence it is proved that refraction and regular reflection do not exist to a noticeable degree. The experiments were carried out with finely-powdered rock salt, with pulverulent electrolytic silver, and with the zinc powder much used in chemical work. In no case was any difference observed between the transparency of the powdered and solid substance, either when using the fluorescent screen or the photographic plate.

It follows from what has been said that the X-rays cannot be concentrated by lenses; a large vulcanised-rubber and glass lense were without influence. The shadow of a round rod is darker in the middle than at the edge; that of a tube filled with any substance more transparent than the material of the tube is lighter in the middle than at the edge.

8. The question of the reflection of the X-rays is settled in one's mind by the preceding paragraphs, and no appreciable regular reflection of the rays from the substances experimented with need be looked for. Other investigations, which I will describe here, lead to the same result. Nevertheless, an observation must be mentioned which at first sight appears to contradict the above statement. I exposed a photographic plate to the X-rays, protected against light rays by black paper, the glass side being directed towards the discharge tube. The sensitive layer was nearly covered, star-fashion, with blanks of platinum, lead, zinc, and aluminium. On developing the negative it was clearly noticeable that the blackening under the platinum, lead, and especially under the zinc, was greater than in other places. The aluminium had exercised hardly any effect. It appeared, therefore, that the three above-mentioned metals had reflected the rays. Nevertheless, other causes for the greater blackening were thinkable, and in order to make sure I made a second experiment, and laid a piece of thin aluminium, which is opaque to ultra-violet rays though very transparent to X-rays, between the sensitive layers and the metal blanks. As again much the same result was found, a reflection of X-rays by the above-mentioned metals was demonstrated. But if we connect these facts with the observation that powders are quite as transparent as solid bodies, and that, moreover, bodies with rough surfaces are, in regard to the transmission of X-rays, as well as in the experiment just described, the same as polished bodies, one comes to the conclusion that regular reflection, as already stated, does not exist, but that the bodies behaved to the X-rays as muddy media do to light.

Again, as I could discover no refraction at the point of passage from one medium to another, it would seem as if the X-rays went through all substances at the same speed, and that in a medium which is everywhere, and in which the material particles are embedded; the particles obstructing the propagation of the X-rays in proportion to the density of the bodies.

9. Hence it may be that the arrangement of the particles in the bodies influence the transparency; that, for example, equal thicknesses of calcspar would exhibit different transparencies according as the rays were in the direction of the axis or at right angles to it. Researches with calcspar and quartz have yielded a negative result.

10. It is well known that Lenard, in his beautiful investigation on Hittorf cathode rays passed through thin aluminium foil, came to the conclusion that these rays were actions in the ether, and that they pass diffusively through all bodies. I have been able to say the same about my rays.

In his last work Lenard has determined the absorption coefficient of various bodies for cathode rays, and amongst other things for air atmospheric pressure at 4·1, 3·4, 3·1, at per centimetre, and found it connected with the exhaustion of the gas contained in the discharge apparatus. In order to estimate the discharge pressure by the spark-gap method, I used in my researches almost always the same exhaustion. I succeeded with a Weber photometer (I do not possess a better one) in comparing the intensity of the light of my fluorescing screen at distances of about 100mm. and 200mm. from the discharge apparatus, and found in the case of three tests agreeing well with one another that it varied very nearly inversely as the square of the distance of the screen from the discharge apparatus. Hence the air absorbs a very much smaller fraction of the X-rays than of the cathode rays. This result is also quite in agreement with the result previously mentioned, that the fluorescing light was still observable at a distance of 2 metres from the discharge apparatus.

Other bodies behave generally like air—that is to say, they are more transparent for X-rays than for cathode rays.

11. A further noteworthy difference in the behaviour of cathode rays and X-rays consists in the fact that, in spite of many attempts, I have not succeeded, even with very strong magnetic fields, in deflecting X-rays by a magnet. The magnetic deflection has been up to now a characteristic mark of the cathode ray; it was, indeed, noticed by Hertz and Lenard that there were different kinds of cathode rays "distinguishable from one another by their phosphorescing powers, absorption and magnetic deflection," but a considerable deflection was nevertheless observed in all cases, and I do not think this characteristic will be given up without overwhelming evidence.

12. After experiments bearing specially on this question it is certain that the spot on the wall of the discharge apparatus which fluoresces most decidedly must be regarded as the principal point of the radiation of the X-rays in all directions. The X-rays thus start from the point at which, according to the researches of different investigators, the cathode rays impinge upon the wall of the glass tube. If one deflects the cathode rays within the apparatus by a magnet it is found that the X-rays are emitted from another spot—that is to say, from the new termination of the cathode stream.

On this account, also, the X-rays, which are not deflected, can not merely be unaltered reflected cathode rays passing through the glass wall. The greater density of the glass outside the discharge tube cannot, according to Lenard, be made responsible for the great difference in the "deflectability."

I therefore come to the conclusion that the X-rays are not identical with the cathode rays, but that they are generated by the cathode rays at the glass wall of the discharge apparatus.

13. This excitation does not only take place in glass, but also in aluminium, as I was able to ascertain with an apparatus closed by a sheet of aluminium 2mm. thick. Other substances will be studied later on.

14. The justification for giving the name of "rays" to the influence emanating from the wall of the discharge apparatus depends partly on the very regular shadows which they form when one interposes more or less transparent bodies between the apparatus and the fluorescing screen or photographic plate. Many such shadow-pictures, the formation of which possesses a special charm, have I observed some photographically. For example, I possess photographs of the shadow of the profile of the door separating the room in which was the discharge apparatus from the room in which was the photographic plate; also photographs of the shadows of the bones of the hand, of the shadow of a wire wound on a wooden spool, of a weight enclosed in a small box, of a compass in which the magnetic needle is completely surrounded by metal, of a piece of metal the lack of homogeneity of which was brought out by the X-rays, &c.

To show the rectilinear propagation of the X-rays there is a pin-hole photograph, which I was able to take by means of the discharge-apparatus covered with black paper. The image is weak, but unmistakably correct.

15. I looked very carefully for interference phenomena with X-rays, but unfortunately, perhaps only on account of the small intensity of the rays, without success.

16. Researches to determine whether electrostatic forces affect X-rays in any way have been begun, but are not completed.

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17. If we ask what X-rays, which certainly cannot be cathode rays, really are, we are led at first sight, owing to their powerful fluorescing and chemical properties, to think of ultra-violet light. But we immediately encounter serious objections. If X-rays be in reality ultra-violet light this light must possess the following characteristics:—

(*a*) It must show no perceptible refraction on passing from air into water, bisulphide of carbon, aluminium, rock-salt, glass, zinc, &c.

(*b*) It must not be regularly reflected to any appreciable extent from the above bodies.

(*c*) It must not be polarisable by the usual means.

(*d*) Its absorption must not be influenced by any of the properties of substances to the same extent as it is by their density.

In other words, we must assume that *these* ultra-violet rays behave in quite a different manner to any infra-red, visible, or ultra-violet rays hitherto known. I could not bring myself to this conclusion, and I have, therefore, sought another explanation.

There seems at least some connection between the new rays and light rays in the shadow pictures, and in the fluorescing and chemical activity of both kinds of rays. Now, it has been long known that besides the transverse light vibrations, longitudinal vibrations might take place in the ether, and according to the view of different physicists *must* take place. Certainly their existence has not up till now been made evident, and their properties have not on that account been experimentally investigated.

May not the new rays be due to longitudinal vibrations in the ether?

I must admit that I have put more and more faith in this idea in the course of my research, and it behoves me therefore to announce my suspicion, although I know well that this explanation requires further corroboration.

Würzburg. Physikal Institut der Universität,
December, 1895.

LONGITUDINAL LIGHT.*

BY G. JAUMANN.

In a Paper published in 1888,† a law of discharges was enunciated, which has lately received striking confirmation, and which leads to important conclusions regarding the direction of vibration of cathode rays and light rays. Jaumann's law ran as follows: "Vibrations of electric force, taking place at an electrode, and in a direction normal to it, have a specific favourable effect upon the discharge; but, in order to be perceptible, their amplitude must increase with their period. To a first approximation, the effect is proportional to the product of the amplitude into the vibration frequency, or, in other words, to the maximum rate of change of the electric force during the vibration. Since only such vibrations as take place perpendicularly to the surface of the electrode have any effect, the orientation of the source is of considerable influence. This has been verified by Wanka in the case of electric waves, and by Elster and Geitel in the case of light.‡

The arguments in favour of the view that the cathode rays are longitudinal electric oscillations are the following: In the first place, the cathode rays are strongest in the axis of symmetry of the discharge space. Their intensity is greatest there, and decreases outwards. Hence they are essentially longitudinal, although a radial or tangential transversality may be superposed.

The existence of longitudinal electric waves is not admitted by the Maxwell-Hertzian equations. But almost any change whatever made in them makes their existence possible. Now rarefied air has such a peculiar behaviour towards electric discharges that Maxwell's equations cannot possibly be regarded as adequate. The very fact of discharge contradicts them.

Experiments concerning the influence of the conducting wires upon cathode rays show that their vibration period is of the same order of magnitude as the waves in the wires—*i.e.*, something between 10^{-8} and 10^{-9} seconds. Hence they are not ultra-violet rays. If they were transverse, without being ultra-violet, they would be ordinary light or Hertzian waves. From these they are distinguished, however, by their totally different properties.

But the longitudinal nature of cathode rays may be proved by actual experiments, which have already been performed by Lenard. They were shown to have strong discharging influence when impinging normally upon the surface of the electrode. *Hence their direction of vibration coincides with their direction of propagation.*

Rarefied air has many peculiarities owing to its small capacity for heat *and other forms of energy*. The peculiar electric behaviour of air is due to the fact that electric actions indirectly change its magnetic and electric constants. But as soon as μ and k are made variable in Maxwell's equations, longitudinal waves become possible.

The author works out new equations in accordance with these conditions, from which the existence of longitudinal rays follows as a matter of course. He also explains many of the peculiarities of discharge phenomena, such as the diffuse reflection of cathode rays by a plane smooth surface. This is due to the fact that Huyghens' principle becomes inapplicable when the direction of the cathode rays does not coincide with that of the statical electric force. He also explains the curvature of cathode rays in a magnetic field, and foreshadows the possible discovery of magnetic longitudinal waves. Herr Jaumann next shows that a limited cathode ray contains no transverse components along its axis, but that a radial electric and a tangential magnetic vibration sets in away from the axis, displaced by a quarter of a wave length from the original vibration. Conversely, he shows that transverse rays must always be blurred at the edges, and that even in ordinary air *longitudinal light, displaced by a quarter period, exists at the border of every pencil of transverse light.* This theoretical conclusion is completely substantiated by Elster and Geitel's work on the influence of the azimuth and angle of incidence of light upon liquid electrodes.* In rarefied air the amplitude of the longitudinal vibration is about one-third of that of the transverse vibration.

* Abstract from *Wied. Ann.*, No. 1, 1896, pp. 147-184.
† *Wien. Ber.*, 97, p. 765.
‡ *Wied. Ann.*, No. 52, p. 440, 1894. *The Electrician.*

THE BERRENBERG-CHAPLIN VACUUM PUMP.†

I.—Description of the Pump.

This pump consists essentially (*see* Figs. 1, 2 and 3) of a cylinder having an air inlet near its lower end, and having within it two pistons, working the one within the other, each independently actuated by its own power piston. The action of these pistons is as follows:—

(*a*) They begin moving upwards from the bottom of the lower cylinder (Fig. 1) together, whereupon the air inlet A I is immediately uncovered by the outer piston O P, and the air contained in the lamps and connecting pipes expands into the pump cylinder.

(*b*) Having completed its upstroke (position shown in Fig. 2), the outer piston O P descends, the inner piston I P (dead black in the sketches) still ascending, until the two meet (position shown in Fig. 3), then the outer piston having closed the air inlet, the two pistons descend together for about one inch, until the outer piston rests on the bottom of the cylinder.

(*c*) The outer piston O P now remains at rest, while the inner piston I P continues its down stroke, forcing the air expanded into the cylinder during the up or suction stroke, through the valve V^1, and the oil filling the body of the piston and the holes H, into the space S^1, between the inner and outer piston heads.

The inner piston having completed its down stroke (position shown in Fig. 1), the motions begin again with (*a*), and, during the succeeding cycles, it will be seen that the air from the lamps, after being drawn into the cylinder and forced into the spaces S^1, is pushed through the valves V^2 in the outer piston head, into the upper part S^2 (Figs. 1 and 3) of the pump cylinder, whence it is driven by the upstroke of the outer piston through the valves V^3

* See *The Electrician*, June 21, 1895, Vol. XXXV., p. 272.
† Report by Prof. W. E. Ayrton, F.R.S., to the Langhans-Berrenberg-Chaplin Patents (Limited).

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into the chamber Ch. From the chamber the air exhausts into the atmosphere through the outlet E.

The movements of the pistons, as described above, are given them by the power pistons, P P^1 and P P^2 (Fig. 1) working in the hydraulic cylinders, H C^1 and H C^2 respectively. Oil, under pressure given it by suitable centrifugal or other pumps, is let into these hydraulic cylinders, alternately above and below the power pistons, through rotary valves so made and geared together as to give the requisite movements to the pump pistons.

Examination of the Patent Specifications.—I have examined the Patent Specification No. 11,377, June 12, 1894, and the United States Patent No. 521,432, June 12, 1894, which contain the full description of, and the claims made for, the pump briefly described above, and I have compared them with the following specifications, which were handed to me as the result of a search made at the Patent Office by G. G. M. Hardingham, patent agent, viz. :—"Johnson's (Postle's) Blue Book," No. 3,792, 1876; "Lake's (Burnham's) Blue Book," No. 3,670, 1881; "Haddan's (Reis's) Blue Book," No. 5,688, 1883; "Gubbin's Blue Book," No. 515, 1886; "Lake's (John Patten's Manufacturing Company's) Blue Book," No. 7,426, 1890. At the suggestion of Mr. Hardingham, I have also examined the following specifications, viz., No. 4,716, 1883; No. 16,986, 1887; No. 12,690, 1889; No. 3,377, 1891; No. 12,686, 1892; and the United States Patent, No. 221,201, 1879.

FIG. 3.

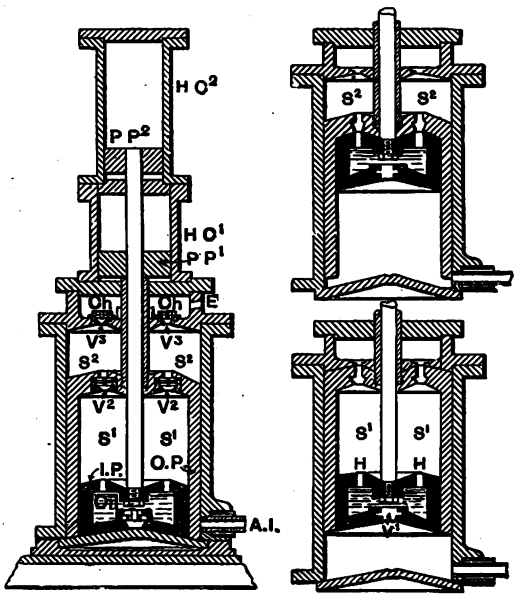

FIG. 1. FIG. 2.

A.I., Air Inlet. O.P., Outer Piston. I.P., Inner Piston. E, Exhaust. V^1 V^2 V^3, Valves. H H, Holes. P P^1 and P P^2, Power Pistons. H C^1 and H C^2, Hydraulic Cylinders. S^1 S^2, Spaces. Ch, Exhaust Chamber.

As the result of a complete examination of these specifications, and comparison of them with Chaplin's specification for improvements in vacuum pumps, I am of opinion that the claim for the "employment of two pistons, one working within the other, the outer one performing the function of a piston, of a cylinder and of a controlling valve," is valid, and has not been anticipated.

II.—The Practical Value of the Pumps Erected at No. 4, Huggin Lane.

Description of the Pumps.—The plant for exhausting incandescent lamps set up at No. 4, Huggin-lane, Queen Victoria-street, consists of two pumps on a common base, each containing two pistons, and working as described in Part I. of this report. While the one pump is drawing air into its cylinder from the lamps the other is discharging the air drawn in by it during previous upstrokes. By this arrangement a continuous expansion of air from the lamps into the pumps is maintained. These two pumps working alternately as described from what is called the "main" pump. As already explained, the air pistons of this main pump are connected with power pistons, working in hydraulic cylinders, and driven by oil under pressure. These hydraulic cylinders are connected with two accumulators, which store up the oil for that part of the cycle during which the pistons are at rest. The chambers above the cylinder heads (Ch. in Fig. 1), which receive the air after it has been exhausted from the lamps, are not, as indicated in the specification, open to the outside air, but are connected with an auxiliary pump which maintains a partial vacuum in them. Thus the main pump does not exhaust *into* atmospheric pressure, and neither does it exhaust *from* atmospheric pressure, for in practice the lamps are partially exhausted by the auxiliary pump before they are brought to the main pump. The function of the main pump is therefore confined to perfecting a partial vacuum by drawing the residue of the air into its cylinders and forcing it into spaces in which a partial vacuum is maintained by an auxiliary pump.

This auxiliary pump, which is called the "tank" pump, consists of four cylinders, each with an air inlet in the middle of its side, and containing a single cup-shaped piston. The four cylinders are placed in a tank and surrounded with oil. Air from the vessel to be exhausted expands into two of these cylinders, whence it is discharged into the remaining two, which in turn discharge it into the atmosphere. The last two cylinders also maintain a partial vacuum on the top of the oil in the tank, so that any air which may leak into it is drawn off.

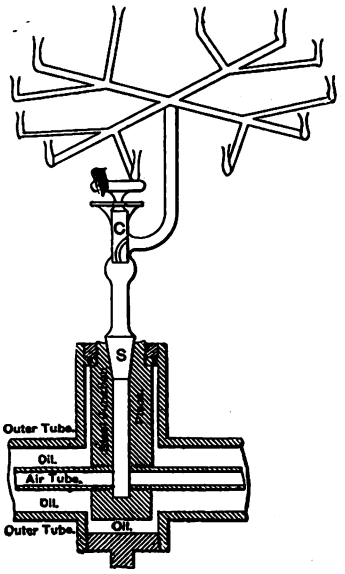

FIG. 4.

When exhausting lamps in practice they are blown in batches on to glass pieces shaped somewhat like the one sketched in Fig. 4. The lower ends S of these glass pieces are ground into stoppers, and the upper and lower parts are divided from each other by stop-cocks C. These stoppers are placed in a lamp rack connected with the tank pump, and after a partial vacuum has been produced in the lamps the stop-cocks C are closed, and the lamps are transferred to a system of pipes in connection with the main pump.

This system of pipes, a sketch of which is given in Fig. 5, consists of a main pipe which leads through a stop-cock, *a*, to the cylinders of the main pump, and six branch pipes (1, 2, 3, 4, 5, and 6 in Fig. 5), which can be separated from the main pipe by closing stop-cocks *b*, *c*, *d*, *e*, *f* and *g*. All these pipes are *double*,

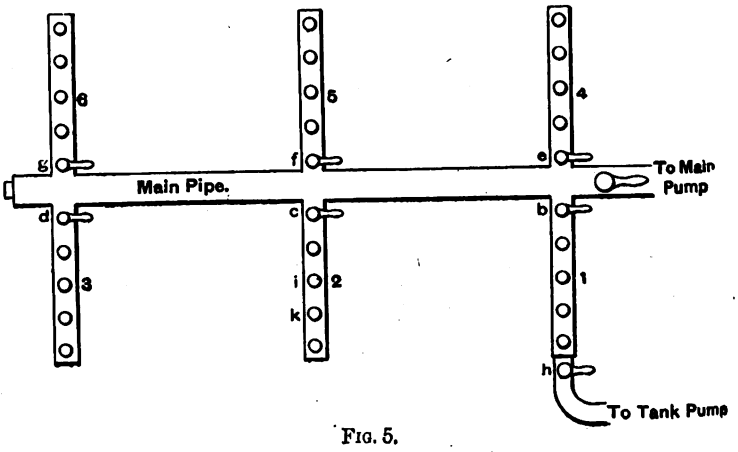

FIG. 5.

consisting of a brass inner air pipe and a cast-iron outer pipe, the space between the two being filled with a special oil which renders all the inner tubing perfectly airtight. Any air which may leak through the outer pipe into the oil is sucked out by the tank pump, so that none of it is able to leak through the *inner* pipe into the lamps.

In each of the branch pipes there are four junction boxes (Fig. 4) containing conical holes leading into the inner air pipes. In these holes are placed the ground ends, S, of the glass pieces carrying batches of lamps. Within these lamps, as explained above, a partial vacuum held by the glass stop cocks, C, has been produced

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by the tank pump. The sketch in Fig. 4 shows how these ground ends fit into the conical holes, and the way in which the junction pieces are made and surrounded with oil. The glass stoppers are ground on a machine, so as to be perfectly alike and interchangeable, and the joints are greased with a special mixture of Russian deer tallow and beeswax and may be finally sealed with a little oil.

Method of Testing Pumps.—For the purposes of my tests 14 glass bulbs, shaped as in Fig. 6, and having a capacity, as measured by me, about equal to that of 15 lamps, and five bulbs having a capacity about equal to that of 11 lamps, were blown on to glass stoppers (S in Fig. 6) and placed in the junction boxes in the branches 2, 3, 4, 5 and 6 in Fig. 5. The total capacity of the bulbs on the pumps was therefore about equal to that of 265 lamps.

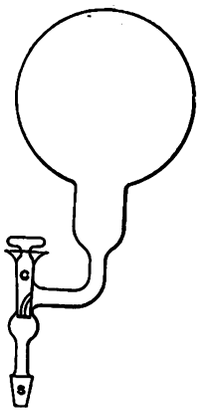

Fig. 6.

For measuring the pressure of the vacua produced by the pumps, I used the McLeod gauge, sketched in Fig. 7. This gauge consists of a glass bulb B, terminating in a capillary tube C, closed to the air at the top, blown on to the glass tube P, to the lower end of which a glass vessel M, containing mercury, is attached by a rubber tube. The upper end of the tube P is ground into a stopper S, which was fixed in the junction box *i*, in branch pipe 2 (Fig. 5). When it was desired to measure the pressure of the vacuum produced by the pump in the gauge, the vessel M was raised, and the mercury rising past the opening *a*, closed the little floating valve V, and compressed the air in B into the capillary tube C. The length of the tube occupied by the compressed air when the mercury was at the same level in the vessel M as in the capillary

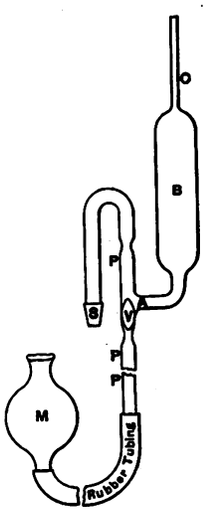

Fig. 7.

tube C, was a measure of the pressure of the vacuum. The sensibility of this McLeod gauge was stated by the makers, Messrs. Cetti, to be such that 1mm. remaining in the capillary tube after the mercury had been raised indicated that the pressure had been reduced to 1/500,000th of the atmospheric pressure. It was, of course, impossible to test the exact accuracy of this figure without entirely dismantling the gauge. I made, however, some rough measurements which showed that the number was, if anything, too large rather than too small. Hence, by using the figure 1/500,000 to determine the pressure of the air remaining in the lamps from my readings of the gauge, the performance of the pump is under rather than over-estimated.

As explained above, in practice the lamps are partially exhausted by the tank pump *before* they are placed on the system of pipes in connection with the main pump; but as it had not been thought necessary to erect in Huggin-lane a rack on which the partial vacuum could be made, and as the pump does not work to its best advantage when exhausting from ordinary atmospheric pressure, a pipe was, at my suggestion, brought from the tank pump and connected with branch pipe 1 (Fig. 5) through a temporary stop-cock *h*. By this means both the partial and the final exhaustion could be done with the bulbs in position on the system of oil jacketed pipes, the method of proceeding being as follows:—

The main pump was shut off from the system by closing the stop-cock *a* (Fig. 5), and all the cocks *b*, *c*, *d*, *e*, *f* and *g* were opened, and then by opening the cock *h* the tank pump was connected with the bulbs, in which it produced a partial vacuum. When this had been done the tank pump was disconnected from the system by turning off the cocks *h* and *b*, and then cock *a* was opened to enable the main pump to complete the exhaustion.

Vacua obtained.—On the afternoon of Friday, December 13, 1895, the following tests were made: The tank was started at 2.48 p.m., and 2½ minutes later the main pump was started. At 2.53 p.m., or five minutes from the starting of the tank pump, the cocks *b* and *h* (Fig. 5) were opened. After two minutes a partial vacuum having been produced in the pipes and bulbs, the tank pump was isolated from the system by closing the cocks *b* and *h*, and the cock *a* leading to the main pump was opened. After 15 minutes pumping the McLeod gauge read 2mm., showing that the pressure in the bulbs was but 1/250,000th of an atmosphere; after 20 minutes pumping the gauge read 1mm., and 1 minute later, under 1mm., proving that the pressure had been reduced to less than 1/500,000th part of an atmosphere. The stop cock at *a* (Fig. 5) was now shut and that at *b* opened, and air let into the system by taking out one of the stoppers in branch pipe 1. The glass stopper having been

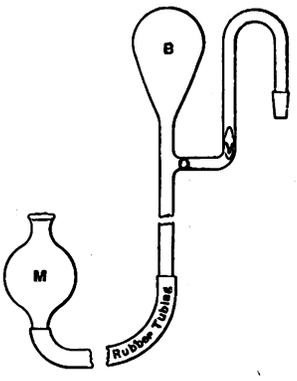

Fig. 8.

replaced, a partial vacuum was produced for 1½ minutes by the tank pump, which was then turned off and the main pump turned on. Readings, the results of which are shown in the following table, were taken with the McLeod gauge at intervals.

Time for turning on the main pump.	Reading of McLeod gauge.	Approximate pressure in atmospheres.
5 min.	13 mm.	13/500,000
9½ min.	4½ mm.	1/111,111
14 min.	3 mm.	1/166,666
16½ min.	2½ mm.	1/200,000

Comparison with Vacua in Commercial Lamps.—With the object of comparing the vacua I was obtaining with those found in commercial lamps, the gauge sketched in Fig. 8 was put in junction box *k* (Fig. 5). In this gauge the vacuum is produced in the lamp bulb B, and on lifting the vessel M, mercury rises past the opening O, and compresses the air in the bulb into a bubble at the top. By comparing the size of this bubble with the size of that obtained when an ordinary commercial lamp is broken under mercury a comparison could be made between the vacuum created with the pump under test, and the vacuum created by the pumps used in the manufacture of the glow lamps examined.

After putting the new gauge in position, and after producing a partial vacuum with the tank pump, the main pump was turned on and the following results were obtained:—

Time from starting the main pump.	Reading on McLeod gauge.	Approximate pressure in atmospheres.	Approximate diameter of air bubble in lamp bulb.
2⅔ min.	5·5mm.	1/90,900	0·1in.
15 min.	2·0mm.	1/250,000	0·06in.
21 min.	1·5mm.	1/333,000	0·03in.

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To obtain the comparison required I had broken under mercury eight glow lamps of two well-known makes. Of these lamps one gave a bubble of air of about 0·12in. in diameter, four gave bubbles having diameters of the order 0·06in., and three gave bubbles varying in diameter from 0·25in. to 0·5in.

From these results it will be seen that the pump produced in 21min. a better vacuum than that found in any of the eight commercial lamps extended.

Facility with which the Glass Joints can be Made.—To test whether or no there was any difficulty in making the glass joints airtight, my assistant, Mr. Medley, took one of the bulbs out of its junction box and removed from its connecting tube the glass stop-cock (C in Fig. 6). He then regreased the cock and stopper, and replaced them in their respective positions. The tank pump was then used for one minute to create a partial vacuum, after which the main pump was turned on, with the following results :—

Time from starting the main pump.	Reading on McLeod gauge.	Approximate pressure in atmospheres.	Approximate diameter of air bubble in lamp bulb gauge.
5min.	14mm.	1/35,700	0·18in.
15min.	5mm.	1/100,000	0·08in.
21min.	1·5mm.	1/333,000	0·03in.

Pumping against a Leak.—As explained above, the tank pump was connected with branch pipe 1 (Fig. 5) through a temporary cock *h*; when both the pumps were off, this cock, which was *not* jacketed with oil, leaked sufficiently to reduce the readings on the McLeod gauge from 40mm. to 60mm., or by about 1/25,000th of an atmosphere, in 6½sec. In order to test how good a vacuum the main pump could create when working against this leak, the cock *b* (Fig. 5) was left open, so that the air leaking in through *h* could get into the rest of the system. Working under this condition the main pump was able to produce a vacuum of about 1/25,700th of an atmosphere, corresponding with an air bubble in the lamp-bulb gauge having a diameter of about 0·18in. This test, therefore, proved that even when working against a leak of some considerable size the main pump was able to create a fairly high vacuum, and also pointed to the necessity of there being a continuous oil jacket throughout the whole system.

Air-tightness of the Pipes, &c.—I thought it would be desirable to know whether, if a batch of lamps, in which a good vacuum had been created at the end of a working day, had to be left on the pipes during the night or possibly over a Sunday, it would be necessary to repump them when work was resumed.

On Saturday morning, December 14th, I therefore had the pipes and bulbs pumped out until the McLeod gauge read 3mm., corresponding with 3/500,000ths of an atmosphere. The stop-cocks, *a*, *b*, *c*, *d*, *e*, *f*, *g* and *h* (Fig. 5) were then closed to divide the system up into sections, the pumps were stopped and the latchkeys of No. 4, Huggin-lane were delivered up to Mr. Medley. On returning on Monday, December 16th, and testing the vacuum in branch pipe 2 (Fig. 5), it was found to be still as high as 6/500,000ths of an atmosphere. Air had, of course, leaked through the temporary stop-cock *h*, into branch 1, and a little had also leaked past the cock at *b* into the main pipe. The main pipe was, therefore, pumped out until it also showed a vacuum having a pressure of 6/500,000ths of an atmosphere. The pump was then turned off and the cocks *e*, *f*, *d* and *g* opened in succession, readings of the McLeod gauge being taken after each opening. The readings so obtained from the gauge were as follows :—

After opening cock.	Reading on the McLeod gauge.	Approximate pressure of vacuum in atmospheres.
e	8mm.	1/62,500
f	12mm	1/41,700
d	15mm.	1/33,000
g	15mm	1/33,000

After these cocks had all been opened a reading was taken on the lamp-bulb gauge, and it showed a bubble of air about 0·12in. in diameter.

Therefore, after the pumps had been stopped for some 46 hours, there was still in the branch pipes 2, 3, 4, 5 and 6 a good vacuum; and, although a little air had leaked through the cock *b* into the main pipe, it must be remembered that, owing to the leakage through the temporary cock *h*, the cock *b* had had to hold for many hours the difference of pressure between the full vacuum in the main pipe and the very partial vacuum in branch 1.

Effect of a Rush of Air into the Main Pump.—My next test was designed to answer the question as to whether the working of the main pump would be affected if an abnormal rush of air into its cylinders took place. Such a rush of air would occur if a batch of lamps while being exhausted was accidentally broken off its glass stem, or if a cock communicating with the atmosphere was accidentally opened. I had placed in one of the junction boxes in branch pipe 1 a glass stopper with a cock in it, as in Fig. 6, but open to the atmosphere above, so that the whole system could be opened to the air by turning the glass stop-cock C. After a good vacuum had been obtained, and while the main pump was still working, this glass stop-cock was twice opened, and air allowed to rush into the pipes, bulbs and cylinders. At the first trial the air was allowed to rush in for a rather longer time, and at the second trial for a much longer time, than was necessary to reach and turn off the stop cock *b* (Fig. 5), and so to shut off the supposed breakage from the rest of the system. After each opening the main pump reproduced a vacuum of about 3/500,000ths of an atmosphere in about 20min.

From these results it was clear that the working of the main pump was in no way affected by an abnormal rush of air into its cylinders, lasting for a time considerably longer than that necessary to reach and turn off one of the stop-cocks.

Conclusions.—As the results of these various tests, I am of opinion—

(1) That the combination of pumps as erected at No. 4, Huggin-lane, is capable, in 15min., of creating a vacuum as *good* as that in the best, and *much better* than that in the worst, of the glow lamps I examined; and that it is capable, in 20min., of creating a vacuum *much better* than that in *any* of the lamps I had broken under mercury.

(2) That the system of pipes, cocks and glass stoppers is, for all practical purposes, perfectly airtight.

(3) That even should a small leak occur, the pumps are able to work against it until it is remedied.

After an examination of the drawings for and the structure of the pumps at No. 4, Huggin-lane, I am also of opinion—

(4) That they are well and solidly constructed, and not liable to get out of order.

(5) That, owing to the absence of heat, the slow movements of the working parts, and the unusual quality of the lubrication (due to the continual passage of small quantities of oil through the pump), the wear of the rubbing surfaces will be very slight indeed.

MR. W. P. J. FAWCUS'S PRESIDENTIAL ADDRESS TO THE NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

[ABSTRACT.]

I must sincerely thank you for the honour you have done me by electing me your President. To follow in the footsteps of my predecessor, Mr. Edmunds, is no easy matter, but my connection with this Society from its commencement has been so intimate and my friendship with a large portion of the members is such that my task will be easier than it might otherwise have been.

In electric traction it is satisfactory to see the large number of schemes which are in the process of development or in course of construction; there is little doubt that in the course of a few years the majority of the tramways in this country will be worked by electricity. The vast superiority of electric power for this purpose over either horse, steam, or cable traction has been amply proved, at all events to the minds of all thoughtful electrical engineers, although no doubt much remains to be done in convincing many of our municipal authorities.

The stumbling blocks so far in the way of development in this direction have been the supposed unsightliness of overhead wires and the imaginary difficulties in the use of conduit systems. In the former case the objections have arisen from the temporary character of work of that kind in the States, but the excellently-arranged systems recently inaugurated at Bristol and Coventry have already gone far to remove these prejudices. And in the latter case the successful working of the new systems in operation in the United States and on the Continent, and the inventive efforts at present being devoted to the subject, will no doubt shortly remove this difficulty also. It is very satisfactory to note that at Leeds both overhead and conduit systems are to be installed. The use of electrical transmission of power, especially in large works, is increasing rapidly, and I have no doubt a large amount of work and I hope profit will come to the industry from this source.

A step of great importance to engineers, especially those having charge of continuous-current stations, is the introduction of high-voltage lamps. At the present time lamps are in use in several stations working at pressures of from 200 to 230 volts, and have proved themselves satisfactory when properly made. Those which have so far proved the best have two or more filaments arranged in series, no filament having to stand an abnormal pressure. Made in this manner it is possible to obtain a good lamp for 230 volts as

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small as 8 c.p., while a lamp of 16 c.p. can be made to run with pressures up to 400 volts.

The possibility of obtaining lamps for such high voltages will no doubt induce engineers to gradually raise voltages within the premises of consumers; and here I should like to strike a note of warning. Although there may be no objection to using pressures up to 400 volts in public buildings or elsewhere when the installation is under experienced control, and the fittings are inacessible to the public, for private houses and ordinary business premises where the inexperienced cannot be prevented from having access to the wires and fittings, 200 to 230 volts is quite high enough for personal safety. Even if there is no actual danger to life from the direct effects of a shock of from 250 to 400 volts—a question which is open to doubt—the indirect results of such a shock might be most injurious or even fatal if received by a delicate person or one in a dangerous position. It would be an evil day for the industry if through the occurrence of fatal accidents to the general public that the electric light should again get the name of being dangerous, which, fortunately, it has now practically lived down.

There is another reason why considerable caution should be exercised in converting existing installations from low to high pressures: the types of switches and other fittings commonly in use are totally unsuited to pressures much beyond what they were designed for, and, in the case of some of the older installations, the insulation on the wires will be insufficient.

Attention has recently been drawn to the subject of life and efficiency of incandescent lamps by the tables and correspondence which have appeared in the technical papers on lamp tests. It is surprising how few of the public, or even of practical electrical engineers, take the trouble to learn anything about incandescent lamps, when by using a little knowledge easily acquired on this subject, it may often be to reduce the cost of lighting to one half. It is possible for the lamp manufacturer to produce to suit a variety of different conditions, provided he is made aware of them, but as he seldom is furnished with any particulars beyond the candle-power and volts at which the lamps will have to work.

He frequently has his lamps condemned as bad when in reality there is nothing the matter with them if used under proper conditions.

In certain cases it may be desirable for the consumer to use a lamp which, although working at a comparatively low efficiency, will keep its full candle-power during its life; lamps of this type can easily be procured.

In other cases it may be preferable, on account of the cost of energy, to use a lamp which will consume a minimum of current. In this case the consumer must be prepared to sacrifice either constancy of candle-power or duration of life; no lamp has so far been produced which combines a long life with high efficiency and constant candle-power. Again, it may be impossible to guarantee the regularity of the pressure at which the installation runs. Under these conditions an ordinary lamp would have a short life, but if the maker is made aware of them he can specially construct one suitable.

I have for the last few weeks been engaged on a series of experiments upon lamps of most of the leading English and Continental makers. During these experiments, one or two interesting points, which may not be known to all of you, have come under my notice.

I have observed in the case of many lamps, commencing their life with an efficiency of about 4 watts per candle-power (a very usual efficiency), that in the course of from 100 to 150 hours run the candle-power has increased as much as 20 to 30 per cent., and the watts from 15 to 25 per cent., and has then gradually fallen until the end of their life. Installers should bear this point in mind, as the use of such a lamp in an installation where the plant had not a fair margin of power might well lead to trouble through over-loading.

I have also observed that in some lamps commencing their life with an efficiency of from 2½ to 3 watts per candle-power, no rise, or at all events a very slight one, was observable in the candle-power at any period of their life, but a steady and fairly rapid fall from the commencement until a critical period is reached at between 300 and 500 hours, when the lamps reach almost their minimum efficiency from 4 to 4½ watts per candle-power, and continue in this state for the remainder of their life, which, in the case of some of the better lamps, has averaged considerably over 1,000 hours.

This would point to the advisability of using a high efficiency lamp as such for a time, and subsequently moving it to a less important position for the remainder of its life, being content with about its original light; it would then be no worse than an ordinary lamp of the lower candle-power.

I hope in the near future it may be possible for supply undertakings to sell light to their customers, and not current. For only in this way will it be to the advantage of the engineer—generally the only person competent to come to a just conclusion—to see that the current is being consumed by suitable and efficient apparatus.

It is somewhat an unsatisfactory sign that so much foreign material is being sold in this country, and is in many cases introduced and encouraged even by those who are striving in other branches of the industry to compete against it.

British electrical engineers are now entering on a critical period of their existence; they are being threatened on all hands by foreign competition, and unless they wish their business to get into the hands of the German, they must not only strive to keep up the high reputation which English workmanship has always possessed, but must be prepared to support one another by reciprocating business and refusing to buy abroad when it is possible to obtain as good an article at home.

THE INSTITUTION OF ELECTRIC AL ENGINEERS AND NATIONAL DEFENCE.

At the ordinary general meeting, held at the Institution of Civil Engineers, 25, Great George-street, on Thursday evening, January 16th, the retiring PRESIDENT (Mr. R. E. B. Crompton), after distributing the various premiums to the successful readers of Papers, said his last duty was to vacate the chair in favour of a better man. He did not think the choice of the Institution could have fallen on a more worthy man than Dr. Hopkinson, to whom they all owed so much, and who by his scientific work and by his practical contributions to their scientific knowledge of the dynamo, and by his careful studies of the properties of the materials that they used in the construction of electrical apparatus, had done more almost than any Englishman, or he might say more than any man in any country, to forward the great cause of electrical engineering. In conclusion, he could only say that he felt himself a proud man to be succeeded by such a great man.

Major-Gen. WEBBER said it was his unexpected but warmly-appreciated duty to ask the Institution and all their guests present that evening to agree with acclamation "That the cordial thanks of the Institution are due to Mr. Crompton for the energy and ability he has displayed in performing the duties of President during the past year." Of his energy and his efficiency those who had attended their meetings were fully aware, and therefore he would occupy none of their time in bringing home to them what they felt for themselves. But of his efficiency in the Council Chamber, and as Chairman of their committees, they could have very little knowledge, except from previous acquaintance with the energy, zeal and ability he had given to all the work he had undertaken during the many years that they had had the honour and pleasure of knowing him both as a friend and as a fellow engineer. To him (the speaker) this had been a red-letter year, having sat, as he had done, under Mr. Crompton in committees, for their late President's activity, constant attendance, and intimate acquaintance with detail had brought about results which he was glad to say would last through the history of their Institution. As Chairman of one committee in particular—one which came most readily to his mind—the Committee for the Revision of the Fire-Risk Rules—he showed a power of leadership and a power of direction and guidance which he (General Webber) had rarely seen exercised by any other Chairman under whom he had sat.

Mr. DANE SINCLAIR seconded the resolution, which was carried with acclamation, and briefly responded to by Mr. CROMPTON.

The PRESIDENT, who was loudly cheered, having taken his place in the chair, said that before delivering his Address he wished to say something with regard to a matter which intimately concerned the country. Recent events had made unpleasant revelations to many of them. They proved that among other peoples there were certain persons who would regard with satisfaction any danger that might befall us, and that the error of a few of our countrymen might be magnified by persons who did not like us, so as to involve us in quarrels with people we had always regarded as our friends. To provide against such danger was no Chauvinist or Jingo move. It threatened no one; it simply meant that they, as Englishmen, would not allow the evils that might result from the follies of their countrymen abroad to cause mischief at home. Continental nations met this and all other dangers by forcing military service on every able-bodied citizen. We hoped to attain the same object without compulsion. Surely it was the duty of every one of them to consider what they could personally contribute towards the nation's defence. And for such societies as theirs it was their duty to consider what action they could take in their corporate capacity to the same end. They had a number of past and present Royal Engineers on their roll. Electricity was put to innumerable uses in military operations at the present day — for the training and firing of guns and the firing of mines; for telegraphs, for signalling, for search lights. Their technical knowledge might be very useful indeed, and it could not be doubted that many of them would be glad to give their services. The question was, how it could be done, and what steps should be taken to do it. He knew certainly for a fact that anything they could do effectively would be welcomed heartily by the highest authorities in the Army. He had consulted some of their best-known members. He wrote to Lord Kelvin and asked him what he thought of the idea of utilising the qualifications of electrical engineers for purposes of national defence. Lord Kelvin cordially approved of it, and said he would be glad to do all he could to further the movement, from which he expected valuable results. Other distinguished electricians had agreed that such a movement would be eminently useful, and at the present moment would be likely to be successful. The Council of the Institution had passed a resolution that steps should be taken to render available for purposes of national

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defence the technical skill of their members, and a Committee had been formed to consider the question, constituted as follows:—Dr. Hopkinson (president), Mr. Crompton, Mr. Henry Edmunds, Sir F. Abel, Mr. A. E. Mavor, and Mr. R. S. Erskine. Probably this Committee would first of all ascertain what members were willing to serve and what time they could give to training, and what places could be filled in existing corps. If they had more men than were necessary to fill these places a new corps might be formed. If each of them would do his duty according to his opportunities they would succeed in rendering valuable service to their country. The President then proceeded to the delivery of his Inaugural Address, which will be found in full elsewhere in the present issue.

LONDON COUNTY COUNCIL.

At the first meeting of the London County Council held at Spring-gardens after the Christmas recess, Sir Arthur Arnold presiding, it was reported that the chief officer of the Fire Brigade was of opinion that every effort should be made to encourage persons to place their premises in electric communication with fire stations, and with that idea he recommended that the annual charge now made for the privilege should be substantially reduced. The Committee had decided to reduce the charge to £2. 2s. a year, and wished attention to be called to the advantage to manufacturers and others of having their premises in direct communication with fire stations instead of relying on the public fire alarms. The order prohibiting the introduction of call bells had been revoked for the chief officer stated that there had recently been submitted to him a new form of fire alarm, by means of which an accidental ringing of the bell from contact of wires or other causes could at once be distinguished in a fire station from a proper call.

County Council Subways.

Mr. EMDEN moved: "That it be referred to the Highways Committee to consider and report without delay on the expediency of the Council applying to Parliament for power for the Council and the local authorities to construct subways under the streets of London, for the reception of the tubes and wires of the gas, water, electric and other companies, and to charge rents for the same." He pointed out the great loss that accrued to the ratepayers from the continual pulling up of the streets to lay electric, gas, and other tubes, and he contended that great advantage would be gained by the companies interested. Further, he thought the cost of construction and maintenance would be met by the rents which would be obtained for the use of the subways.

Major PROBYN seconded the motion.

Mr. JOHN BURNS thought none had a better right to bring forward such a motion than the representative of the Strand (Mr. Emden) for that district was treated in a scandalous manner by the electric lighting and other companies; but he thought the object sought would not be obtained unless there was some degree of compulsion exercised to make the companies use the subways.

Mr. CHARLES HARRISON suggested that the matter should also be referred to the Parliamentary Committee.

Mr. EMDEN accepted the suggestion, and the motion as amended was then carried.

Provisional Orders—Opposition.

The Highways Committee reported that three applications had been made to the Board of Trade for Electric Lighting Provisional Orders this sesison. Two of those were by the Vestries of Battersea and Newington as regarded their respective districts, and followed substantially the form in which Orders had been obtained by other local authorities, and appeared to require only very slight amendments. They recommended "That the Board of Trade be asked to insert in the Battersea and Newington Orders the amendments prepared by the Highways Committee." The third Order applied for by the County of London and Brush Provincial Electric Lighting Company, and entitled the County of London (South) Order, related to the St. Saviour's district and the parishes of Newington, Battersea, Lambeth and Camberwell. The district of St. Saviour's was already included in the areas referred to in the other two companies' Orders, the parish of Newington in one, parts of the parish of Lambeth in two (while the Vestry itself also had an Order), and the parish of Camberwell in two. The Vestry of Battersea strongly objected to the granting of the Order so far as related to that parish, and it appeared to the Committee that ample provision was made under previous Orders for the electric lighting in the district referred to in the Order now asked for. Accordingly they recommended that the Board of Trade be asked not accede to the application.

The recommendations were agreed to.

A Large Tramway Car House.—A car barn, said to be the largest in the world, has been built by the Brooklyn Heights Railroad Company. It has a floor area of 700ft. by 200ft., and is three storeys high. It serves as a depôt for six lines, and has a housing capacity of 1,000 cars. Each floor of the building has a direct entrance from the street, and therefore no elevators are required. Transfer tables at the front and rear of the barn assist in shifting the cars about. Well-equipped repairing shops are on the premises.

LEGAL AND POLICE INTELLIGENCE.

On Saturday and Monday last, at the Central Criminal Court, before the Common Sergeant, Edward Augustus Ingold, 30, engineer, and Alfred Attride, 34, horse trainer, were indicted for falsely applying to certain lamp holders a mark resembling the trade mark of the Edison and Swan United Electric Light Company, Limited, in such a manner as to be calculated to deceive.

Mr. C. Mathews and Mr. C. F. Gill prosecuted; Mr. Schulters Young defended Ingold, and Mr. Hurlton and Mr. Collison appeared for Attride.

In opening the case for the prosecution, Mr. MATHEWS referred to its importance to patentees generally, and said the facts which they had to inquire into ranged between August and November last. The prosecutors were the registered patentees of certain holders for electric lamps, in respect of which they had fixed a standard price as between themselves and those engaged in the manufacture of electric lamps. This was well known in the trade, and so far as the prisoner Ingold was concerned this fact would be brought home to him beyond the possibility of doubt. Ingold, as the jury would hear, was for some years in the employ of the Company as invoice clerk, but he left their service in January, 1892. He immediately afterwards went into the employment of a firm who were licensees for the manufacture of the holders. The jury would understand that the prosecutors, although they were patentees of the holders, granted licences to others in the trade upon conditions as to royalty, and also upon the undertaking that the holders should not be sold below a standard price. These licensees were allowed to stamp the holders they made as "Edison-Swan" patents, while the prosecutors stamped those they made "Ediswan." Both marks, however, were registered as trade marks, and Ingold particularly would be aware of the conditions under which the licensees were allowed to make the holders and as to the standard price. A copy of the conditions would be before the jury, and they would hear, as the case proceeded, that the holders so made by the licensees were to be of the best material and workmanship, and that they were not to be sold at a lower discount than 33 per cent., and, further, that the licensees were to pay to the prosecutors a royalty of 10 per cent. on the standard price. As he had before said, Ingold left the employment of the Company in January, 1892, and went into the employ of a firm of licensees of the prosecutors, and the jury would hear that in November, 1894, he got into communication with a Mr. Phillip James Cremer, of Cologne, who was a manufacturer on a large scale of electric lamp holders and other electrical accessories. Mr. Cremer appointed Ingold as his selling agent in England, and from that time until these proceedings were instituted Mr. Cremer became a victim of Ingold, as the large mass of correspondence which had been seized clearly showed that Ingold was putting forward a number of fictitious firms for the purpose of inducing the Cologne manufacturer to send over to this country very considerable quantities of electric lamp holders, for an object for which there could be no doubt when they came to consider the evidence. To this intent Ingold associated himself with one confederate after another for the purpose of getting their holders stamped with the Edison Swan trade mark, selling the holders at prices more profitable to him than if they had been obtained and stamped in the legitimate way. In the first instance he renewed his acquaintance with a man named Findley, who also had been in the employ of the Edison and Swan Company, and for the purpose of carrying out the unlawful purpose on which he had embarked, there was formed the firm of Findley and Co., of Walthamstow, who were described by Ingold to Mr. Cremer as electrical engineers and general railway contractors. Findley, no doubt, was as well aware of the rights and privileges of the licensees as Ingold himself. He also was aware of the fact as to the standard price, but Findley would be called as a witness for the prosecution, and he would tell the jury as to the holders which his firm obtained from Mr. Cremer. Then Ingold introduced Attride and Co. to Mr. Cremer. Attride was the man who stood by the side of Ingold in the dock, and Attride and Co. must, no doubt, be read as Ingold himself. Prior to this time the holders had been stamped with a genuine stamp belonging to the firm of Paterson and Cooper, who were licensees of the prosecutors. Unknown to Paterson and Cooper, one of their employees, a man named Cosgrave, who they would hear of hereafter, obtained possession of the stamp, with the cognisance, no doubt, of an overseer, who could not now be found, and he (Cosgrave) at his own house stamped large numbers of the holders. The matter came to the knowledge of Messrs. Paterson & Cooper, who promptly discharged both Cosgrave and the other man. In this difficulty it became necessary to resort to other means to get the holders stamped, and accordingly they would find Attride arranging with a worker of metal and die and stamp maker in St. Luke's, named Tucker, for the manufacture of the stamp "The Edison and Swan Patent" and for the stamping of the holders. In arranging with Tucker, Attride, as they would expect when a person embarked on a course of fraud of this character, did not give his correct name, but said he was James Ford, and that he lived at 22, Downham-road, Kingsland. This address was not a true one. Between October and the 1st inst. no fewer than 14 gross of these holders were stamped by Tucker. Attride took these holders to Tucker and fetched them away when stamped, and both Attride and Ingold were afterwards concerned in the disposal of them. Some of them were taken to the Electrical and General Engineering Company in Leadenhall-street, and the manager, Mr. Bowyer, would be called as a witness. He would state that Ingold told him that he was acquainted with a bailiff who had taken them for debt. On another occasion, when the manager was still curious as to how Ingold possessed himself of the holders, made a similar inquiry, and was told by Ingold that he was acquainted with a dealer who sometimes picked up job lots, and that thus he was enabled to sell the articles at below the standard price. This

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part of the evidence would become of the greatest importance when the jury came to consider whether the mark on the holders was a colourable imitation of the prosecutor's trade mark, because they would find that Mr. Bowyer, in purchasing the holders, believed that he was purchasing the genuine article. Attride also would be connected with the sale of the holders to Mr. Bowyer. The matter was brought to the attention of the Edison and Swan Company, and they took steps to bring the matter home to the accused. They employed a man named Davis, who was known to Attride, and, acting under their instructions, Davis saw Attride and gave the latter six dozen holders to get stamped. Attride was followed and seen to take the holders to Tucker, who stamped them, and on Attride handing back the stamped holders he was arrested. He (Mr. Mathews) was at a loss to understand what the defence could be, for the evidence of Findley would be overwhelmingly corroborated, and if Ingold and Attride were engaged in honest transactions what was the need for all the secrecy which was observed by the accused. There was no doubt Ingold was the originator of this scheme, and he it is who introduced the various fictitious firms of Findley and Co., Attride and Co., Ryder and Co., Walters and Co., H. W. Walworth and Co., and so on to Mr. Cremer, who was induced to send large quantities of holders to this country under the pretence that the several firms were substantial business houses. The jury would judge of their substantiality when he mentioned, by way of illustration, that H. W. Walworth and Co., whose address was given as 18, Eldon-street, had no existence whatever, the address mentioned being a newsagent's, where letters and parcels were received. The other addresses were either newsagents or private houses, where Ingold could get possession of the holders. These holders, after being stamped, were left by the accused at cloak-rooms of railway stations, or at public-houses, until they could be disposed of. Ingold's private address in the Woodlands-road, Kilburn, was used as the address of one of the firms, and at the time of his arrest Ingold was negotiating with Mr. Cremer for the execution of an order from a very large Midland firm, whose business was of such a character that their name could not be disclosed, and who were to do all their business through Ingold, whose name alone was to be mentioned in the transaction. The jury, he thought, would have no difficulty in coming to a conclusion when they heard the evidence.

Witnesses were then called to substantiate counsel's statement, and Findley, in his evidence, stated that Ingold told him that he should wait until the bills of exchange, which had been given by the several firms ordering the goods, became due, when he should give information to the Edison and Swan Company and get £20, and should then "go." It was on hearing this that he (Findley) gave information to the prosecutors. In cross-examination Findley admitted that he expected £100 for his information.

Mr. HUTTON addressed the jury on behalf of Attride, urging that he had been the dupe of Ingold. He (Attride) was a rough rider at the Aquarium, and not a man of considerable proficiency in his profession.

The accused were both called as witnesses on their own behalf, and other evidence was called in defence.

Mr. SCHULTERS YOUNG, on behalf of Ingold, complained that the prosecution had taken criminal instead of civil proceedings. He denied that there was any trade mark in the words "Edison and Swan," and that, had civil proceedings been taken, Ingold was prepared to contest the registration of the trade mark. His case had been greatly prejudiced by his having been placed in the dock, and the prosecution hoped to crush a man by bought and tainted evidence.

Mr. GILL replied for the prosecution.

The COMMON SERJEANT in summing up the case for the jury, pointed out that the Act expressly provided that the imitation of trade mark need not be exact, but that it sufficed if the imitation was colourable and of such a character as to be calculated to deceive. It was suggested that the offence was created by the Trades Mark Act of 1887, but this was not so. The offence itself had always been an offence and a forgery at common law. Doubts however were created that these became more apparent after the case of Borwick's baking powder, in which a person made a mixture of his own in packets bearing the exact resemblance to those of Messrs. Borwicks. In 1862, the offence of doing this was made a statutory offence, and in 1887, when the Trades Marks Act was passed, the provisions of the Act of 1862 were repealed, but some of the most useful provisions of the Act of 1862, including this particular one, were re-enacted in the Act of 1887. They had nothing whatever to do with the matter of civil proceedings. The prosecutors were entitled to whichever remedy the law allowed them they liked; and the fact that they had taken criminal proceedings when they could have resorted to the Court of Chancery ought not to affect the minds of the jury one way or the other. No doubt the case of Ingold and Attride was entirely different. Attride might be the innocent agent it was stated that he was, but the evidence of Ingold alone threw considerable light upon his own guilt. According to his own showing he engaged Cosgrave through the other man employed by Messrs. Paterson and Cooper to stamp the holders with what he knew was the genuine stamp of the prosecutors' licensees. He therefore, according to his own showing, was engaged in a conspiracy with Cosgrave and the third man, Marsden, who could not now be found, to stamp the holders with the genuine stamp, the mark of which, the jury would bear in mind, was registered as a trade mark equally as well as was the trade mark "Ediswan." Had Ingold, as he said, simply desired to test the legality of the trade mark nothing could have been easier. He could have opened premises and notified the prosecutors of his intention, but he did nothing of the kind. On the contrary, the greatest secrecy was used in all the transactions. False names were used, and the holders, when stamped, were deposited at railway stations and other places until they could be sold. Then they had the untrue representations to Mr. Bowyer as to the manner in which Ingold had come by the holders. No better evidence as to the colourable imitation of the trademark could have been adduced than that given by Mr. Bowyer, because he, an experienced man, bought the holders believing that they were the genuine articles and that the trade mark upon them was that of the prosecuting firm.

The jury, without hesitation, found Ingold guilty and acquitted Attride.

The COMMON SERGEANT in discharging Attride, told him that he had acted most indiscreetly in the matter. He hoped this would be a caution to him against mixing himself up in a matter of this kind again. He (Attride) had much better follow his own legitimate business, in which he (the Common Sergeant) was told he was a man of considerable proficiency.

George Cosgrave, 22, engineer, then surrendered to his bail and pleaded guilty to a similar offence as that of which Ingold had been convicted.

Mr. CORNEY addressed the Court on behalf of Cosgrave, and as Mr. Mathews said the prosecution would be content if he were merely bound over, the Common Sergeant directed that he (Cosgrave) should enter into his own recognisances in £100 to come up for sentence if called upon.

No evidence was offered by the prosecution on the charge against Ingold of conspiring with Attride and defrauding the prosecutors of large sums of money, and a verdict of not guilty was returned.

Mr. MATHEWS said the prosecution regarded Ingold as the prime mover in this matter, and, as he had told them on his evidence, he had dealt very largely in these electric lamp holders, for he had confessed that some 13,000 of them had been delivered in London. In addition, he had ordered 3,000 more, and he was sending orders for 4,000 or 5,000 others. But this was not the worst feature of the case, because he had no doubt tempted the man Marsden who, prior to Ingold's acquaintance, had done honest service for the firm by whom he was employed. He had also been the means of bringing the man Cosgrave into the dock, and Attride also owed the position he had occupied during the trial to his connection with him. Therefore the case, so far as Ingold was concerned, was one of a very serious nature, for, having made himself familiar with the prosecutor's course of business, he had used his knowledge for an unlawful purpose.

The COMMON SERGEANT said Ingold had been engaged in the most mischievous and nefarious occupation, and the case could not have been proved against him by clearer evidence. He had no reason to believe that the forgery of trade marks was by any means a prevalent offence, or he should have dealt very differently with the accused than the manner in which he proposed to do. It was extremely desirable that the registration of trade marks should be protected, and he should sentence Ingold to nine months' imprisonment without hard labour.

Gulcher (New) Electric Light and Power Company v. Murray.

This case came before Mr. Justice Vaughan Williams, in the Chancery Division, on the 18th inst., for judgment. The case was referred to in our last issue. The facts of the case sufficiently appear in the judgment.

His LORDSHIP, in giving judgment, said that the question was whether Mr. Murray was liable to be put on the list of contributories in respect of 300 Preference shares in the Company. Mr. Murray was the holder of £300 in Debentures in the Company—Ten per Cent. Debentures—but in March, 1890, the Company was minded to raise a sum of some £37,000 by the issue of Ten per Cent. Preference shares, and it was proposed to use the money raised by the issue of those Preference shares to the extent of £16,000 in paying off those Ten per Cent. Debentures. It was intended that the whole of the £37,000 should not be called up in the first instance before 10s. in the £ was called up by instalments of 2s. 6d., the first being payable on application, and the last being payable some time at the end of August, 1890. Upon March 11th the Company seemed to have proceeded to allotment of those Preference shares. They seemed, after the manner of company promoters and company directors, to have made their allotment first and got their applications afterwards. In that state of things they, on March 11th, allotted Mr. Murray the 300 shares, and proceeded to send an allotment letter to him; but there had, apparently, been some conversation between Mr. Murray and Mr. De Castro, the chairman of the Gülcher Company. He (his Lordship) did not think that Mr. De Castro had filed any affidavit in the matter, for his attention had not been called to it—and the only affidavit as to the conversation was the affidavit of Mr. Murray. Judging from the subsequent conversations, he (his Lordship) had no doubt that Mr. Murray's account was true. Mr. Murray stated that he stipulated that he should not be called upon to accept any allotment unless and until 10s. in the £ were paid up on the 37,423 shares. Of course, Mr. De Castro, if he had accurately recollected what had passed between himself and Mr. Murray, had no right to make such statements to the Directors—if he did do so—as should induce them to allot in any other way except in accordance with the statement in that paragraph of the affidavit; but on March 17th Mr. De Castro wrote to Mr. Murray, saying: "I send you allotment letter with the condition you desire set out on the face of it." The allotment letter was dated, in print, March 13th, 1890. He supposed that most of those allotment letters were printed immediately after the allotment of March 11th. The letter stated that "his allotment has been made, conditional upon at least 10s. per share being paid up on 37,423 shares before you are called upon to pay up anything." On March 18th Mr. Murray wrote acknowledging the letter and stating that, providing the condition in the allotment letter was carried out, he would accept the shares. On March 19th Mr. De Castro wrote a letter to Mr. Murray which showed clearly that Mr. De Castro understood perfectly well Mr. Murray's letter of March 18th, and accepted it because the letter did not speak of it as a simple allotment but as an arrangement of which it was desirable to have a record. The application form was then forwarded. It was dated March 11th—which was, of course, untrue—and stated on it that the application was made on the terms of the Memorandum of Association and upon the special condition endorsed thereon, and then was set out that same condition which was set out on the face of the allotment. In his opinion the allotment letter was only intended to take effect upon

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the happening of the particular condition endorsed upon it. When the end of August came it was admitted that this money had not been paid up on those other Preference shares. The Company was not in a position to carry out that which they had proposed to carry out. The result was that this arrangement, which was simply an arrangement under which Mr. Murray was to change his investment in the Company *pro tanto* from Debentures to Preference shares, was not carried through, because the company were not in a position to perform that condition. His Lordship then said that he found as a fact that Murray had no knowledge whatever of his name being on the register. In these circumstances he thought that Mr. Murray was not liable, and that the claim against him failed.

Mr. MARTELLI, who appeared for the respondent, asked that the application might be dismissed with costs.

His LORDSHIP said that he did not think that he ought to order the liquidator personally to pay the costs. If there were assets enough the respondent would get them.

Mr. GORE BROWN remarked that he thought that the assets would prove ample for such payment.

His LORDSHIP said that he always meant that the costs should be paid at once to the successful litigant where there were assets.

Mr. GORE BROWN replied that as this was the last incident in the winding-up, the time would be very short before they were paid, he was glad to say.

In re Woodhouse and Rawson, Limited.

This was an action before Mr. Justice Vaughan Williams, in the Chancery Division, on Friday last, on a summons taken out by the Official Receiver and Liquidator, asking leave under Section 10 of the Companies Acts to proceed against the Directors and Auditors of the Company.

Mr. HOWARD WRIGHT, who appeared as counsel for the Liquidator, reminded his Lordship that when the matter came before the Court on May 16th last the Court directed certain meetings to be held of the three classes of debenture holders to ascertain whether they desired to proceed or not. The result of that was that they decided not to proceed. Again the summons was adjourned to obtain the opinion of the debenture holders as to whether they would forego their claims on any sums recovered as the result of proceedings instituted by the other creditors. After stating the results of voting upon this question, Mr. Wright said that the first charge on the assets were the Six per Cent. Debentures, and the Five and a-Half per Cent. Debentures were a second floating charge. Doubts had arisen as to the rights of certain parties to vote; but the effect of inquiry on this point would be to increase, though not very substantially, the number desiring to institute proceedings. He had also to call attention to the letter of Mr. John Wood, holder of 6,000 Five and a-Half and 2,000 Six per Cent. Debentures, read at the meeting. It was dated October 29, 1895, and in it he wrote that it seemed to him that the question of proceedings against the Directors was one of a pure matter of business. He personally did not think very much would be recovered and no benefit would accrue except to the lawyers; but if there were people who thought otherwise, they would be prepared to pay a substantial sum to step into the position of the debenture holders, and if a proposal of that sort were made to him he would consider it on its merits. So that he did not abandon his claims.

His LORDSHIP: I am not bound to express an opinion, but I say I do not think the letter of that gentleman represents the commerce in the City of London generally. I think it is a private view of this gentleman.

Mr. MACNAGHTEN was about to address the Court for Mr. Wood and the other objecting debenture holders, when

His LORDSHIP said they must see whether this matter could be dealt with practically. Here were very serious charges against the Directors. Facts had been laid before counsel, who had advised that those parties would be liable on those facts to contribute large sums to the assets of the Company. Mr. Wood came forward and said: "I do not believe these claims are worth anything, but it is not my habit to do anything—even to assist justice—unless I am paid for it, and I expect to be paid for it. If I am paid for it I shall be pleased—more than pleased—to assist." Very well; what was Mr. Wood's figure? His Lordship continuing said: What I propose to do is to give Mr. Wood and his friends an opportunity of naming their price, and letting the unsecured creditors consider it.

Mr. MACNAGHTEN: Our position is perfectly intelligible. We do not think it is worth while bringing the action, but——

His LORDSHIP: Well, then, if it is not, it is not. But if your refusal to agree is only a commercial one, name your price—and I should say it ought not to be a big one. If these people do not want to sell because they wish to shield the guilty, I will not put them to the trouble of holding a meeting to consider their price.

Mr. AUSTEN CARTMELL, representing the Five and a-Half per Cent. Debenture-holders, pressed the Court to direct that proceedings should be taken.

His LORDSHIP said that the right thing to do was for the Receiver for the debenture holders to put their interest in these claims against the Directors and auditors up to auction and for the liquidator to buy, with directions as to the proper conditions.

For this purpose his Lordship again adjourned the summons.

New British Electric Installation Contractors' Company.

The examination of the Directors and officials of this Company (in bankruptcy) was resumed on Wednesday at the Shire Hall, Worcester, before Sir R. Harington.

Mr. TREE apologised for the absence of Mr. Duce on the last occasion, he having mistaken the date of the adjournment.

Mr. W. J. HILL (secretary to the Company) said that in drawing up any agreement between the old and new Companies he acted under the instructions of Mr. Millington.

His HONOUR said that the date of the signing of the debenture shares was very material, as Mr. Millington was not a shareholder of the new Company.

WITNESS said he was unable to give the date, but said they were issued in February, 1893; £130 was actually paid by Mr. Millington, and £125 by Mr. Griffiths, his partner, for shares; £425 was paid for Mr. Duce's shares held in trust by Mr. Millington, but no cash was paid for the 69 promoters' shares.

Mr. DUCE said he was not the only person connected with the Company who had an electrical knowledge; Mr. Millington was a very good commercial electrician. Witness had been engaged in the electrical trade in a general capacity. Before 1890 he had had little scientific knowledge. He was brought up in the spirit trade, at Wednesbury. He was adjudged a bankrupt at Walsall, and was still undischarged. He had had bitter experience in company matters. He could not say who suggested the formation of the New British Company. He thought the formation of the new Company was justified by the fact that the Corporation of Worcester had nearly finished their electric light station, and the Company had every reason to believe that there would be a large amount of additional work follow. The old Company wanted more capital to carry out some of the concessions, but as they did not get it they went on with the new Company on a better basis. He denied that the new Company was formed for the purpose of recouping losses which were sustained in the old Company.

Mr. JOHN MILLINGTON, recalled, said that the concessions would have become very valuable if money could have been found to work them. The old Company was not wound up with a view to getting rid of its liabilities. The bonuses were given for services rendered and money advanced, and he himself was given a bonus of £1,000, for which he had given months of service, both to the old and new Companies.

Mr. LUKE SHARP, the Official Receiver, asked if witness did not think £1,000 very considerable for services to a company that came to grief in 12 months.

WITNESS: How could it come to grief when it paid its debts?

Mr. Receiver SHARP: Yes, with the money of the new Company. If you had such confidence, why did you not issue shares instead of debentures?

WITNESS: My partner would go no further, and it was purely a matter of private arrangement. The Company fitted nearly the whole of the public buildings in Worcester for the electric light. No shareholder except the promoters themselves would lose a penny; those who had put money in would be indemnified by himself. Mr. Martin was the only shareholder who actually paid any cash for the debenture shares. He paid £500.

The examination was closed.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January 10, 1896.*

Storage Battery for Telephone and Telegraph Purposes.—The Western Union Telegraph Company and some of the district American Bell Telephone Companies have for some time been using small storage batteries for local service, and, it is said, with excellent results. The storage battery used is of the Planté type and of small size, costing about $1. As applied to telephony, the battery is under charge from the central exchange at all times when the receiver is on the hook, while when the receiver is removed for conversation the battery is switched into the local microphone circuit.

Gas Engines.—An electric railway plant is now being constructed in the West which will have an auxiliary gas engine for use during hours of heavy load, the object being to have the steam plant of such size that it may be worked near to its full capacity during the long hours of steady load. A gas engine has just been placed upon the market for use in isolated electric lighting, which is sold with the guarantee that the difference of speed will not exceed 1 per cent. for changes of load from 10 per cent. to full load. A company in Chicago has been installing gas-engine plants for block lighting, a recent plant supplying over 4,000 lamps in buildings on six blocks.

Telephony in Germany.—According to the report of the German Posts and Telegraphs Department, which has lately been issued for the year 1894, there were at the end of that year 475 German towns provided with telephone exchanges, as compared with 54 at the end of 1884. The number of inter-urban telephonic connections stands at 602, as against 22 ten years ago.

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CORRESPONDENCE.

AN "ECCENTRIC" SYSTEM OF ELECTRIC SUPPLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As to "An Eccentric System of Electric Supply," in your issue of 17th inst., I would like to have it explained how the common return differs in principle from both circuits being earthed at the far end and the corresponding dynamo terminals earthed also.

As far as practice is concerned it would be interesting to hear how the dual current affects the common return as to resistance, heating, &c. That is, suppose 1,000 amperes per square inch of conductor of continuous current is passed through, and also 1,000 amperes per square inch of alternating, is the volt loss that due to the sum of the currents, or do they not affect each other?—Yours, &c., J. E. RITTER.

Limavady, January 20, 1896.

[An unearthed common return connecting two systems differs from an earthed return in many respects, but chiefly in the fact that in the former case accidental interruption of the return circuit will send the current from one system into the other, whereas this cannot happen in an earthed return. The heat developed in a joint return conductor would, of course, be determined by the $\int c^2\,dt$ of the combined continuous and alternating currents, and would *not* be the sum of the heats developed separately by the two.—ED. *E.*]

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is in active preparation, and will be ready at the end of January. Orders for Advertisements and Subscriptions (5s. 9d. post free, abroad 6s. 6d.) should now be sent in. Full particulars post free on application.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES *can be obtained of the Booksellers or direct from the Publishing Offices:—*

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

TENDERS INVITED.—The District Council of Swadlincote (Burton-on-Trent) invite tenders for the lighting by electricity of the thoroughfares of the township of Stanton. Particulars can be obtained from Mr. R. Cartwright, surveyor. Tenders must be in by the 27th inst.

——— The General Direction of the French Posts and Telegraphs requires tenders for the supply of 100 kilometres of submarine cable. Tenders to the Direction Générale des Postes et des Télégraphes, 103, Rue de Grenelle, Paris, by the 30th inst. The same department invite tenders for the supply of 500 tons (in five lots) of galvanised iron telegraph wire. Tenders by February 15th.

——— The municipal authorities of Soria, Spain, invite proposals for the concession for the electric lighting of the town for 20 years. Tenders to be sent to El Ayuntamiento de Soria by the 30th inst.

——— Tenders are invited for the concession for the electric lighting of Sainte Croix de Teneriffe, Canary Islands for 35 years. Tenders to the Ministère de la Gobernacion, Madrid, by Feb. 29th.

——— The Cologne Direction of the Prussian State Railways invites tenders for the supply of 137½ tons of galvanised iron telegraph wire, 5½ tons of bronze wire, 1½ tons of insulated wire, 12,300 porcelain insulators with supports, 17,400 porcelain insulators without supports, &c. Tenders to the Königliche Eisenbahn Direction, Domhof No. 28, Cologne.

TENDERS INVITED.—Tenders are invited for electric lighting work at the Zion Methodist New Connexion Chapel, Lindley, Huddersfield. Tenders to Messrs. John Kirk and Sons by the 29th inst.

——— Tenders are invited for certain electric bell-fitting work at the School for Technical Instruction, Maidenhead. Particulars from Mr. E. J. Shrewsbury, Queen-street-chambers, Maidenhead. Tenders by 4 p.m. on the 24th inst

——— Tenders are invited for installing the electric light at the Promenade Pier, Palace of Varieties and Marina Restaurant, by the Ramsgate Marina Pier and Lift Company. Particulars from the Secretary, 23, Martin's-lane, Cannon-street, E.C.

LIGHTING SCHEMES INVITED.—It will be seen by our advertisement columns that the Urban District Council of Eston, Middlesboro', invite schemes for lighting the district by electricity. A plan of the district can be seen and particulars obtained on application to Mr. F. W. Stainthorpe, A.M.I.C.E., District Surveyor, Grangetown, Yorkshire, to whom schemes must be sent in not later than May 1st next. Mr. Jno. T. Belk is clerk to the Council.

TENDERS ACCEPTED.—The tender of Messrs. Graham and Biddle has been accepted for fitting up an electrical-wiring installation with fittings in the new Chelsea Infirmary, for the Guardians, at £338. 12s. 6d.

——— The Bearpark Parish Council have accepted the tender of the Bearpark Coal and Coke Company to light the parish electrically. It is proposed to use 37 lamps of 32 c.p., and the charge is to be £3 per lamp per annum.

——— The British Thomson-Houston (Limited) and the Fowler-Waring Company have received orders from the Taunton Town Council for the supply of transformers and concentric cable respectively.

TENDERS RECEIVED.—The Shoreditch Vestry received ten tenders for the erection of the engine house and offices in connection with the Vestry electric lighting scheme. The tenders, which varied in amount from £10,540. 16s. to £8,535, have been referred to a Committee for consideration and report.

POSTPONEMENT OF SALE.—The sale by auction by Messrs. Wheatley Kirk, Price and Goulty of the works at Acton Hill, referred to in our last issue, has been postponed from the 29th inst. to a future date, particulars of which will shortly be announced.

APPOINTMENTS VACANT.—The Corporation of the Borough of Plymouth invite applications from duly qualified persons for the important office of Electrical Engineer to the Corporation. It will be seen by the advertisement on another page of the present issue that applicants must have had previous experience in a similar capacity to a corporation or a company supplying electric current under Parliamentary powers, and must be competent to design and superintend the construction of generating plant, &c. Commencing salary £300 per annum, rising to £400. Applications have to be sent in to J. H. Ellis, Town Clerk, Municipal Buildings, Plymouth, not later than February 14th.

——— A general foreman for an electrical engineering works is required. Regarding the appointment some particulars are given in our advertisement columns.

REMOVAL.—The City office of the Southgate Engineering Company (Limited), makers of electric, steam and hand cranes, and whose works and chief offices are at New Southgate, N., has been removed from 172, Fenchurch-street, to Leadenhall House, Leadenhall-street. This office is under the management of Mr. James Reid.

DISSOLUTION OF PARTNERSHIP.—We are informed that the partnership lately existing between Messrs. E. W. Donovan and F. C. Twemlow, trading as J. S. Leach and Co., mechanical and electrical engineers, &c., at Harpurhey and at Broughton Bridge, Salford, has been dissolved. The business is carried on as formerly under the same name by Mr. E. W. Donovan, who pays and receives all debts due by and to the late firm. The dissolution dates from November 30th last.

LIQUIDATION.—A meeting is to be held at 38, Coleman-street, E.C., on February 17th, at 11 a.m., for the purpose of receiving an account of the winding-up of the International Electric Subway Company (Limited).

THE GÜLCHER COMPANY.—In the action brought by the Liquidator of the Gülcher (New) Electric Light and Power Company against a Mr. Murray the defendant was successful in proving his non-liability for the payment of the sum of £300. Mr. Justice Vaughan Williams decided that Mr. Murray only accepted the allotment of certain debentures on certain conditions, which were not fulfilled; but the point in the action which has the greatest interest for ourselves, and will doubtless interest many of our readers, is the statement made by Mr. Gore Brown, who represented the plaintiffs, "that the assets of the Company would prove

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ample for the payment of the costs in the action, and as this was the last incident in the winding-up of the Company the time would be very short before the costs were paid." Perhaps some of the creditors and contributories of the Company can also share in the distribution of these assets, although in a letter before us the Liquidator writes to a correspondent: "I regret to inform you that there is no prospect of a dividend being paid" in this matter. At a meeting of shareholders and others called some time back the Chairman gave those present to understand that on the realisation of the New Zealand Company's assets funds would doubtless be forthcoming to liquidate all liabilities.

PERSONAL.—We are asked to state that Mr. L. Pyke (late of Messrs. Pyke, Harris and Co., Limited, Westminster) has sent in his resignation to that Company as Managing Director, owing to his having entered into partnership with Mr. Owen Lucas and Mr. Leopold Lucas under the title of Messrs. Owen Lucas and Pyke, consulting engineers.

PORTABLE LIGHTS.—The arrangement adopted by the London General Omnibus Company to provide its ticket inspectors with pocket batteries and button-hole electric lamps has been followed by a similar equipment of the ticket inspectors at the Vauxhall Station of the London and South-Western Railway. All up-train tickets over the South-Western Company's extensive lines are collected at Vauxhall. The arrangement is on trial, and if successful should lead to a large demand for these serviceable lamps and batteries. It has been suggested that the postal department might substitute electric lamps for the cumbersome bullseyes now used by suburban and provincial postmen.

GEIPEL'S STEAM TRAP.—We have received a copy of a new price list for this contrivance, issued by the Shillingford Works Company. The list states that during the past year the trade in these traps has rapidly increased. A description of the trap appeared in *The Electrician* for November 23, 1894. Many electricity supply stations are using the traps.

ELECTRIC SIGN.—A new form of electric sign has been brought out by the Jewels Advertising Syndicate, of New Oxford-street. It consists of a glass cylinder, composed of strips of coloured glass, which revolves slowly between a row of glow lamps fixed to a rod suspended inside the cylinder between its bearings and the sign or line of letters intended to catch the public eye.

TRUNK TELEPHONES.—The Post Office trunk telephone lines are to be extended to Portsmouth, which town will, it is stated, be in direct communication with London at the end of this month.

POCKET CATALOGUE.—While some leading firms in the electrical industries find it necessary to issue from time to time large volumes of illustrations, prices and particulars of their manufactures, other companies are in the fortunate position of being outside the necessity for this heavy expenditure. We have received from the Electrical Power Storage Company (Limited), of 4, Great Winchester-street, E.C., a handy pocket-book, which gives all necessary particulars concerning the well-known E.P.S. batteries. The Company's terms for maintenance, instructions for working E.P.S. batteries (with plan of general arrangement), illustrations, prices and particulars of various types of cell, charges for renewals and particulars of sundry apparatus used in connection with the batteries, are duly set out in a neat pocket companion 5in. by 3½in. The letterpress is printed from photo blocks, which somewhat mars its clearness. The offside of the printed matter is scale paper, and several useful fuse, resistance, acids, &c., tables are included.

MEDICAL SURGICAL APPARATUS.—Mr. K. Schall sends a copy of his new price list of apparatus for utilising currents from dynamos for medical and surgical purposes. The list is illustrated.

CALENDAR.—Messrs. Shand, Mason and Co., the well-known fire engineers and experts, of Upper Ground-street, Blackfriars, London, send a pictorial calendar neatly designed and arranged, from which, amongst other matter, we find that 36 powerful engines of Messrs. Shand and Mason's make have been supplied to the London County Council. The same firm also issue an "occasional" circular, which those interested in fire brigade department matters should obtain.

BAKER-STREET AND WATERLOO RAILWAY.—The engineers of this railway have deposited with the Private Bill authorities an estimate of the cost of the proposed extension of the railway to the St. John's-wood terminus of the Sheffield Extension Railway. The cost of the additional length of line is put at £99,043.

BRADFORD.—At a meeting of the Gas Committee of the Bradford Corporation on Friday last it was decided to have a survey made of the land at Valley-road required for the purpose of the proposed extension of the electricity works.

BRIGHTON.—At the meeting of the Town Council last week, the report of the Electric Lighting Committee, referred to in our last issue, was, after a short discussion, agreed to.

CARDIFF.—The Lighting Committee have just prepared their estimates for the next half year, and it is anticipated that there will be a profit of £848 on the electric lighting department, a sum sufficient to meet interest, expenses, &c., and the repayment of the loan.

CAMBERWELL (LONDON).—At the meeting of the Vestry last week the special Electric Lighting Committee reported that they had considered the notice received from the County of London and Brush Provincial Company for a Provisional Order. The Committee recommended that the Board of Trade be informed that the Vestry would offer no objection to the application provided that separate accounts be kept for Camberwell, and that after the expiry of 21 years the Vestry may have the option to purchase the undertaking. The Committee's report was, after some discussion, adopted.

COLCHESTER.—A special meeting of the Town Council was held last week for the purpose of further discussing the special report recently presented by the Lighting Committee on the question of establishing electric light works in Colchester. An abstract of this report appeared in our issue of the 3rd inst., and the Committee now further recommended the Council to purchase the piece of land adjoining the Stanwell-street depot for £500, to serve as a site for a station. It was stated that the War Office authorities offered to take current for about 500 lamps at the new Military Hospital, provided the charge did not exceed 6d. per unit, and that the supply was available by May next. The Committee recommended the Council to accept this offer, and that a communication be made to the Department, asking that, in the event of the electricity works being established, the Council be also allowed to supply current to the new Infantry Barracks, where about 750 lamps would probably be required. As to the estimated cost of the work the Committee reported that they had been in communication with Mr. W. H. Massey with a view to ascertaining the lowest possible expenditure which a scheme for lighting North Hill, Head-street, High-street (from North Hill to the end of St. Nicholas-street), St. Botolph's-street, Long Wyre-street, Short Wyre-street, St. John's-street, and part of Stanwell-street, and also the barracks and Military Hospital, would involve, and Mr. Massey put this initial outlay at £13,000. Mr. Barritt moved the adoption of the old report, but Mr. Nash moved an amendment that they invite schemes, with plans and specifications, from four firms of good standing, and arrange terms with Mr. Massey to advise them on such plans. The report was after some discussion adopted in the amended form. The new report was then put, and carried by 14 votes to 2.

COVENTRY ELECTRIC TRAMWAYS.—On Thursday last the section of this line, from the tramway depot at Foleshill to Bedworth, was officially inspected on behalf of the Board of Trade, and it is expected that the entire line will in a few days be certified for working.

DERBY AND ASHBOURNE ELECTRIC TRAMWAY.—A detailed estimate of the cost of the proposed electric tramway between Derby and Ashbourne has been prepared by Messrs. A. Dickinson and Co., of Birmingham. The length of the tramways will be nearly 12 miles, but only one mile will be constructed as a double line, and it is estimated that the entire work will involve an expenditure of £31,172.

EDINBURGH.—At the last meeting of the Council, a letter was received from Mr. E. W. Monkhouse, intimating that he had determined to start in business in London as a consulting engineer, and therefore tendered his resignation as borough electrical engineer. The Lord Provost said they were all very sorry to lose Mr. Monkhouse, who had done his work with great energy and success. It was agreed to accept the resignation with regret, and to remit the question of the appointment of a successor to the Electric Lighting Committee. The Town Council at their meeting on Tuesday discussed the joint report of the Cleaning and Lighting and the Electric Lighting Committees referred to in our last issue. The report recommended the Council to carry out various extensions of the public electric lighting. Councillor Mackenzie, in moving its adoption, said ample provision had been made for the lighting of all the main streets of the city, and if the Council adopted the present report they might consider this question of extensions pretty well finished, at any rate for the present. He estimated the total capital expenditure for the present extensions, which would necessitate the erection of 237 lamps, at £11,850. He was certain that if the Council continued to take the same broad view of the electric lighting question which it had hitherto adopted, in 12 months' time it would be possible to reduce the charge for street lighting to £16 per lamp per annum. Mr. Jamieson moved the recommittal of the report, and Bailie Anderson seconded the amendment and said that, though he admitted that great improvement was necessary in the street lighting, still he thought "they were going wild on the matter of electricity," and he thought such expenditure injudicious, in view of the very large and important scheme already in hand. After considerable discussion, the proposals of the Committee were taken *seriatim*. The first, which provided for 36 lamps at an annual cost of £648 for the lighting of Morningside was defeated by a small majority, while another proposal for the extension of the mains into Stockbridge was reduced by 10 lamps, thus diminishing

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the cost of the whole scheme by about £800. The remainder of the Committee's proposed extensions were adopted.——It is proposed to light City Chambers and Royal Exchange-square electrically at an estimated cost of £256.

ELECTRIC RAILWAY EXTENSIONS.—In connection with the extension of the City and South London Railway to the Royal Exchange, a meeting was held at the Mansion House on Wednesday to recommend that opposition be offered to the proposal to demolish the church of St. Mary Woolnoth, at the corner of Lombard and King William-streets. This was the church where some years ago it was discovered that owing to various causes the bodies buried beneath the structure emitted insanitary odours, and a suggestion was then made that, for the general benefit it would be advisable to seriously consider the demolition of the church. It appears now, however, that the attempt of the City and South London Railway Company to obtain the position for the purpose of erecting station in connection with the proposed extension is to be desperately fought. One of the grounds upon which this action is proposed to be taken is that the church was built by a pupil of a pupil of Sir Christopher Wren, a further reason being that one of our leading banking firms has for 600 years carried on its business under the shadow of of St. Mary Woolnoth. There are dozens of city churches in the immediate neighbourhood, in a very few of which do the citizens foregather either on Sunday or week-day, and the opposition to the proposals of the Company seem purely sentimental. There is no objection to be taken to this if the sentiment is healthy and has reason for its foundation, but in this case the building to be demolished has nothing to recommend it from an architectural point of view, and its position is not a favourable one for a church, whereas for a passenger station, which would materially assist to reduce the excessive and dangerous pedestrian traffic at this point, the position is a most desirable one. There was a lack of real feeling in the matter at the meeting, and it is doubtful whether success will attend the proposed opposition.

EXETER.—On the 16th inst. Col. J. O. Hasted, R.E., held a Local Government Board inquiry into the application of the Council to borrow £11,000 for the purchase of the undertaking of the Exeter Electric Light Company, and for the construction of works, in the event of the Council being empowered to purchase the undertaking. The Town Clerk (Mr. G. R. Shorto) supported the application, while Mr. Pitt Lewis, Q.C., appeared on behalf of opposing ratepayers, and the Exeter Company were represented by Messrs. C. T. K. Roberts and S. Andrews. Dr. J. A. Fleming was the first witness called, and said he had made a complete inspection of the whole of the Company's plant and buildings, and he considered that it would be advisable for the Corporation to purchase the undertaking, as in all cases in which local authorities had the electric light under their control a profit had been made. He valued the undertaking at £7,500. New and independent electricity works could not be erected for less than £10,000. The City Surveyor (Mr. Donald Cameron) said he valued the undertaking at £7,556. The building he estimated at £1,000, plant at £3,200, and mains, motors and transformers at £3,156. Mr. H. D. Munro, chief engineer of the Exeter Company, put the value of the concern at £12,000. Mr. A. E. Mavor, manager of the Fowler-Waring Cable Company, was also called, and he stated that the cables were originally laid under his supervision. They were of the highest quality known at the time, and there was now no trace of deterioration. The Secretary of the Local Company (Mr. E. J. Rigby) gave details of the working of the Company. The inquiry was then adjourned till Saturday, when further evidence was given in support of the application. Mr. Pitt Lewis, Q.C., intimated that he would call no witnesses, but he maintained that the value of the undertaking was not anything near the figure given in Dr. Fleming's evidence, and that the present financial condition of the Corporation did not warrant them in purchasing the works. Mr. Roberts replied on behalf of the Company, and the proceedings then terminated.

FAREHAM.—Application was made on Wednesday for a stay of execution for 14 days in the award recently made by the Court against the District Council for £3,800 damages in the action brought by the Fareham Electric Light Company, the contending parties not having arrived at a satisfactory arrangement.

GLASGOW.—At the meeting of the City Council last week a long discussion arose on the Electric Light Committee's report. Mr. Guthrie referred to the small increase in the income from the sale of electric current, viz., £167 10s., and he thought the recently-appointed sub-committee should visit other towns where the electric light had been adopted. Treasurer Gray and Mr. Fife defended the action of the Committee, and Mr. Walter Paton admitted that the electric light had not been such a success as it ought to have been in a city like Glasgow. Mr. W. F. Anderson said the committee had hitherto been going on too narrow lines, and the undertaking would never prove a success until it was entirely dissociated from the Gas Committee. He considered that, after what Glasgow had done in other respects, they should not be dependent on the example of Edinburgh. Mr. Bailie Burt, the convener of the Committee, in his reply, deprecated the statements made as to their non-success. He had no hesitation in asserting that the electric light in Glasgow had been an unqualified success. Various extensions had, from time to time, been made, and even now the Committee had a proposal before them for further extending the system. It was true that they had lost one of their best customers, the Post Office, who had laid down an independent plant, but in spite of this fact their revenue continued to increase.

HANLEY.—At last week's meeting of the Town Council the General Purposes Committee presented the report by the borough engineer and surveyor, Mr. Joseph Lobley, and signed by the joint managers of the electric lighting works. The year's working of the electricity works shows most gratifying results. The report repeats the notification that although the covered market and fish market are wired completely for the electric light, and have been so wired since the autumn of 1894, the demand for current for other purposes so closely exhausts the available power at the station that it has not been considered safe to light the markets by electricity. Owing to the sanction of the Local Government Board for the extension asked for in March, 1895, not having been received till November last, the new plant has not been available for supply during the heavy load of the last few months. Notwithstanding these drawbacks there are now 11,550 lamps connected. The report refers in some detail to the question of the reduction of the price of current, and to the fact that a reduction equal to 16 per cent. (from 6d. to 5d.) has naturally been considered by those responsible for the preparation of the report as a serious matter, and that, therefore, it was determined to await the result of the first year's working under constant supply conditions before advising on the subject. The announcement is then made that sufficient details are to hand to show that the revenue has exceeded expenditure by more than £100, after allowing for interest and repayment of loans. On the whole, however, it is Mr. Lobley's opinion, in which he is supported by Messrs. Cowell and Sutherland, the joint managers of the works, that the time has not come for a reduction in the price per unit being made, except in the application of the Brighton system, regarding which more than usually complete particulars are given for the benefit of the councillors. It is proposed that the existing price of 6d. per unit shall be the basis of the arrangement as now, but that the 5 per cent. discount hitherto allowed should be discontinued. It is also proposed to practically abolish meter rents and to introduce certain abatements for prompt monthly payments on accounts of £1 and upwards. Alderman Shirley, in submitting the report, pointed out that it was hardly anticipated when the electric light undertaking was first discussed that there would be any reasonable prospect of profit at least for some years. This, however, thanks to the able officials who were responsible for the working of the concern, had not proved to be the case, but after meeting all charges, there was already a moderate balance to put to reserve. He proposed the adoption of the report, and with special reference to the rearrangement of charges, including the charge of 4d. per unit for churches, chapels, &c., requiring light principally on Sunday evenings. This was seconded and unanimously adopted. Certainly all concerned are to be congratulated upon the results attained. Of the amounts borrowed from time to time for electric lighting purposes, £13,747 remains available for future extensions. The actual working expenses of the station were £2,286, and the revenue £3,724. 3s. 8d. £754. 8s. 10d. has been paid for interest, and £587. 18s. 10d. has been set aside for repayment of loan. 180,000 units of current were sold during the year.

HUDDERSFIELD.—The London and Provincial Traction Company (Limited) has deposited a Bill in Parliament for power to incorporate the Halifax and District Tramway Company and to construct tramways in and near Halifax. The Company recently approached the Huddersfield Corporation with a view to obtaining a lease of the Council's tramways for the purpose of connecting the system with the Colne Valley, Brighouse, Elland and Halifax. The chairman of the Company, in reply to an inquiry from the Corporation, has sent a lengthy letter to the latter body, in which he points out the advantages of having Huddersfield connected with the various towns above-mentioned by a system of electric tramways. He was unable to say at present what expense would be involved in the construction of the suggested line, but it was the intention of his Company to lay a large extent of double lines in order to increase the frequency of the car service. The Corporation have appointed a sub-committee to consider and report upon the matter.——The electrical engineer has been instructed to prepare an estimate of the cost of the proposed lighting of the top portion of the Market Hall, and a sub-committee has been appointed to consider and deal with the report when presented. It has also been decided that, in the event of the re-pavement of King-street, the engineer is to have electric lighting mains laid in the street.

JERSEY.—It is reported that the Parochial Assembly is disposed to accept the proposal made by a French Company to supply the town of St. Heliers with electric current. An offer has also been made, we understand, by the Jersey Gas Light Company to supply whatever electric current is necessary for the town.

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LIVERPOOL.—At the annual meeting of the Liverpool United Tramways and Omnibus Company, the Chairman (Sir David Radcliffe), in moving the adoption of the report and accounts, referred to the efforts the Directors had made to introduce a suitable system of mechanical traction on their lines. First of all steam was tried, but the Corporation were opposed to its use, and then experiments were made with compressed air and the accumulator system of electric traction. The latter system proved suitable in every respect except as to cost, which they found would be more than 15 per cent. above the cost of horse traction. Finally, the Company had turned their attention to the cable system, but this proved to be the least suitable of all for their lines.

MAIDSTONE.—The Electric Lighting Committee recommend the Council to transfer their Provisional Electric Lighting Order to Company, to be promoted by Mr. Thomas King, electrical engineer, of Brighton and Maidstone.

MERTHYR TYDVIL.—At the last meeting of the District Council the Parliamentary Committee reported that they had seen Mr. J. C. Howell in reference to his application for a Provisional Order for lighting the district electrically, and he had met them to the extent of increasing the area proposed to be lighted electrically. The question of the purchase of the undertaking was also discussed, and it was stated that on certain conditions the Council would be prepared to give their consent to the Order.

MILE END (LONDON).—The consulting electrical engineer of the Mile End Guardians (Mr. B. H. Jenkinson) has submitted plans, &c., for the proposed electric lighting of the workhouse, and these have been referred to the Works Committee, who have been instructed to consider and report on the same.

OKEHAMPTON.—Recently the Charity Trustees decided to have the town clock lighted electrically, and the work has just been completed by Henry Green, of Okehampton.

PERTH.—At the last meeting of the Police Commission Mr. Wood moved that it be remitted to a sub-committee to consider and report as to how the spare power under the control of the Corporation could be best utilised with a view to the electric lighting of all the Corporation buildings. The motion was agreed to.

PERTH (W. AUSTRALIA).—The *Newcastle Journal* states that Messrs. J. H. Holmes and Co., of Newcastle, have entered into a contract to re-organise the electric lighting arrangements at Perth. The work will involve the establishment and full equipment of a central station of as large a capacity as that which the firm are now fitting up at Sunderland, and on the same lines.

SOUTHAMPTON.—A meeting of the Harbour Board is to be held on Tuesday next for the purpose of considering an offer from the Southampton Electric Light Company to supply current at a reduced rate.

ST. JAMES'S (LONDON).—At the last meeting of the Vestry the Works Committee recommended that the following thoroughfares be lighted electrically, viz.: Regent-street, Piccadilly-circus, Shaftesbury-avenue, Coventry-street, Lower Regent-street, Waterloo-place, Pall-mall, St. James's-street and Piccadilly, and that it be referred to a committee to take the necessary steps for carrying out the work in connection therewith. Mr. W. Jenkins, in moving the adoption of the report, said the St. James' and Pall Mall Company would maintain and keep in repair each lamp for £30 per annum. The lamps would be erected in the centre of the street on iron posts 25ft. high, and each would form a refuge. The lamps would be of the same candle-power as those in the Tottenham Court-road and Euston-road, and if the Committee's recommendation were adopted the light in the streets named would be increased about 800 per cent. The lamps are to be placed 60 yards apart, and will be distributed as follows: 16 in Regent-street, 6 in Piccadilly-circus, 4 in Shaftesbury-avenue, 2 in Coventry-street, 5 in Lower Regent-street, 3 in Waterloo-place, 8 in Pall Mall, 8 in St. James's-street and 8 in Piccadilly.

SWANSEA.—On Wednesday last Col. W. M. Ducat, R.E., held a Local Government Board inquiry into the application of the Council to borrow £60,000 for the purpose of erecting electric lighting and dust destructor works. The Corporation were represented by Mr. S. T. Evans, M.P., while Mr. Villiers Meager appeared for the Swansea Coffee Public House Company, who opposed the dust destructor portion of the scheme. Evidence in support of the application was given by the Mayor (Alderman Fred. Bradford) and the Town Clerk (Mr. J. Thomas). Mr. Meager said the ground of his client's opposition to the dust destructor was that it would be offensive to the Company's customers at the Welcome Tavern. Several gentlemen then endeavoured to offer opposition to the Corporation's tramway scheme, but the Commissioner pointed out that he had only to deal with the electric lighting and dust destructor proposals. Mr. Thornton Andrews (Manager of the Gas Company) also opposed the application, and gave certain figures, which he contended proved that gas was cheaper than the electric light. The ground for the opposition of the Gas Company was that the Corporation desired to secure the public and private lighting of the central part of the town, leaving the Gas Company to light the outside districts, where the private consumption of gas was at present almost *nil*. In cross-examination Mr. Andrews admitted that the Company had themselves considered the question of forming an electric lighting company, but that was, of course, owing to the action of the Corporation. The inquiry then closed.——The estimate of the cost of constructing the 28 sections of the new tramways set out in the Corporation Tramways Bill has been prepared by Mr. J. E. Waller, C.E., and is put at £31,315. 17s.

WIMBLEDON.—As a result of the recent Local Government Board inquiry and the notification received by the Council from the Board, it has now been decided to apply for a Provisional Order in place of the licence expiring in July next.

WORKHOUSE LIGHTING.—The House Committee of the Sunderland Board of Guardians have appointed a sub-committee to act in conjunction with the architect of the new workhouse buildings to ascertain (1) the cost of putting down an independent plant for generating electric current for the lighting of the workhouse, and (2) the lowest figure at which the Corporation would supply current from their station.

WORCESTER.—A Sub-Committee of the Watch Committee are considering the advisability of extending the public electric lighting.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

January 6, 1896.

342. J. R. WELLAND. London. A new or improved combined portable electric light and current generating apparatus.
347. C. B. WOOD. London. An improved switch for electrical purposes.
355. A. L. DAVIS. London. An electrical regulator for regulating arc lamps and for other purposes.

January 7, 1896.

390. J. T. LEROUX. Birmingham. Improvements in electrical switches.
452. H. H. LAKE. London. Improvements in apparatus for controlling electric motors. (Bradley, Allan Fiske, United States.)*
474. W. C. BERSEY. London. An improved turning plate for electrically or mechanically-propelled vehicles.
475. W. C. BERSEY. London. Improvements in electric accumulators.
477. C. N. STEWART. London. Improvements in electrical storage accumulators.

January 8, 1896.

533. SIEMENS BROS. AND CO (LIMITED). London. Improved automatic remontoir apparatus for Hughes's telegraph apparatus. (Siemens and Halske, Germany.)
535. H. W. HEADLAND. London. Improvements in primary and secondary batteries.
546. R. J. BOTT. London. Improvements relating to electric incandescent lamps, and to adapter fittings therefor.
547. H. EDMUNDS. Improvements in devices for joining or connecting electrical cables or conductors.
551. L. B. ATKINSON. London. Improvements in dynamo-electric machines and motors.
557. R. COLLINS and F. COGAN. London. Improvements in electric batteries
565. H. H. LAKE. London. Improvements in apparatus for transforming continuous electric currents. (Cie. de l'Industrie Electrique, Switzerland.)

January 9, 1896.

604. S. W. BAYNES. London. Improvements in insulated anchoring apparatus for use on underground or overhead conductors of electricity.

January 10, 1896.

699. H. N. MOODY. London. Improvements in electric arc lamps.
701. B. MARINOVITCH. London. Improvements in electric signalling apparatus.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1895.

20,435. DEVONSHIRE (Case). Electric brakes.
20,940. JOHNSON (Woodbridge). Printing telegraphs.
21,556. THOMPSON (Hammacher and Paetzold). Telephone transmitters.
21,623. FOX. Electric lamp fittings.

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COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Company (Limited).

The forty-seventh half-yearly meeting of this Company was held on Thursday, at Winchester House, the Marquis of Tweeddale (Vice-chairman) presiding.

The SECRETARY (Mr. George Draper) read the notice calling the meeting.

The CHAIRMAN expressed regret that the respected Chairman of the Company, Sir John Pender, M.P., was confined to his house; but he hoped that the indisposition from which he was suffering would pass away speedily. He believed that a little rest from his arduous labours, and, perhaps, a visit to a more genial climate, would restore Sir John to his usual good health. The half-year which was under notice was the most satisfactory that the Company had ever experienced. It was distinguished by two very satisfactory features. One was a large increase in the receipts, and the other was a decrease in the expenditure. The gross revenue for the half-year amounted to £409,780, against £362,557 in the corresponding period of 1894, an increase of £47,223. An examination of the message receipts from various sources showed a satisfactory increase in all classes of traffic. The principal increase was in the traffic with West Australia and South Africa, which was due to the activity that had taken place in the gold-mining markets. With regard to the traffic with South Africa it was satisfactory to note that, notwithstanding the large reduction in the tariff, an increase had taken place in the value of the traffic at the former rate, but as this was entirely due to special circumstances they could hardly count on its being maintained. The total ordinary expenses for the six months ending September 30th last amounted to £96,704, against, in the corresponding period of 1894, £97,533, or a decrease of £829. Although every care was taken in controlling the expenses, the shareholders must not be surprised if in the future the amount became larger. Their business was growing so rapidly that an increase in the expenditure must be contemplated by them. After providing the usual amount for interest on debentures and debenture stock and the usual two quarterly dividends, they were enabled to carry £10,000 to the maintenance of ships' reserve, £50,000 to the general reserve fund, and the balance of £49,352 it was proposed to carry forward to the next half-year. The value of their reserve fund, about £422,000, showed an appreciation of nearly £60,000, so that altogether the accounts might be fairly considered as very satisfactory. He was glad to say that their cables were, speaking generally, in a very good condition. These cables were, however, of all ages and all lengths, and in seas differing very much in condition in respect of cable-laying. In view of these facts and of the numerous interruptions that occurred the necessity was apparent of further increasing their reserve fund, which, in the opinion of all those whose opinion was worth having, was in a very inadequate state at the present time. The sum at which it stood was about £422,000, but it should be something like double that before it could be regarded as satisfactory. It might interest them to know the actual facts with reference to their recent interruption on the east and west coast of Africa. On December 24th the Aden-Zanzibar cable was interrupted. They had two ships available for its repair, one belonging to the Eastern Extension Company, which had just left Suez and was on its way to Aden, and the other to the Eastern and South African Company, stationed at Cape Town. The latter Company found by hiring the Eastern Company's ship there would be a saving of about a week in restoring the cable, and orders were given for that vessel to proceed to the spot. She hooked the Aden end of the cable at the second swoop, and communication was restored on the East Coast on January 4th. Meanwhile events had happened in the Transvaal the nature of which they were aware of, and the West Coast route had been called on to perform an enormous amount of additional traffic. Until December 30th the West Coast route was able to keep up to the traffic, but on the news of Dr. Jameson having crossed the frontier of the South African Republic the line became occupied almost entirely by telegrams sent by and to European Governments, who had the right of priority of transmission, and this particular traffic was transmitted without exceptional delay. Immediately the East Coast route was restored the delay began to diminish, and on January 10th they had recovered their normal condition of working. It was a time of great anxiety to the Board. They desired to do everything to meet the demands made on them, and he believed they succeeded. At any rate not a single complaint, as far as he was aware, had come from our own Government. On the contrary, he had reason to think that our own Government were highly satisfied at the manner in which the business was done, and they had not received any complaint from any other Government having large interests with South Africa. He thought they might look forward to the coming half-year with confidence. The war clouds were lifting, and the traffics continued good, reflecting, he believed, the improved condition of business and commerce. With these observations he moved the adoption of the report and accounts.

Lord SACKVILLE A. CECIL seconded the motion.

Mr. BAINES, after alluding to the regret he believed all the shareholders felt at the illness of Sir John Pender, complained that, notwithstanding the splendid traffic of the half-year under review, the ordinary shareholders were left with the same dividend as before. He thought the ordinary shareholders were entitled to more liberal treatment at the hands of the Board.

Capt. GOODSALL also contended that the ordinary shareholders should be paid a larger dividend.

Mr. JOHN NEWTON said he did not agree with Mr. Baines and Capt. Goodsall that the dividend was a small one. It was a large one in his opinion, and he thought that, having regard to the remarkable career and success of the Company, the shareholders might be content to leave the management of its business and finance to the Directors. He also expressed regret at the indisposition of Sir John Pender, and hoped the Chairman would convey to him the sympathy of the meeting (hear, hear).

The CHAIRMAN, in reply, said he should take an early opportunity of conveying to Sir John Pender the kind expressions which had fallen from several shareholders, and which, so far as he could judge, had been cordially received by the whole meeting. (Cheers.) He would remind Mr. Baines that that was the half-yearly meeting, and it was not usual to expect so large a dividend on such an occasion as at the close of the financial year. The remarks and suggestions which had fallen from him and other shareholders would, however, have the careful consideration of the Board.

The motion was then adopted.

The CHAIRMAN then proposed the re-election as a Director of Lord Sackville A. Cecil.

Sir ALBERT J. LEPPOC CAPPEL seconded, and it was agreed to.

The CHAIRMAN next proposed the re-election of Mr. G. G. Nicol as a Director, who, he stated, was also absent through illness.

Lord SACKVILLE A. CECIL seconded, and it was carried.

On the motion of Mr. BAINES the auditors were reappointed, and the proceedings terminated with a vote of thanks to the Chairman, proposed by Mr. J. NEWTON.

[A full report of this meeting will appear in our next issue.]

Direct United States Cable Company (Limited).

The thirty-seventh ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Tuesday. Sir John Pender, G.C.M.G., M.P., presided.

The SECRETARY (Mr. T. Finnis) read the notice convening the meeting and the minutes of the last ordinary general meeting, which were confirmed. The report of the Directors was taken as read.

The CHAIRMAN: The revenue for the six months to December 31st (forming the first half of our current financial year) amounted in round figures, and after deducting the out-payments, to £43,938, and the working and other expenses, including income-tax, but exclusive of cost of cable repairs, absorbed £19,058, leaving a balance of £24,880 as the net profit of the half-year, making, with £1,410 brought forward from the previous half-year, a total of £26,290, which has been appropriated as follows:—Interim dividend of 2s. per share for quarter to September 30th last, £6,071; further interim dividend of 2s. per share for quarter to 31st December last, £6,071; set aside to reserve fund account, £10,000; leaving a balance to carry forward to the current half-year of £4,148. The revenue, which had commenced to improve in the early part of last year, has still further progressed during the past six months, for which period it shows an increase of £5,596, or more than 14 per cent. as compared with the corresponding six months of 1894. The expenses in London, as shown by abstract A in the accounts, are a little higher in one or two cases, but most of the items remain practically the same as in the corresponding period of 1894. The expenses at stations, as shown by abstract B in the accounts, exhibit reductions of £124 in salaries, £15 in petty expenses, £121 in printing and stationery, and £138 in agencies, with an increase of £104 in maintenance. Altogether these disbursements show a reduction of £216. In the remaining expenditure a saving of £158 is shown in Directors' remuneration, while use of patents cost £150 more, due to the automatic transmitter. This automatic transmitter, I may mention, is an invention whereby we increase the speed of our cables by about 30 per cent. Freight of cable stands for £214 extra through the sending out to our tanks at Halifax of stock cable for repairing purposes. The aggregate ordinary expenditure of the Company is only £34 greater than the corresponding period, notwithstanding the before-mentioned considerable increase of 14 per cent. in the receipts. The cost of cable repairs has, unfortunately, been heavier than for a considerable period, having amounted to £6,984, which has been charged against the reserve fund account, as usual. On the other hand this fund has been credited with £4,619 for interest on the investments and with £10,000 from the revenue account, bringing the balance of the reserve fund up to £306,005. It was higher at one time—nearly twelve years ago—but since that time we have had very heavy repairs made, one of which cost us £58,814. The investments have been increased during the half-year by £16,400 and the present market value of the investments as a whole is about £335,000, or about £50,000 more than their cost to the Company. We have considered it very advisable to keep up our reserve fund. We are getting to a period when our cable will have reached 25 years of age, and although we have put in a great many repairs during the last twelve months—in fact, in the last two or three years—still, we find that if we were to be suddenly brought to our beam ends, we should be short of the amount required to give us a new cable. We have, therefore, always to look ahead and take care that we are not caught sleeping. The six months which we have passed through has been rather an exciting period. We have had a great many things going on in America which have naturally caused us some anxiety, but I still think that common sense will prevail, and that it will bring about a settlement of the question which is being agitated in America now. There may probably be some reason for this agitation at the present time, seeing that an election in the United States is not far off, and people there generally get up some excitement on such an occasion to carry their party into power with its followers. I do not expect it will come to much, but at the same time when people get into a little excitement it is not very easy to judge what they may do. Nevertheless I think that there is common

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sense sufficient to prevent anything like a war between America and England—people of the same blood, who, I believe, may eventually dominate the world. We have received four letters from different shareholders, all complaining, and very properly complaining of the want of dividend. We have passed through very hard times, probably the hardest ever seen in the United States, but we are very much improving, and I am hopeful that when things settle down in America we shall go improving still further. Meantime I wish to be courteous to the gentlemen who have written to us to say that they hope we shall give them more dividend. We should be only too glad to give them more, but we have to be careful not to give away that which we may require. Mr. Houston, of Dumfries, writes asking for a higher dividend, and he is entitled to consideration. He holds 120 shares. Mr. Maxwell, also of Dumfries, writes a very sensible letter, with which I have no fault to find. Mr. John Woodman, of Exeter, and Mr. Steel, of Newcastle-on-Tyne, also ask us to give the shareholders an additional dividend. We have only had these four letters, and I am not very much astonished that these gentlemen have written. We have shown a very considerable increase this half-year. The current six months is the final period of our financial year, and I hope that if things go on as well as they are now, I shall be able to give you something in the shape of a better dividend. I daresay you think I am exceedingly cautious, but I find that it is far more easy to declare a dividend than it is to get one back. Therefore, we have to look round and see that all our system is in proper working order, and we must see six months ahead of us, but with that period ahead of us I think I can promise you something more than we are giving you to-day. I may repeat that it has cost us nearly £7,000 this half-year to repair the cables. That is a very serious item in our budget, and therefore I hope that we may go through this year with very little expenditure of that kind. We have just repaired our cable on this side, which has been hanging on a rock for 22 years. Notwithstanding this, it had continued to work without interruption until December last.

A SHAREHOLDER: On what coast?

The CHAIRMAN: The Irish coast. We had another line broken—the short line on what is called Brown's Bank; but that is now repaired, and we are in perfect working order, having re-established the duplex on our main cable. I have referred to the receipt of four letters from shareholders. I should like to point out that while we carry an amount to the reserve fund, we draw out of that fund the amount required to effect the repairs, so that, although we carry £10,000 to the reserve fund, we have in this particular case taken about £7,000 out of that amount for repairs. I think that is all I have to say to you to-day. I am pleased to be able to tell you that things are looking very much brighter, and I am quite certain that if this goes on for the six months we have now entered on we shall be able to be a little more cheery at our next meeting. I now propose the following resolution:—

"*That the Report of the Directors, dated the 7th of January, 1896, together with the Statements of Account to 31st December, 1895, annexed thereto, be, and the same are, hereby received and adopted.*"

Mr. E. M. UNDERDOWN, Q.C., seconded the motion.

The CHAIRMAN, in answer to Mr. Goodsall, said: We have adopted Dr. Muirhead's and Mr. Herbert Taylor's system of automatic transmission. These two gentlemen have put their heads together, and entered into partnership with respect to these patents, and, so far as I can remember, I do not think I have ever taken so much care in selecting the most suitable instruments as I have done on the present occasion. I had Lord Kelvin's opinion and I have had our scientific men's opinion. I am therefore quite satisfied that we have got what is a very valuable acquisition.

Mr. J. VARLEY said he thought it quite natural that shareholders should wish for a higher dividend, but during the years in which he had been a shareholder in the Company he had urged them to strengthen their position by building up a good reserve fund. They now had such a fund, and he hoped the Directors would still increase it before paying the shareholders a higher dividend. He had been a shareholder for 15 years, and he was a very large shareholder, but he was able to sleep on his shares because he knew that they had a large reserve fund. During the time that he had been a shareholder, however, he had never known their shares to be so low. They had actually £5 a share in cash, so that their cable was only valued at £3 a share, which was perfectly absurd after what the Chairman had told them.

Mr. JOHN GRIFFITHS remarked that £5. 15s. was the value of the shares in cash.

Mr. VARLEY, continuing, said that that brought down the value of their cable in the market to £2. 5s. a share. Last year he suggested that they should sell their consols, seeing the magnificent profit they could obtain by doing so. Some, however, thought at that time that Consols would go to 110—a point to which they had not reached, but they had seen them much lower. If people expected to sell at the highest and buy at the lowest points they usually did nothing whatever. He hoped that in the course of a short period they would take the profit which their Consols still showed them.

Mr. W. GRIFFITH said he thought when he read the Director's report that they were all to be very much congratulated on the great improvement which had taken place in their affairs. The large increase in their business must gladden the hearts of all who took an interest in the Company, and he himself had thought that with such an improvement they might have had an increase in the dividend. He knew that the concern was in a thoroughly sound state. They had a large reserve fund, which was also worth £50,000 more than was shown in the balance sheet. Their reserve fund was better than it was in the case of some of the companies, as a dividend could be paid out of it. He hoped that the Chairman would be able at the end of the current half-year to realise the hopes just held out to them, and that they might then receive an increase in the dividend. He quite agreed with the last speaker that their shares were far below their real value. Unfortunately, however, the general public did not always reason on sound data. They looked simply at the dividend, and concluded, rightly or wrongly, that if a dividend was large the shares were worth so much more. They would, he believed, increase the value of the shares by increasing the dividend to some extent. The Chairman had spoken of the increase in their business in the past year, and he would like to know whether the increase continued in the present year.

The CHAIRMAN: I daresay that in looking over the accounts you saw that repairs had cost us about £7,000. If there had been no amount charged this half-year for repairs, we might probably have given an increased dividend this time, but we are pretty certain now that things are tending in that direction. I have no doubt myself that we shall be able to give you a better dividend next time. I do not think it is necessary to enlarge on this point, excepting to remind you that everything is uncertain with America at the present time, and if we had to close our cable to traffic, which might be the case, we should be affected in our revenue. It is better not to begin to pay a higher dividend until one sees the way clearer. The increase in our traffic to-day is very remarkable. We are now earning 17 per cent. more, as compared with the same period last year. This is a very satisfactory state of things. I would not have said what I did with respect to the question of dividend were it not that I believe we shall realise in the proper time what I have said. Our cable, however—and I think it is well for you to bear this in mind—is getting to a certain age. Although we have repaired our cable and done a great deal to it, and it is in good working order to-day, still those who are watching cables are aware that when a cable reaches 25 years old you begin to ask questions about it. However, I am happy to tell you that we are earning at the present time the additional amount I mentioned. With respect to the sale of our Consols, I do not think it is very bad advice to sell them. We can probably invest the money at the present time, if not at a very remunerative rate, probably at a rate safer than Consols would be if war were to break out in which this country engaged. In that case Consols would go down very considerably, and I think it is well worth while to consider the question of selling our Consols which cost us about 98½ per cent., so we should get a good profit on them.

Mr. KEARTLAND enquired whether in repairing the cable to which the chairman had referred, the rock on which it had been suspended had been avoided.

The CHAIRMAN: Yes, we have taken it round. It is a most interesting illustration of the length of time a cable will wear hanging on a rock. He then put the resolution, which was carried unanimously.

Mr. W. GRIFFITH proposed a vote of thanks to the Chairman and directors for the able way in which they had conducted the affairs of the Company.

Mr. VARLEY, in seconding the motion, said he desired especially to congratulate the Directors on the reserve fund. At a critical time before, when we were threatened with war, it was said that all cables would be torn up, and the shares of the Eastern Extension Company, whose property was the finest in the world, were then quoted at about 7 on account of the possibility of their being torn up.

Mr. GRIFFITH said he thought they were to some extent protected by international law.

The CHAIRMAN: I remember once going to the Foreign Office when old Mr. Hammond was there. I said to him: "I want you to do a very important thing—namely, to get the Government to agree to the protection of the cables." He replied: "I would agree to it to-morrow, but the general who would be in command would break it." That is what we all feared, but what we think is that although in time of war the cables might be interrupted, they would not be—I do not believe it—deliberately broken if it could be helped. I think that common sense is prevailing a little more, and I believe the value of the cables is more recognised, because the moment the contest is at an end the whole thing bursts into life again. I am hopeful, therefore, that we shall not be put to any inconvenience through having our cables in the deep sea cut.

Mr. JOHN NEWTON said he believed that in the event of war the cables would be cut, but that would only be putting matters in suspense. There would be no destruction of property.

The CHAIRMAN remarked that they had ten or twelve steamers traversing the ocean doing nothing but repairing the cables.

Mr. NEWTON said he did not think it ought to go forth that cables in a time of war were in greater danger than was railway property. He was sure that the destruction of bridges on the railways would be far more disastrous than the damage which would be done to cables, which could be stopped working by one effective cut, and this could be easily repaired afterwards. He had never had the slightest apprehension that war would interfere with cable property beyond stopping the revenue for the time being of any particular cable.

The CHAIRMAN: I am very disposed to take that view also. I am obliged to you for your vote. I hope you will have a prosperous year this year, and that all these troubles will quieten down.

The proceedings then terminated.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30⅝d. per oz. (Jan. 23rd). Consols (2¾ per cent.) 107⅝—107¾ for money, 107⅝—107¾ for account; 2½ per cent. 104¼—104½ (Jan. 23rd). Stock Exchange Settling Days: Consols, Feb. 3rd; Stocks and Shares Continuation Day, Jan. 28th; Ticket Day, Jan. 29th; Pay Day, Jan. 30th.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The Directors of this Company recommend a dividend at the rate of 5 per cent. per annum on the preferred shares, and 3½ per cent. per annum on the ordinary shares, as against 2 per cent. on the ordinary shares for the corresponding period last year. A balance of £2,074 has been carried forward.

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City and South London Railway Company.

The following Report of the Directors of this Company for the half-year ended December 31st last will be submitted to the half-yearly ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., on Tuesday, the 28th inst., at twelve noon :—

The receipts from all sources for the past half-year have amounted to £24,554 9s. 2d., and the cost of working has been £14,638 16s. 4d., leaving a profit of £9,915 12s. 10d. Inclusive of the balance brought forward from the 31st December last, the net revenue account shows an aggregate total of £10,922 7s. 4d. After making provision for the Debenture and Debenture Stock interest, a balance remains available for dividend of £7,111 7s. 1d. Out of this sum the Directors recommend that the full dividend of 5 per cent. per annum be paid on the Preference shares, and that a dividend at the rate of 1¼ per cent. per annum be paid upon the Consolidated Ordinary Stock, leaving a balance of £1,219 16s. 1d. to be carried forward to the next account. During the past six months a further sum of £9,400 terminable Mortgage Debenture Bonds has been paid off.

A table, accompanying the report, shows the number of passengers (exclusive of season ticket holders) carried since the opening of the railway to be 30,441,609, and the receipts £222,827 2s. 3d. For the first complete half-year (30th June, 1891) the passengers carried numbered 2,412,343, and for the half-year to 30th December last to 3,172,438.

During the summer quarter of the past half-year the traffic of the line was considerably diminished by the unusual and prolonged heat which then prevailed, and since that time the traffic of the line has suffered from the entire closing of the Oval for football matches, but, notwithstanding these drawbacks, there is an increase in the receipts, and this is especially noticeable in the item of season tickets, which indicates the steadily growing confidence of the public in the convenience, safety, and punctuality of the line.

In regard to the extension of the line to Finsbury Pavement, the Directors state that most satisfactory arrangements have now been entered into in respect of the more important properties required, and are such as justify them in fully believing that the proposed extension can be carried out within the estimated time. Preparations are therefore being made for carrying out the extension without delay, and the proprietors will be asked at the extraordinary general meeting called for that purpose, out of the capital of the Act, 1893, to be then created, to sanction the issue of 20,000 Five per Cent. Preference shares of £10 each, which it is estimated will be sufficient to provide the amount required. It is intended that in the issue of these shares, arrangements shall be made that no charge will fall upon revenue in respect to the dividend upon them, until after the time at which it is estimated the extension will be open for traffic, and earning a larger sum than will be required for that purpose.

The alterations at King William-street Station, to which reference was made at the last meeting, have occupied a longer time than was expected, owing to the necessity of avoiding interference with the existing traffic ; but they are now completed, and will be brought into use in the course of a few days. The difficulty of dealing with the morning and evening traffic still continues, involving a considerable loss of revenue, but it is hoped that the additional trains, which these alterations will accommodate, will enable the press of traffic at those times to be better provided for. The additional sidings at Stockwell are now finished, and will add greatly to the convenience of the working of that station. In view of the increased number of trains to be run, seven additional carriages have been ordered, and an additional locomotive built in the Company's own shops is nearly completed. The generating plant, which is in good working order and repair, has been materially strengthened by the erection of a small engine and dynamo, which will effect a decided economy in working the traffic in the less busy part of the day. An order has also been given for the erection of a condensing apparatus at the generating station, which it is anticipated will make a considerable reduction in the quantity of coal consumed.

As the powers of the Company for the compulsory purchase of lands in connection with the Act of 1893 will expire in August next, application is being made to Parliament for a further extension of that time, and powers are also sought for the acquisition of a site for a temporary shaft in the High-street, Borough, with the view of saving expense in the construction of the junction of the new extension with the existing tunnels.

Mr. Basil Mott, the engineer of the Company, having resigned his position in order to take up an appointment in connection with the construction of the Central London Railway, Mr. P. V. McMahon, who has acted for some years as assistant engineer, has been appointed to succeed him.

Messrs. Charles Seymour Grenfell and Edwin Tate offer themselves for re-election as Directors, as does Mr. J. L. Oliver as auditor.

Waterloo and City Railway Company.

The Report of the Directors to be submitted to the Shareholders at the fourth half-yearly general meeting, to be held at Waterloo Station, London, on Thursday, the 6th prox., at 2 p.m., states that the expenditure amounted to £62,321 8s. 4d., making the total outlay £122,736 5s. 7d., at the 31st December, 1895. The works have continued to make good progress. An agreement has been settled with the South-Western Railway Company for the easements required from them for the terminus at Waterloo, and arrangements have also been made with the Central London Railway Company with respect to the City terminus. The Directors who retire are Mr. Wyndham Spencer Portal, The Right Hon. Sir Algernon West, K.C.B., and Mr. Percy Mortimer, who seek re-election. Mr. H. W. Notman, one of the auditors, also seeks re-election.

The following is the Engineers' Report :—

"We beg to report that during the past six months the works have made steady progress on both sides of the Thames. Towards the City both tunnels are in the London clay beneath the low level sewer, the Metropolitan District Railway and Queen Victorias-treet, and have reached a point about midway between Benet's Hill and Lambeth Hill, near the College of Arms. Towards Waterloo the tunnels have for some time past been driven under compressed air under Stamford-street, and are on the average about 150 yards eastward of the junction of the Waterloo Bridge-road with Stamford-street.

The total length of single tunnel driven during the past six months has been	1,635 yards
The total length of single tunnel completed is now	2,835 „
Leaving a total length of single tunnel to be constructed between the terminal stations at either end of the railway of	1,565 yards

December 31, 1895. W. R. Galbraith, J. H. Greathead, } *Engineers.*"

NEW COMPANIES, STATUTORY RETURNS, &c.

DAIMLER MOTOR COMPANY (LIMITED).—This Company was registered on January 17th with a capital of £100,000, in £10 shares, to acquire, develop or otherwise turn to account any patents, licences or concessions, to manufacture, sell or deal in motors of every description, cycles, vehicles, flying machines and carriages of all descriptions, and to carry on the business of electricians, mechanical engineers, machinists, wire drawers, galvanisers, electro-platers, &c. The first subscribers, with one share each, are : J. T. Higginbottom, W. Tees, E. Richards, H. Mobbs, J. Herbert, J. F. Vickery and P. Smith.

ELECTRIC METER COMPANY (LIMITED).—The annual return to January 3rd has been filed ; 2,007 shares have been taken up out of a nominal capital of £50,000, in £10 shares, and 2,000 of these have been issued as fully paid. The full amount has been called on the remainder.

ELECTRIC OZONE SYNDICATE (LIMITED).—The statutory return to November 29th has been filed. Seven shares have been subscribed for out of a nominal capital of £12,000 in £10 shares, but no calls have been made.

OKONITE COMPANY (LIMITED).—The annual return to January 3rd has been filed. The capital is £340,000, in 17,000 Ordinary and 17,000 Preference shares of £10 each. All the Ordinary and 16,995 Preference have been taken up, and 5,666 of each class have been issued as fully paid. The full amount has been called on the remainder.

CITY NOTES.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended January 19th were £1,004, against £996 in the corresponding week of 1895, an increase of £8. The total receipts for half-year amounted to £3,041, against £3,001 for the corresponding period of 1895, an increase of £40.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The revenue return of this Company for the quarter ended December 31st last is as follows :—Sale of current for public lighting, £3,107, against £3,181 in the corresponding quarter last year ; private lighting, &c., £40,757, as compared with £26,052 ; estimated revenue from other sources, £750, as against £404 ; total—£44,614, as compared with £29,637, or an increase of £14,977. There was an equivalent of 8 c.p. lamps connected on December 31, 1895, of 195,317, an increase of 24,490, and of 21,429 as compared with 1894.

EASTERN TELEGRAPH COMPANY (LIMITED).—The coupons on this Company's Five per Cent. Debentures, due February 1st next, will be paid on and after that date by Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C. Coupons must be left three days for examination.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—The payment is announced on February 1st of interest for the half-year ending January 31st on this Company's Four per Cent. Mortgage Debentures. The transfer books will be closed from the 28th inst. to 1st prox. inclusive.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 19th inst. amounted to £1,172. The amount for the corresponding week last year was £900 ; increase, £272.

ST. JAMES' AND PALL MALL ELECTRIC LIGHTING COMPANY (LTD.).—The Directors of this Company recommend a dividend at the rate of 10½ per cent. per annum on the Ordinary shares for the half-year ended December 31st last, making, with the interim dividend, 7½ per cent for the year 1895.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended January 17th, 1896, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), amounted to £2,915.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half-month ended January 15th are £2,516, as compared with £1,970 in the corresponding period of 1895. The September receipts, estimated at £3,144, realised £3,237.

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED.)—The Directors of this Corporation have decided to recommend that a dividend at the rate of 9 per cent. for the past half year, making with the interim dividend already paid, a dividend of 7 per cent. for the year.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Jan. 15.	Price Wednesday, Jan. 22.	Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending Jan. 18. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	10/0	Anglo-American	44 46	45 47	4 15 9	Jan., Apr., July, Oct.	45	..
£2,993,560	Stock	20 0	Do. Preferred	83 85	85½ 86½	5 4 0	" "	86½	79⅞
£2,993,560	Stock	5/0	Do. Deferred	6 6½	6½ 6⅝	..	..	6⅞	5⅛
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	100 104	100 104	3 16 11	January and July	..	..
£250,000	£10	..	Amazon Telegraph	9⅜ 10⅛	9⅜ 10⅛	..	..	8⅛	8
180,000	£10	3/0	Brazilian Submarine	18 18⅜	18 18⅜	5 7 5	Mar., June, Oct., Dec.	..	..
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110 114	110 114	4 7 9	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	160 170	160 170	4 2 7	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12½ 13½	12½ 13½	5 14 4	February and August	12½	..
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 13 0	" "	..	..
12,981	5	2/0	Direct Spanish (fully paid)	3⅜ 4⅛	3⅜ 4⅛	4 8 11	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	..	..
£80,000	Stock	4½%	Do. 4½% Debentures of £50 each	102% 105%	102% 105%	4 5 9	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877 xd	8 8½	8 8½	4 14 2	Jan., Apr., July, Oct.	8½	..
460,000	10	2/6	Eastern xd	16½ 16⅝	16½ 16⅝	3 17 7	" "	16⅝	16⅛
70,000	10	6%	Do. 6 per Cent. Preference xd	17⅛ 18	17⅛ 18⅛	3 5 9	" "	17⅛	..
£1,297,337	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	126 129	126 129	3 2 6	May and November	129	126
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 12 7	February & August	..	..
250,000	10	2/6	Eastern Extension xd	17 17⅛	17 17⅛	4 0 0	Jan., Apr., July, Oct.	17⅛	17⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	127 130	128 131	3 1 11	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900	100 104	100 104	4 16 2	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb.,1900	100 104	100 104	4 16 2	" "	102	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	107 110	107 110	3 18 11	February & August	108½	107⅜
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 115%	3 10 0	May and November	..	..
180,227	10	1/6	Globe Telegraph and Trust xd	9½ 10	9½ 10	4 5 0	Jan., Apr., July, Oct.	9⅛	9⅛
190,042	10	6%	Do 6 per Cent. Preference xd	16½ 17	16⅝ 17	3 10 7	" "	16⅛	16⅛
150,000	10	5/0	Great Northern	21⅛ 22½	21⅛ 22½	3 16 5	Jan., April, and July	..	..
£130,000	100	5%	* Do. 5 per Cent. Debentures, 1883 Issue	104 107	104 107	4 15 0	March & September	104½	..
17,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	48½	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106 110	105 109	5 12 2	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	108 111	108 111	3 12 1	..	..	..
11,889	8	4/0	Reuter's	4½ 5½	4½ 5½	..	April and October	..	..
3,381	£100 Cert.	3/0	*Submarine Cables Trust 6 per Cent.	127 132	126 131	4 11 7	" "	128	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	..	January and July	..	..
£338,300	100	5%	* Do. 5 per Cent. Debentures (red.)	101 104	101 104	4 17 4	March & September	..	..
80,000	10	2/0	West Coast of America	1 2	1 2	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	94 99	94 99	8 1 7	June and December	..	..
88,321	10	1/3	West India and Panama	⅞ 1⅛	⅞ 1⅛	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10⅛ 10⅝	10⅛ 10⅝	5 11 7	May and November	10⅛	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8⅝ 9⅛	8⅝ 9⅛	6 6 4	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108 111	108 111	4 10 1	June and December	..	..
64,248	15	3/9	Western and Brazilian	9 9⅛	9 9⅛	5 4 0	May and November	9	..
38,129	7½	3/9	Do. 5 per Cent. Cumulative Preferred	6½ 6⅝	6½ 6⅝	..	..	6⅝	..
38,129	7½	1/6	Do. Deferred Ordinary	2⅜ 3⅛	2⅜ 3⅛	..	..	3⅛	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 14 10	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 14 10	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	113 118	113 118	5 13 8	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	102 105	102 105	5 16 6	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chill Telephone (fully paid)	3½ 3⅝	3½ 3⅝	..	..	..	..
224,850	10/0	1⅛d.	Consolidated Telephone Const. & Maintenance	1/16 1/8	1/16 1/8	..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	1/8 1/4	1/8 1/4	..	Yearly	..	..
484,597	5	2/6	National	5½ 6	6 6½	4 0 0	June and December	6	5½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15½ 16½	15½ 16½	3 12 9	" "	16⅛	..
119,284	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅛ 6⅝	6⅝ 6⅞	3 15 6	..	6⅞	6⅛
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	104 107	104 107	3 5 5	January and July	106½	104⅜
58,000	5	3/0	United River Plate	2½ 3	2⅝ 3	..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	90 95	90 95	5 5 3	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12⅜ 13⅛	12⅜ 13⅛	1 17 9	..	13⅛	..
48,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15⅝ 16	15⅞ 16⅛	3 13 10	..	..	..
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	132 136	133 137	3 13 0	June and December	134½	133½
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½ 5⅝	5½ 5⅝	..	..	..	..
£67,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
22,475	£8	..	County of London & Brush Prov. Ord. (fully paid)	8 9	8 9	..	..	..	..
10,000	£10	9½d.	Do. Pref. (£6 paid)	10½ 11	10½ 11	..	..	..	..
8,322	£5	..	House-to-House Electric	.. ..	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 8⅛	7⅞ 8⅛	3 13 10	..	..	..
111,000	5	..	London Electric Supply	.. ..	.. ..	..	..	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	10½ 10⅝	10½ 11½	3 18 3	..	10⅞	10⅜
150,000	Stock	4½%	* Do. 4½% Debs.	114 117	114 117	3 16 11	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9	8½ 9	..	..	..	..
..	..	..	Rand Electric	⅜ ½ prem.	⅜ ½ prem	..	..	..	..
19,980	£5	2/0	St. James and Pall Mall	8½ 8⅝	8½ 9	..	..	8⅝	8½
20,000	£5	7%	Do. 7 per Cent. Preference	9 9½	9 9½	3 13 8	..	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8½ 9	8⅝ 9⅛	2 19 6	..	9	8½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1 1½	1 1½	12 1 0	..	1⅜	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅜ 2	1⅜ 1⅝	6 8 0	..	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 115	112 115	3 19 8	March & September	112⅝	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2 2½	2 2½	..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1½ 1⅝	1½ 1⅝	..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 4 1	..	102	..
420,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..	..	..	..
110,000	2	..	Electric Construction	⅜ ½	⅜ ½	..	..	..	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 12 0	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅛ ⅜	⅛ ⅜	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	⅛ ⅜	⅛ ⅜	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	19 20	20 21	3 11 5	February & August	19⅜	18⅜
£800,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 7 10	March & September	..	..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	½ ⅝	½ ⅝	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	41 43	43 45	4 0 0	March and July	43½	..
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	102 105	4 15 3	January and July	..	..
87,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	13½ 14½	13½ 14½	4 2 9	..	..	..
£30,000	10	7/0	Do. 7 per Cent. Preference	15½ 16½	15½ 16½	4 4 10	..	..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108 111	108 111	4 2 7	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway	40 42	40 42	2 16 6	May and November	41	40
7,650	10	5%	Do. 5% Perpetual Preference	14⅜ 15½	14⅜ 15½	3 5 7	..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	128 130	130 132	3 0 7	May and November	131	..
37,500	£10	2½%	Liverpool Overhead Railway	11½ 11⅝	11⅛ 12⅜	1 13 0	..	..	..
10,000	10	5%	Do. 5% Preference	15½ 15⅝	15⅝ 16	3 3 6	..	..	..
115,000	Stock	4%	Do. 4% Debenture	113 114	112 114	3 10 2	January and July	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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THE ELECTRICIAN:

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NOTES.

LONGITUDINAL ether waves are developing quite a romantic history of their own. The exponents of the electromagnetic theory of light first threw them on to the scrapheap of Nature, as it were, by making their velocity infinite. Thus conveniently got out of the way, they were not likely to interfere with the normal behaviour of the transverse ether waves. Later on, someone noticed these neglected longitudinal waves, and was struck with the idea that they might fit in very nicely as an explanation of gravity. Their infinite velocity, in view of the absence of gravitational aberration, was their chief recommendation; and for a long time they seemed the only candidates for a post from which LESAGE'S ultra-mundane corpuscules and every other occupant had been summarily dismissed. But somehow or other longitudinal waves of ether did not go very far to explain gravitation; and they remained disconsolately out of work until quite recently, when an attempt has been made to put them to a good account in connection with the discovery of RÖNTGEN'S X rays. Unfortunately, in order to secure this post, it would seem that they must relinquish their property of infinite velocity, which, unless their finite velocity is practically infinite for the purpose, would seem likely to disqualify them as couriers of gravitation.

A PROBLEM which has to be solved by the engineer almost every day of his life is to determine the minimum margin of safety permissible in any given undertaking. The solution certainly involves calculations based on theoretical investigations and experimental knowledge of the strength of materials; but it also involves the results of an experience derived from lengthened use under varied circumstances. It is not as a rule difficult to find a solution when the problem is one of general engineering, but in some cases which present themselves in electrical engineering it is difficult even to state the problem fully, and this largely because of the small time-integral of experience at the command of the electrical engineer. Take, for instance, the comparatively simple job of wiring a building for the electric light. Absolute immunity from accident may be obtained in two ways: by spending no money on such work—having no electric light!!—or by spending an extravagantly large sum, z, on the work. For a certain expenditure, y, the factor of safety may be such as to bring us perilously near the danger line; while for an expenditure x, (something between y and z), there will be a sufficiently large factor of safety. The solution x is subject to a certain amount of risk, which may be covered by insurance. If the risk accepted is fairly covered by the premium, the profit on the transaction should be merely a fair dividend on the capital employed, and not the whole amount of the premium paid minus the proper proportion of establishment charges. Now it has been stated more than once recently, as an evidence of the excellence of certain rules, that not a single shilling has as yet been paid on account of loss through the failure of work conforming to these rules. Doubtless this is a most happy state of things, but how does it look from the insurer's point of view? Is this not a case of requiring a factor of safety which implies an expenditure too near the maximum value z, whilst the *premium* has been fixed for a factor of safety obtainable by a minimum expenditure near the value y? Why pay the premium at all? When one considers the sublime indifference shown by the insurance companies as to the condition of the gas piping and gas fittings in a house, it strikes one as somewhat illogical that electric light wiring should be so closely looked after. If the insurance offices could be brought to see that leaky, carelessly-run gas piping is, to say the least, no less a source of danger to life and property than jerry wiring, it would be fatuous to complain of rules which result in good work being done instead of bad. So long, however, as the insurance offices are afraid to treat a powerful interest with the same severity that they treat a comparatively weak one, they lay themselves open to the charge of unfair dealing and deprive themselves of the unanimous support they would otherwise receive from the electrical industry in raising the present standard of indoor wiring.

AT a discussion which recently took place at the American Institute of Electrical Engineers, the engineer of the Boston Edison Illuminating Company's station criticised English supply station equipment practice, as compared with German. He was in favour of using two or three large engines in conjunction with a storage-battery plant, and opposed the English plan of using many small engines. Engineers in this country will be astonished to hear that "the actual economy of these small engines running under the best possible conditions is less than the economy of the large engine run under the best possible conditions, and a storage battery of 75 per cent efficiency." To begin with, this statement is not correct. At least, disregarding any defects in American small engines, we

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know that high-speed engines can be built for 200 H.P. or thereabouts, which will have an economy of steam not more than a shade lower than the best of the large 800 H.P. or 1,000 H.P. low-speed engines; the question of batteries being left out altogether. But, in the next place, the statement is misleading since it does not cover actual practice in supply stations. To ensure that the engines in a station equipped with two or three large engines should always run at the best possible load, or even at as good a load as in a station more subdivided, a prohibitively large battery plant would have to be used. Even as it is, at some of our best stations where there are as many as from 9 to 13 engines besides batteries, it is found to be impossible to get a higher engine load factor than about 80 per cent. To attain even this, in a three-engine station, the storage capacity would have to be enormously increased, unless, indeed, transatlantic local conditions produce a far more favourable load curve than is ever met with in this country. Engineers in other countries, before they condemn English practice—innovation as it may be—should look into our results as regards working expenses, and we feel sure that the majority of our highly-subdivided stations will bear considerable scrutiny by foreign engineers.

It was at the Chicago Electrical Congress, in August, 1893, that Mr. Louis B. Marks introduced his incandescent-arc lamp to the electrical world, and set forth the advantages of surrounding an electric arc by an inert gas at a high pressure. The life of the carbons would be increased, and it was claimed that for all practical purposes the new form of lamp was as efficient as the older type. Since that time there have been other inventors of enclosed arcs, who have prophesied that the end of the ordinary arc was at hand. It was with feelings of considerable curiosity, therefore, that we recently lighted on an article in the *Electrical Engineer*, of New York, entitled: "The Marks Ventilated Enclosed Arc." Further investigation revealed that Mr. Marks had foresworn the use of a high-pressure jacket of inert gas, and had replaced this by a glass globe, throughout which the free passage of air currents is encouraged. The arc is certainly enclosed; but, so far as the influence of air on it is concerned, it might just as well be surrounded by an ordinary globe. In fact, there are many ordinary arc lamps in the market in which ventilation is not so complete as in the new pattern of Marks enclosed arc lamp.

The reasons which are put forward in justification of this interesting departure are not less instructive than the change itself. The shortening of the arc for a given potential difference due to the enclosure of the arc by a high-pressure gaseous jacket has made it necessary to work such an arc at unusually high potential differences, and the absence of an oxidising agent develops a flatter crater and a stumpier negative tip. Moreover, we are told that when the enclosed arc is worked at ordinary potential differences, unsteadiness of the light results, and mushrooming occurs on the negative tip. It is to avoid these difficulties that Mr. Marks has adopted the construction just described.

Glancing recently through the pages of an esteemed German electrotechnical contemporary, our attention was arrested by an article with the, to us, startling heading of "Zur Frage der Vagabundiren Ströme," which, being hastily interpreted, might mean "The Question of Current Vagabonds." This was obviously an article intended for the columns of the German equivalent of the *Poor Law Journal*. A perusal of the text revealed, however, that the question under discussion was not the growth of contemporary pauperism, but related to what are known in the Anglo-Saxon world as "stray" currents. The palm for picturesque vigour must certainly be awarded in this instance, as in most others, to Teutonic electrotechnical nomenclature. At the same time, it seems rather hard upon return traction currents, which, after all, are only seeking the electrically best, shortest and least-crowded path home to the negative pole, that they should be thus brutally characterised and handed over, as it were, to the tender mercies of the German police.

The British Association and American Units.—We warned England long ago, says the *Electrical Journal* of Chicago, "that the usurpation of electrical units by the British Association would lead to war."

Aluminium and Electrolysis.—Mr. Arthur H. Vesey announces that the proprietors of *Aluminium and Electrolysis* have decided to postpone the publication of the paper for two months in order that an interesting number may be submitted to the public.

Royal Society.—The following Paper was down for reading yesterday: Prof. G. M. Minchin, F.R.S., "The Electrical Measurement of Starlight. Observations made at the Observatory of Daramona House, co. Westmeath, in January, 1896. Second Report."

Electric Traction for Leeds.—At a meeting of the Highways Committee of the Leeds Corporation on Thursday, it was resolved to adopt, subject to the approval of the Council, the recommendations with regard to electric traction contained in the Report of Dr. John Hopkinson, briefly summarised in our issue of January 10th.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
St. Thome—Loanda	January 15, 1896 ..	January 26, 1896
Puerto Plata—Martinique ...	December 19, 1895 ...	—
Perim—Obock	January 2, 1896 ...	—
Odessa—Constantinople	January 17, 1896 ...	—
Aden—Zanzibar	January 26, 1896 ...	—

Municipal Telephony.—A number of business men in Manchester are about to ask the Corporation to inaugurate an independent telephone system for the city. A Committee has been formed, and the requisition has already received the signatures of 1,000 of the leading firms in Manchester. It will be presented to the Lord Mayor in the course of a few days.

Steel Tubular Telegraph Poles.—The wrought-iron and steel tube makers in the Midlands have been informed that the Government is considering the advisability of adopting metal poles for the construction of telegraph lines instead of the timber ones now in use. The particular pole which is believed to find favour with the authorities is a corrugated galvanised one, lately patented in this country and abroad.

Electric Bicycle Lamp.—A compact little bicycle lamp has recently been brought out in America. It consists of a 2 c.p. low voltage incandescent lamp mounted in a parabolic reflecting case, in the lower part of which is a small alternator of simple construction. Power is obtained by means of friction gear from the upper part of the front wheel. It is not clear from the descriptions which have reached us how the great ranges in speed which the bicycle would have are prevented from affecting the brilliance of the lamp.

Electric Car Accidents.—The method of preventing electric street tramway accidents adopted by the Steinway Electric

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Railway, of Long Island City, N.Y., is worthy of general adoption. In accordance with an agreement made a year ago, *Engineering News* says, prizes of $25 each were paid each motorman and conductor who got through the year without an accident to his car. The full prize was given to 98 men, and lesser prizes were given to 94 men who had served less than a year, over $4000 in all being distributed.

"The Western Electrician."—Our Chicago contemporary, the *Western Electrician*, in its issue of January 11th, comes out with a quite unnecessary apology for "a day's delay and the slightly changed appearance of the paper," due to a fire which took place on the previous Saturday, and by which the composing room was completely gutted. We diagnosed the condition of our contemporary as "normal" until it gave us an insight into the very abnormal conditions amid which its issue of January 11th had been brought out.

An Electrically-Driven Punching Machine.—An electrical punching machine has recently been brought out by Messrs. Craig and Donald, and is now being used in one of the shipyards of Messrs. Denny Bros. The motor is of 18 B.H.P., and runs at 700 revolutions per minute. Two holes are punched at a time at each end of the machine, the diameter of each hole being 1in. By a throwing-out gear it is possible to make each end work independently of the other end. A description and illustration of this machine are given in a recent issue of *Engineering*.

Expiring Patents.—On Sunday next will expire Patent No. 513, of 1882, granted to Mr. Vernon Boys for "Improvements in Electric Meters." The patent is for an invention for "measuring and registering the electricity passed through a conductor by counting the oscillations of a balance wheel governed by a torsion spring, the torsive length of which is determined by a lever acted on by the attraction of an electro-magnet having its coil in the circuit of the conductor."——On Thursday next will expire Patent No. 563, of 1882, granted to A. J. Jarman for "Improvements in Arc Electric Lamps." The patent specification describes a lamp with an adjustable solenoid controlling a clutch mechanism.

The Controller and a Substitute.—"The series-parallel controller," says the *Electric Railway Gazette* of New York, "has but two really economical running points, the others involving the introduction of wasteful resistance, and that this is duly recognised by engineers is shown by the extensive calculation and experiment which are now being carried on with a view to provide such methods of regulation as will render the induction motor suitable for railway purposes. The experiments are being pushed principally along the lines of varying the number of poles presented to the armature, and machines have been designed with as many as 24 poles, but have been abandoned on account of self-inductive action."

A Physical Millennium.—According to an article in the *Electrical World* of New York, Nikola Tesla thinks that "the discovery which would do most to better our condition would be the demonstration that the earth's electrical charge can be disturbed, and thereby electrical waves efficiently transmitted to any distance without the use of cables or wires." According to the article immediately following this, in the pages of our contemporary, Edison says that "the discovery or invention which would do most to better the conditions of life" would be "the production of electricity direct from coal." The moral is that every enthusiast believes his own pet scheme to be a panacea for all the ills the flesh is heir to.

Subway Work in Brooklyn.—The annual report of the Commissioners of Electrical Subways in the City of Brooklyn shows that the aggregate length of electric conductors of all kinds within the city limits is 20,371 miles, of which 3,599 miles were added during the past year. Over 12,000 miles of wire is placed underground or suspended beneath the elevated railways. The underground conduit now in place is 126 miles in length; length of single duct, 343 miles. Until specific appropriation is made the wires of the police and fire departments cannot be placed in subways. "The work of the extension of the telephone system during the year," the report says, "has been unprecedented, owing in part probably to the adoption by the Company of cheaper rates for a certain class of service, such as the ordinary householder wants, and partly to the natural inevitable growth of the system."

Novel Application of the Trolley System.—The proprietors of a mine in Michigan are considering a novel application of the trolley system of electric traction. The mineral from the mine is freighted down an inclined railway, the length of which is 15 miles and the fall about 800ft.; and the empty trucks have to be hauled up this inclined track on a parallel line. It is proposed to utilise the weight of the heavy freight trains to drive dynamos on the axles, these acting as brakes and transmitting their current to a trolley system, from which it would be taken by motors on the light empty trains. Given a sufficient gradient and a large enough difference between the weights of the full and empty trains, the plan appears to be perfectly feasible.

"Terrestrial Magnetism."—We have received the first number of this new quarterly journal devoted to geomagnetism, which is published by the Chicago University Press, under the auspices of Prof. A. A. Michelson and the editorship of Dr. L. A. Bauer, with the co-operation of a long international list of magneticians. The first issue consists of 54 imperial octavo pages, and contains an article by Prof. Schuster "On Electric Currents Induced by Rotating Magnets and their Application to Some Phenomena of Terrestrial Magnetism," and an article in German by Prof. A. Schmidt, of Gotha, entitled "Die Verteilung des Erdmagnetischen Potentials in Bezug auf Beliebige Durchmesser der Erde"; also a reproduction of Halley's earliest equal-variation magnetic chart, and several pages of reviews, letters, notes, &c

Erratum.—In our footnote to Mr. J. E. Ritter's letter on "An Eccentric System of Electric Supply," on page 425 of our issue last week, it was incorrectly asserted that the heat developed by a superposed continuous and alternating current would *not* be the same as the sum of the quantities of heat separately developed by each of the currents. A valued correspondent has pointed out that the time integral of the square of the composite current is, in such a case, equal to the sum of the separate time integrals of the squares of the separate currents. It will thus be seen that the heat generated by 10 continuous amperes and 10 alternating amperes flowing through the same conductor is only half that generated by 20 continuous amperes flowing through that same conductor.

Röntgen's Rays.—The great interest taken in the results of Prof. Röntgen's experiments has led the proprietors of the *Photogram* to arrange a special issue of that journal entirely devoted to this subject. The issue, entitled the *New Light*, was published yesterday.—The excitement which Prof. Röntgen's discovery has created generally has resulted, according to the *Berliner Tageblatt*, in the formation at Berlin of a society for scientific photography. Amongst the 40 members with whom the society has started we note the names of Profs. E. Wiedemann, Kohlrausch, L. Weber, and Dr. Ebert. The aim of the society is not only photography, but the investigation of related optical phenomena. The erection of a laboratory is in contemplation, and monthly meetings will be held at which lectures and experiments will take place. At first the *Photographische Mittheilungen* will be the organ of the society. At the first meeting of the society a series of new shadow photographs, taken by the Röntgen method, was shown and discussed. All further information can be obtained from Herr Fr. Damke, Photographic Laboratory, Technical High School, Charlottenburg.

The Waste of Steam in Small Pumps.—According to the *Journal of Gas Lighting*, a remarkable disclosure respecting the wastefulness of steam, and consequently of fuel, in a large factory where additional pumps and other machinery had been put up promiscuously to meet requirements as they arose, has been made by Mr. Charles E. Emery, in a Paper read at the last meeting of the American Society of Mechanical Engineers. Mr. Emery was called in to advise an Oil Company in New Jersey how to reduce their fuel account; the consumption of coal for raising steam having risen by degrees to 64,000 tons per annum. Mr. Emery found that besides a large amount of steam required here for heating purposes, a great deal was

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needed for pumping, pressing, and so forth. It was found that many of the steam pumps were using as much as 240lb. of water per net horse-power per hour; and only in exceptional cases could one be found to take so little as 80lb. of feed water per horse-power. Mr. Emery recommended the establishment in the works of a number of power stations, in which would be erected good high-pressure non-condensing engines operating power pumps to take the place of the scattered steam pumps; the exhaust from such engines to be distributed by mains for heating purposes. Electric transmission was also recommended for reaching outlying parts of the works. The recommendations were adopted, with the net result of reducing the consumption of fuel by one-half.

The Central Station Industry in France.—In its issue of January 25th, *l'Industrie Electrique* publishes the sixth edition of its provincial central station table. In January, 1895, France, exclusive of Paris, possessed 328 electric supply stations; to-day the total is 438. The increase in the total horse-power has not, however, been very great; the figures for the 378 stations which sent in returns showing a total of 47,712 H.P. (126 H.P. per station), as against 39,420 for the 328 stations at work last January. The 378 stations may be classified as follows:—

Motive power.	No. of Stations.	H.P.
Hydraulic	182	11,665
Hydraulic and steam	48	7,422
Steam	128	26,802
Producer gas	6	206
Town gas	13	1,605
Petroleum	1	12
	378	47,712

System.	No. of Stations.	H.P.
Continuous	293	31,935
Alternate	75	14,927
Polyphase	4	850
	372	47,712

Worm-geared Motors.—A statement that worm gearing, if used for power transmission in electrical work, should be employed only in conjunction with low-speed motors, has brought out a statement from E. Kolben, of the Oerlikon Engineering Works in Switzerland, who, in a contribution to a German publication, says that high-speed motors should be adopted in such cases if the best results are to be obtained. He points out, says the *Engineer*, that a great prejudice against worm gearing has hitherto existed, on account of its having been regarded in the old text and handbooks as an inefficient means of transmission. He believes, moreover, that much depends upon the construction of the gearing, and refers to tests recently carried out by Professor Stodola, of the Zurich Polytechnic, with the ordinary double-thread worm gear of the Oerlikon Engineering Works. The worm was 80mm. (3·15in.) in diameter, had a multiple ring bearing, and engaged with a worm wheel having 28 teeth, the wheel being of bronze, 373mm. (14·7in.) in diameter. The whole of this gear was placed in oil in a cast-iron box. The gear was coupled to a 20 H.P. electric motor, and the brake was applied on the worm-wheel shaft. At 1,500 revolutions, a useful performance of 21 H.P. was given on the brake, the efficiency amounting to 87 per cent. Herr Kolben is of the opinion that the efficiency with the motor fully loaded will increase even beyond 90 per cent. if the speed is high, the worm made of tool steel polished, the worm teeth of bronze, and the friction of the whole mechanism on the starting of motors at full load is reduced by having the pressure taken up by starting discs arranged on both ends of the worm. These results are in accord with tests of worm gear made some years ago by Mr. A. Reckenzaun.

Mr. Edward Weston and "Electricity."—In its issue of January 15th the *Electrical Engineer* of New York, on the authority of the *New York News Bureau*, states that "Mr. B. E. Greene, editor of *Electricity* (New York), has retired from the management of that paper, and hereafter, including this week's number, *Electricity* will be issued under the direction of Mr. Edward Weston, electrician, of the Weston Electrical Instrument Company, of Newark, N.J., who has associated with him Mr. C. D. Shain, eastern agent of Siemens and Halske." In a leaderette in the same issue our New York contemporary has the following:—"The announcement which we made last week as to the intention of Mr. Edward Weston to enter again the larger field of general electrical manufacture is one that has naturally been received with much surprise and interest. Of late years Mr. Weston has made an international reputation for himself as a designer of beautiful and accurate instruments, but it was not easy to see why he should so utterly abandon the scenes of his earlier successes. His work in electro-deposition and plating, his efficient and finely-regulating dynamos, his methods of distribution, his incandescent lamps—including those with the tamidine filament—all attested his master hand. We are glad to welcome Mr. Weston back to electrical engineering, and can assure him that there is plenty of work awaiting his skill and genius. The reports that Mr. Weston intends also to devote himself actively to electrical journalism are the sheerest absurdity. Mr. Weston is a creator, not a critic or historian, and it is needless to say that he is perfectly willing to leave the drudgery of newspaper work to those who, while they record his progress with satisfaction, will not dream that they too are inventors." We do not suggest that these two statements are irreconcilable, but their reconciliation certainly would appear somewhat difficult.

"Capital Expenditure" Supplement.—This week's supplement of capital expenditure in electrical supply undertakings in this country is complementary to the table issued with our January 3rd number, and completes the set of supply station statistics usually published with this journal in January. It will be seen that a large increase in capital expenditure has taken place during 1895. No reference is made to the borrowing powers possessed by local authorities, which are in many cases far in excess of the sums set out in the table. Bedford has borrowing powers up to £39,000. Blackpool contemplates borrowing a further £30,000, Cheltenham a further £10,000. Henley has borrowing powers up to £46,110. At Harrogate most of the contracts have been let, and a loan for £29,000 has been obtained. Hampstead Vestry is applying for a new loan of £30,000. Hammersmith's expenditure of £7,200 is quite preliminary. Islington's total estimated outlay when the station is fully opened in March is £90,000. Manchester has borrowing powers up to £250,000. Newport (Mon.) is applying for borrowing powers up to £40,000. In cases like Croydon, St. Helens, South Shields, Wakefield and Wigan, considerable capital expenditure has been incurred, as is the case also at places from which we have been unable to obtain information. At Shrewsbury the station is actually in operation, but it is too early to obtain the figures. It may, therefore, safely be estimated that a total of about £10,000,000 is invested in electric current supply undertakings in this country. It will be seen from the supplement that 27 stations are in progress, and of these Islington (London) is announced for opening in March next. In several other cases, the contracts for buildings, plant, mains, &c., have been given out, and in all others the preliminary stage of operations is in a forward state. In some cases, moreover, considerable capital expenditure has been incurred, but the figures are too approximate to justify inclusion in this list.

The Alternate-Current Transformer.—At the commencement of his second Cantor lecture on the "Alternate-Current Transformer," on Monday evening last, Dr. Fleming showed a very pretty hydrostatic model illustrative of the action of the alternate-current transformer. It consisted of a U-tube half full of water, the legs of which were of different diameter the column of water in each leg, when that in one was exposed to pressure and suction, rose and fell, the amplitude of motion in each leg being in inverse ratio of the diameters of the two tubes. To show the high self-induction of the primary of a transformer when its secondary is open, a 50-volt lamp was connected *in series* with the primary of a small transformer connected across 100-volt wires. The lamp only glowed dimly, but on momentarily closing the secondary, it immediately flashed up, owing to the annulment of the self-induction of the primary. After reference to the formulæ for eddy-current losses given by Prof. J. J. Thomson in *The Electrician* of April 8, 1892, and the results given by Prof. Ewing in *The Electrician* of April 15,

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1892, Dr. Fleming presented his own modification of them in the following useful practical formulæ for core losses, viz.:—

$$E=\left(\frac{t n B}{10^8}\right)^2, \text{ and } E=1{\cdot}4\times10^6\left(\frac{t' n' B'}{10^8}\right)^2,$$

where t = thickness of sheet iron in mils, t' ditto in inches, n = frequency, B and B' = respectively the induction per square centimetre and square inch, E = eddy current losses in watts per cubic centimetre of iron; E' = ditto per pound. If we denote the hysteresis losses in watts per cubic centimetre and per pound respectively by H and H', and the corresponding *total* loss by T and T' we get:—

$$H=\frac{{\cdot}0032\, n\, B^{1{\cdot}55}}{10^7},$$

$$H'=\frac{{\cdot}88\, n\,(B')^{1{\cdot}55}}{10^9},$$

$$T=\frac{{\cdot}0032\, n\, B^{1{\cdot}55}}{10^7}+\left(\frac{t n B}{10^8}\right)^2,$$

$$T'=\frac{{\cdot}88\, n\,(B')^{1{\cdot}55}}{10^9}+1{\cdot}4\times10^6\left(\frac{t' n\,(B')}{10^8}\right)^2.$$

The eddy current loss in a good transformer iron, he said, should not exceed 0·07 watt per pound. According to J. J. Thomson and Ewing it was no use to employ thinner iron sheet than $\frac{1}{100}$th of an inch, and it was no use laminating the core at all unless the laminæ were at least as thin as $\frac{1}{25}$th of an inch. Steinmetz's $B^{1.6}$ law of hysteresis loss was, the lecturer said, in very fair agreement with the actual facts over a range of induction from zero to 10,000 C.G.S. units. The maximum permissible hysteresis loss for transformer iron was about $\frac{1}{3}$rd of a watt per pound at 100 ∼ with $B=2{,}500$. Curves were then given showing the effect of plates of different thicknesses on core-losses, the eddy-current loss increasing rapidly with the thickness of the plate, the hysteresis loss but slightly. In ordinary practice plates about 0·014in. thick were used. Various patterns of core plates were then exhibited, and the serious effect of bad magnetic joints alluded to in connection with the Ganz type of core with butt joints resulting in a "power factor" of 0·4 and 0·5 at low loads. The meaning of the term "power-factor" and the importance of this quantity were then explained. Power-factor = true power : apparent power. To the electric supply engineer the power factor of the transformers connected to his mains was an indication of the fraction of the total current sent out from the station which is paid for. Ewing's molecular theory of magnetism was then explained and illustrated by a model, and the lecture closed with a reference to the respective claims of open and closed circuit transformers; the latter type had the advantage of a higher "power factor," and the core losses were practically no greater for any given output power.

A Telephone Inventor.—A Boston newspaper representative recently interviewed Mr. Francis Blake, of telephone transmitter fame, and the following extracts are taken from a reprint of the interview published in the *Western Electrician* of January 11th. Mr. Blake admitted that for two years he had done no serious work. "Since my invention of the long-distance transmitter," said he, "I have not invented anything of particular commercial value." The inventor related his experiments in arboriculture, and confessed that coffee-roasting had formed a recent diversion. Next to his mechanical experiments and amateur photography, Mr. Blake is most interested in the improvement of Keewaydin, the name which he has given to his fine estate at Weston, ten miles from Boston. In regard to what he proposed to accomplish he was silent. "I think it is a great mistake," he said, "to talk about what you hope to do. Do it first, and then talk about it afterward." "I don't see," he said, when questioned in regard to the future of sound transmission, "what more is to be attained in the short-distance telephone. You may see evidence of this in the fact that men are no longer attempting to improve upon it as they were once." Questioned as to the discovery which bears his name, Mr. Blake said: "My attention was first directed to the Bell telephone in 1876, when Prof. J. E. Hilyard, a prominent member of the Board which awarded Mr. Bell his prize for the telephone at the Exhibition, explained to me the instrument which he had examined. I was very much interested, for I had made a special study of electricity while I was attached to the astronomical service of the Coast Survey, where I was engaged principally in the telegraphic determinations of longitudes in various parts of the United States, Europe and South America. Very soon after this I constructed a pair of hand telephones myself, very much like Mr. Bell's, which I still have in my possession. I devoted a great deal of time—many months—to experiments designed to ascertain the best proportions for various parts of the telephone—the size of the coils, diaphragms, methods of clamping, &c. I constructed a microphone, after an article by Prof. Hughes, which appeared in *Nature*, I think. By experimenting upon the microphone I was finally able, after a great many trials, to construct one which, when placed in the circuit of my small hand telephone, produced most satisfactory results. I well remember that on the first test of this instrument every word was distinctly understood, while even a whisper was perfectly transmitted. I then became satisfied that I had the broad principle of an important invention, and from that time on I devoted myself to a series of careful experiments to perfect the details and to discover the methods of adjustment of the parts necessary to produce the most nearly perfect results." Mr. Blake's life has been a remarkably varied and eventful one. In 1866 he secured an appointment in the United States Coast Survey. He was in the employment of the Government for twelve years. He was stationed for astronomical duty at Harvard, and also in Texas and Louisiana. He was also engaged as assistant in a party organised for a hydrographic survey of the Susquehanna river, the west coast of Florida and the north coast of Cuba. Mr. Blake was sent to Steubenville, Ky., to observe the solar eclipse, of August 7, 1869, and was ordered to determine the astronomical latitude and longitude of Cedar Falls, Iowa, and St. Louis, Mo. He was appointed astronomer to the Darien exploring expedition. Three years after this he was offered charge of the transit of Venus expedition to the southern hemisphere, but he was forced reluctantly to decline. For some time Mr. Blake was stationed successively at Brest, the Imperial Observatory at Paris, and the Royal Observatory at Greenwich. This was the occasion of the third and final determination of the difference of longitude between Greenwich, Paris and Cambridge, and all the observations were made by him.

Contemporary Electrical Science.—*Wiedemann's Annalen* for January contains many somewhat startling contributions.——Electric Waves are, as usual, the staple product of German-speaking physicists, although Boltzmann and Planck deliver two separate attacks upon modern "energetics," chiefly as expounded by Ostwald. It seems that the mechanical theory of the universe and scientific materialism, so ably attacked by the great chemist, will not surrender without a struggle. Planck himself also writes upon the resonance of electric waves, and shows how the distribution of energy in a resounding circuit may be calculated from Maxwell's equations. Elster and Geitel contradict the rumour that positive electricity is dissipated, like negative, by the action of light. They show that it is all due to a secondary action upon the platinum cathode as soon as it gets coated with a layer of vapour from the liquid sodium-potassium alloy forming the anode.——V. von Lang has an interesting little Paper upon The Diminution of Resistance of a Light Contact between Carbons or Metallic Terminals under the action of the slight electric waves produced by an electric gas lighter or by an electrophorus. The experiment with carbon is easy, but that with metals requires great care in order to avoid the slightest concussion. With Jaumann's sensational Paper on Longitudinal Light we have already briefly dealt (see *The Electrician*, January 24th, p. 417). It will be interesting to see how Maxwell's equations will fare in these days of breathless activity and rapid progress. ——Leo Arons discusses the curious fact that Alternate-Current Arcs are much more difficult to produce with metallic than with carbon electrodes, and suggests three possible explanations. The carbon may be better suited to sustain the necessary heat through the zero points owing to its smaller thermal conductivity. Or the gases which carbon always will evolve up to its own death, in spite of all precautions, may undertake this function. Or the metallic oxides are in the way. Perhaps further experiments will bring more light.

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ON THE RAYS OF LENARD AND RÖNTGEN.

BY DR. OLIVER LODGE, F.R.S.

In the days of Gassiot and other early workers on the discharge in rarefied gas it was the stream from the anode that chiefly excited attention. It is this which displays the well-known gorgeous effects which used to be shown at nearly every scientific conversazione.

The discharge starts indeed from both terminals, but that from the cathode proceeds but a very little way, while that from the anode proceeds nearly the whole length of the tube, even though it be many metres in length, travelling with something comparable to half the speed of light, as has been proved by J. J. Thomson.

As exhaustions were improved the discharge was seen to change from a bright continuous streamer into a beaded or striated column, and it was the striæ upon which attention was then chiefly directed, as well as upon the outer or "second" dark space which had been so full of interest to Faraday. De la Rue, Spottiswoode and Moulton added to our knowledge of the occurrences in this stage.

The first, so far as I know, effectively to call attention to the surpassing interest of the events in the inner dark space, most closely surrounding the cathode, was Hittorf; but there can be no question that these dark-space phenomena were developed and expanded, and pressed home to the meanest apprehension most completely, by the highly skilful and brilliant experiments and exposition given to the Royal Society and the British Association in 1879 by William Crookes. Assisted by Mr. Gimingham, and working with vacua higher than anything previously attained, the discoverer of the radiometer irradiated the whole subject with a flood of light and set it on its present basis. The inner dark space was now broadened out so as to fill the whole tube: it was shown to consist of flying electrical particles, and everything exposed to their impact became brilliantly luminescent. Between Hittorf and Crookes must lie the discovery and the effectual vitalisation of that now well-known phenomenon—the cathode ray. This constitutes the third stage in the development.

Then appeared Hertz: certainly one of the most marvellous combinations of mathematical and experimental power that we have seen in recent times. Not a word has been said in excess of the fame due to him; since Clerk Maxwell's death Physical Science has had no untimely loss like his to deplore. He found that the cathode rays impinging on German glass coated with gold leaf and other kinds of metal made the glass phosphoresce not only where it was uncovered, but, at sufficiently high exhaustion, also where it was covered with metal; discovered, in fact, that flakes of metal were more transparent to cathode rays than were flakes of mica of equal thickness.

Before and after his death his *quondam* assistant, Dr. Lenard, took the matter up, and with consummate experimental skill conducted a series of investigations that essentially started our till recently newest era. His ambition was to get the rays out of the vacuum into the open air, and at Hertz's suggestion he "glazed" his vacuum tube with an aluminium window for the purpose. Very thin, very small, and very delicate was Lenard's window, for it had to be thin enough to be cathodically transparent, thick enough not to leak air through imperceptible holes, and strong enough to resist the whole pressure of the atmosphere. The cementing of a metallic window on to a tube intended to be worked at such high exhaustion that an induction coil spark would prefer 3cm. of ordinary air rather than traverse the tube was no easy matter. However, the difficulties were overcome, the aluminium-closed vacuum tube was constructed, cathode rays of great strength were started inside it and directed on to the window,—if necessary, being deflected thereon by a magnet; and outside, in the otherwise perfectly dark region in free air, on the other side the partition, the air itself, as well as the window, were seen to be glowing with a faint phosphorescent light. Strongly fluorescent materials held in this region were, of course, brilliantly lighted up: and photographic plates and films were quickly blackened. The rays from the window were not a mere prolongation of the cathode stream; they started afresh in all directions, as light does when a parallel beam impinges on a minute orifice. The skin and the eye could feel nothing of these rays, but fluorescent and photographic materials were abundantly sensitive. Lenard conceived that he had here a novel kind of ethereal radiation; but whether it consisted of very minute transverse waves, analogous to light but much higher up in the spectrum than those usually called ultra-violet, or whether it consisted of waves not transverse, or of something else not waves at all, he did not pretend to decide. Certainly material bodies introduced into the rays behaved in a very different manner from the way they behaved to light. Dense bodies were rather opaque, rare bodies were rather transparent; and nothing to do with electric conductivity seemed effective in connection with these rays as it was with light—nothing but density seemed much to matter. Hence certainly they were not Hertz waves or anything submissive to Maxwell's equations,—conductors must be opaque to *them;* unless, indeed, the molecules or their interstices could be dealt with instead of coarse groups of them, in which case ordinary conductivity ceases to exist, and abnormal transparency can be fairly explained. Hydrogen was found to be the most transparent of the gases by Lenard, but if it were squeezed till it was as dense as oxygen, then it behaved just like oxygen, and so on. Metals and non-metals of equal density were about equally opaque, roughly speaking. Moreover, nothing was dead opaque or clearly transparent; all substances were turbid, like milk. They did not stop the rays by reflection, but by diffusion. After going through a sufficient thickness of matter, the beam, limited and made definite by a suitable diaphragm, became fuzzy and bordered by a sort of aureole when received on a fluorescent screen. But this turbidity, he is careful to say, is not increased by dust or suspended gross matter. It is a true *molecular* turbidity, and indicates that he is dealing with something of molecular magnitude.

Aluminium was more transparent to these rays than quartz, *and a shadow photograph was taken to illustrate this, by putting a sensitive plate in an aluminium-fronted box,* and then interposing in the path of the rays, between the source and the sensitive plate, a couple of rectangular strips of quartz and aluminium, partially overlapping. The plate, on development, showed four regions; the darkest when it had not been screened at all, except by the walls of its perfectly light-tight box, the next darkest where the shadow of the aluminium rectangle had fallen, lighter still in the shadow of the quartz strip, and almost unaffected in the portion screened by the two overlapping materials. All this, it must be noted, in 1893 and 1894.

One more observation I give in his own words, as translated in your Volume XXXII., p. 576: "On replacing the aluminium window by one of glass it was found possible to repeat all the essential experiments with equal success. But the aluminium window remains the more suitable; not that it is more transparent, but because aluminium is opaque to light and more easily manipulated than glass of equal thickness."

Thus Lenard had actually got the rays to come out of a plain glass vacuum tube, provided it was highly enough exhausted and with thin enough walls.

The writer well remembers trying, in 1894, to get the Lenard rays out of a not unsuitable but rather thick vacuum tube, in stupid ignorance of this just-quoted result, and failing. Failing simply by reason of insufficient pertinacity, as it now turns out, for this very tube is by him now, and with it he has been able, aided always by his admirable assistant, E. E. Robinson, to repeat Röntgen's results and get good photographs without trouble through a quarter-inch of wood and a sheet of aluminium, provided something like half an hour's exposure is allowed. The tube is a large one, without electrodes, and to excite its fluorescence the coil should be provided with knobs, which are allowed to spark directly into each other; the tinfoil coatings on the glass then act as Leyden jars, and give impulsive rushes into the tube.

Lenard tried whether the rays would charge a body electrostatically, but they would not. On the contrary, they rapidly discharged a body already charged; and this equally, whether that initial charge were positive or negative. This experiment probably influenced him to conceive of his rays as something ethereal, and to deny that they were streams of electrified

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particles bombarded off his window by the impact of the cathode stream. He considers that the passage through metal has effectually filtered all the truly *electric* properties from his rays; and, accordingly, he is prepared to find, as he does, that they neither decompose nor liberate gases from anything, as the unfiltered cathode rays themselves do. True, the filtered rays, which it is now convenient, at least for the present, to style Lenard rays, are able to precipitate chemical actions in sensitive silver gelatine films; but, when it is remembered how surpassingly responsive these are to a luminous stimulus, it may well be conjectured that the Lenard rays act only in a physical and secondary manner by the intervention of some kind of phosphorescence (a term much better replaced by "*luminescence*," in accordance with the suggestion of E. Wiedemann, whenever there is nothing of the nature of phosphoric combustion.)

Getting the rays into exhausted tubes he finds them travelling several metres in a straight line, and keeping clear and sharp, provided the tube is sufficiently exhausted, the last traces of mercury vapour being, in this instance, lessened by application of a freezing mixture after days of pumping. In such a tube no cathode rays could have been *generated*, but the Lenard rays are just in their element. Must it not be then, he asks, that this element is really the ether?

Now comes the crucial experiment: are the Lenard rays deflected by a magnet? Experiment answers they are. When the medium is turbid and produces an aureole the experiment is not distinct, hence Lenard did not succeed in either proving or disproving deflection in common air, but in a "complete" vacuum the deflection is clear and sharp; in a partial one, when there is a little aureole, the hazy patch is deflected more than the central spot, and is, in fact, spread out into a kind of "magnetic spectrum."

Varying the pressure of the gas causes no alteration in the deflection of the central spot, it only affects the position of the deflected aureole or diffusion caused by the presence of gross matter; the clear central unaltered spot, he argues, must be something ethereal. How, then, can it be deflected by a magnet? Light waves are not thus acted on. By no direct force, he conceives the answer to be: by a modification of the ether, caused by the magnet, a modification which twists the ray aside somewhat after the fashion of Faraday's rotated plane of polarisation; and in proof of this he adduces an experiment of Hertz to show that there is no reciprocal force acting on the magnet, in other words, that the ray is not *forced* aside, like matter, but skewed aside by an ethereal twist.

The theoretical views of an experimenter are not to be lightly scorned, even when they fail to accord with our well-based prepossessions. A man who lives among phenomena is to be listened to, for he often feels instinctively more than he can logically establish and justify. In this country, however, with all due respect to the illustrious experimenter, his theoretical views have not found favour. The writer, as well as other more competent judges, have felt, and consistently expressed the conviction, that the fact of magnetic deflection pointed to a stream of electrified particles; it might be to a kind of Grotthüs chain, or electrolytic radiation, but at any rate to something material, not ethereal. Arguments based on occurrences which go on in the presumed absence of matter, say in tubes exhausted to the hundred millionth of an atmosphere, are very weak, because every cubic millimetre of such "exhausted" space still contains a hundred thousand million fully-fledged molecules. The marvel is that phenomena in space so crowded with substance can yet be so strikingly different from those which occur when the matter is made, say, a million-fold denser. Nothing, therefore, seemed conclusive *against* the radiant-matter idea, and the fact of magnetic deflection seemed almost conclusive in its favour.

Once more let us ignore theoretical views at present and stick to facts. Lenard found that although varying the gas in his *observing* space left the main magnetic deflection unaltered, so long as it could be clearly observed, yet that a variation in the exhaustion of the *originating* space, where the undeniable cathode rays were impinging on his window, produced a notable effect. An increase in the exhaustion of this vessel was found to decrease the deflecting power of a given magnetic field on the Lenard rays outside. Hence, if the exhaustion could be pushed to extremes it may be urged as probable that the magnetic deflection would almost cease.

(A remark must be interpolated here to the effect that the last-quoted fact lends strength to the idea of electrolytic radiation, or at least of radiant matter in some form, as opposed to an etherial process.

For conceive an atom of mass m charged with the quantity q flying with velocity v through a magnetic field of intensity H. It is equivalent to a current $q\,v$, and it experiences a deflecting force $q\,v\,\mathrm{H}$. Hence its acceleration is $\frac{q\,v\,\mathrm{H}}{m}$; and, since this is normal to the velocity, it can be equated to the usual centripetal acceleration $\frac{v^2}{r}$, where r is the radius of curvatures of the orbit or trajectory of the particle.

Wherefore it follows that the magnetic curvature of the path is

$$\frac{1}{r} = \frac{q}{m} \cdot \frac{\mathrm{H}}{v}.$$

The first factor is the reciprocal of the ordinary electrochemical equivalent of the substance, and is known; hence the curvature is expressed in direct proportion to the reciprocal of the velocity. A lessened curvature, therefore, simply points to a higher velocity, and at sufficiently high exhaustions it may happen that a few of the molecules in the vacuum tube, under the stress of the potential gradient on their enormous charges, are moving with something approaching the speed of light. Most of them are much slower, as J. J. Thomson has indicated, but it is permissible to think of some as having excessive speed. If so, the path of such particles would be probably straight through any ordinary magnetic field such as has hitherto been applied to test them. And on the usual impact principles, of receiving and handing on motion, atoms driven away by them from the other side of a partition might be expected to receive and pass on something like this enormous speed for some distance further.)

Lenard found that there were different kinds of his rays; some of them more deflectible, some of them less; those which are more deflectible are more affected by turbidity, and soon get stopped by moderately opaque substances, but those which are less deflectible are more pertinacious in their passage through matter, and may be expected to penetrate to considerable distances, even through reasonably opaque media.

Can it be possible, the writer now goes on to ask, that Prof. Röntgen has utilised these very rays? It is evident that the apparatus at his disposal is pre-eminently adapted to exhibit Röntgen radiation, whatever it is. No other experimenter seems to have obtained such good results, unless there are some not yet widely published. Mr. Swinton, by application of immense power, has come nearest to it in this country so far, but the rays used by him do not appear to penetrate the flesh of the hand with anything like the ease that Prof. Röntgen's do. Those used by me at present are also less penetrating. They give good results with metals, but with the hand the bones hardly show through the surrounding material (the finger nails come out clearly transparent). Lenard, it appears, used something of this last sort of radiation, and matter appeared to him more turbid than it does to Prof. Röntgen. Why is Röntgen's source of rays so powerful? Is it the kind of glass, or its size, or its exhaustion, or has it something to do with the electrode? He has not yet told us the details, but it may be surmised that his Crookes tube happened to be extra well exhausted and of good German glass (English glass seems useless). At any rate, he seems to get easily what others get with difficulty. Certainly he is most warmly to be congratulated!

Once more, considering the question of the possible hypotheses, Prof. Röntgen leans to the view that they may be longitudinal ether waves. Authorities in this country are hovering between ultra ultra-violet waves, on the one hand, and longitudinal vibration on the other.

The writer only hopes that it *may* turn out a longitudinal vibration. There is a great deal to be said in favour of such a view, and on the whole it seems to the writer the most probable of the etherial hypotheses: more probable than that of extra

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ultra violet light, because of the transparency of the metals. The fact that simple material *density* is the chief factor determing opacity, has a very gravitational look about it. Can it be that at last we are on the track of gravitation experimentally? Anyhow, if it be but something periodic comparable to the size of atoms, many problems of supreme interest would be in a fair way of yielding up their answers. The writer hopes at least that it may turn out something etherial, and may give a method for determining μ and K; but for the present he permits himself to doubt, and inclines to a sort of electrolytic impulsive propagation through and by means of ordinary matter, in spite of the immensely important fact that Prof. Röntgen can detect in his rays no magnetic deflectibility whatever. The clearness of his rays enables him to achieve this result in ordinary air. It is to be remembered that Lenard was only able to observe his deflections in a partial vacuum. Ordinary air was too turbid, and the image too indistinct. This experiment of no magnetic deflection of the Röntgen rays I have indeed so far confirmed as to be satisfied that any deflection there may be is extremely small—far smaller than that appropriate to any kind of known cathode rays. Perhaps it is *nil*, and if so, projection of charged particles is *ipso facto* and finally put out of court, but perhaps it is only small, in which case, as has been shown above, charged particles flying at high velocity are indicated. It would only be the most rapid particles that could get through the obstacles and imprint themselves upon the plate, and it is just these that would be least deflected. Hence, until the details of Prof. Röntgen's magnetic experiments are forthcoming, there is still a loophole for the dullest and most commonplace of all the at present conjectured explanations. Meanwhile, the possibility, even the probability, that in these rays we have a new kind of radiation, even though it be only ultra-violet so high up as to be comparable to the size of molecules, lends to these experiments a prodigious interest in the eyes of physicists, far surpassing the obvious practical applications which have gained the ear of the general public.

Liverpool, January 26, 1896.

THE CROMPTON POTENTIOMETER: ITS USE AND CAPABILITIES.—IV.*

BY W. C. FISHER, ASSOC.MEM.INST.C.E.

A brief *résumé* of the points that necessitated, and the difficulties attendant upon, the construction of such a galvanometer as that shown in Fig. 14 (*see* Article III.) might be of interest.

Six years ago, with a view to very accurate work, it was decided to investigate and obtain, if possible, a d'Arsonval galvanometer of great sensibility. Different makers' instruments were tried, and one by one abandoned as being unfit for the purpose desired, until the Carpentier instrument, with coil resuspended, as has been already described, was proved to be by far the most sensitive instrument available. Still something better was aimed at, and with that object in view, it was decided to try what strengthening the magnetic field would do. For this purpose an electromagnetic galvanometer was constructed having vertical limbs and hatchet-shaped poles, between which a Carpentier coil was duly suspended, but, as had been discovered a few months earlier by Mr. Mather, it was found that whilst up to a certain point the deflections became greater with increased strength of field, beyond that point the deflection gradually fell off as the field was strengthened, this being due, as Messrs. Ayrton and Mather have pointed out, to the presence of iron in the materials used in the construction of the coils. A remedy for the same was found by Messrs. Ayrton and Mather, and it is due to Prof. Ayrton's kindness in disclosing the process adopted that the sensibility of the instrument (Fig. 14) is to a great extent due.

During these experiments it was also found that a false sensibility could be given to the coil by so suspending it, slightly out of its true centre and slightly awry in the magnetic field, that deflection due to current in the coil was materially assisted. This effect was first observed by Prof. Eric Gerard, of Liége, who by such means obtained extreme sensibility; it led, however, to false zeros, false sensibilities, and general instability in behaviour, not the least of which was that the sensibility occurred in one direction only. The effect so produced has been termed the "Gerard effect." It prevents the adoption of a square form of coil for delicate work, which form, under certain conditions, is theoretically considered to be the most efficient in deflectional power. The ring coil was adopted as being least likely to develop this effect; assurance in that respect has been made doubly sure by the adoption of a long bifilar suspension, which would doubtless be still further improved by the

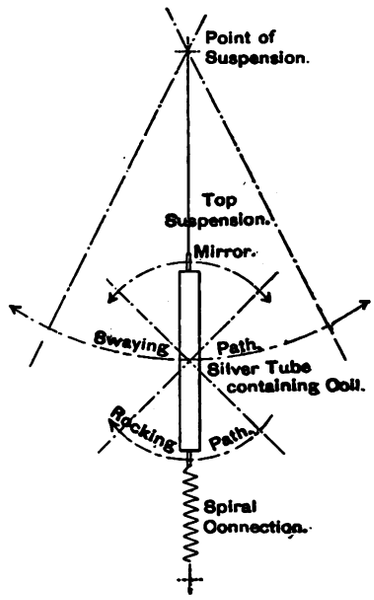

FIG. 16.

adoption of one suspension, the second connection being a spiral of very fine wire around same. The ring form of coil was first sketched out for the writer by Mr. Crompton in 1890, it being thought, next to the square-shaped coil, most suitable for the object in view—*i.e.*, maximum sensibility off zero only.

In addition to the means adopted, as already mentioned, for freeing the coil from iron and so eliminating as far as possible magnetic control, to ensure sensibility an intense field is

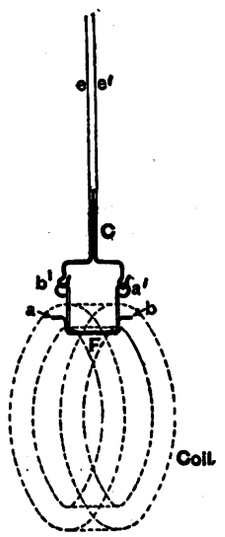

FIG. 17.—Method of Suspending Coil.

obtained by the employment of large powerful magnets having very narrow poles, so concentrating as much as possible the lines of force in the air gap, the magnetic resistance of which is decreased by the introduction of a soft-iron disc. The coil is enclosed circumferentially as much as possible by the magnet poles, so that the amount of waste winding is exceedingly small. These points, in combination with a long suspension, have resulted in the great sensibility above mentioned.

* For previous articles see *The Electrician* of November 29th, December 6th (1895), and January 17th (1896). *Copyright.*

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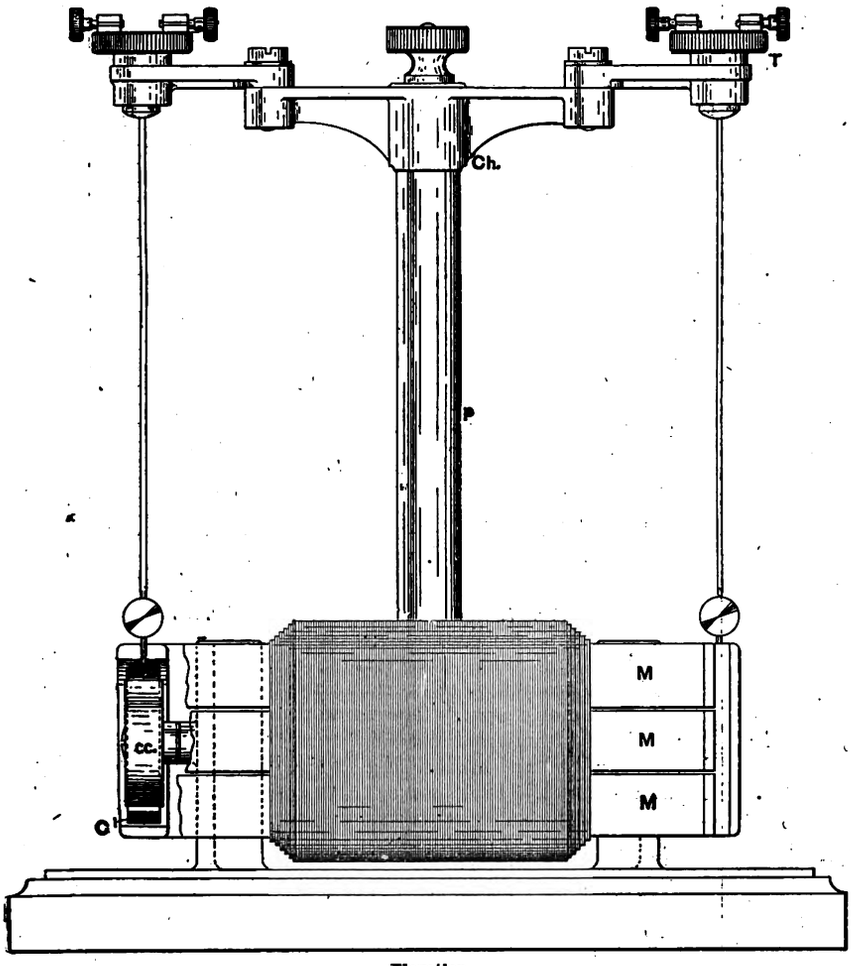
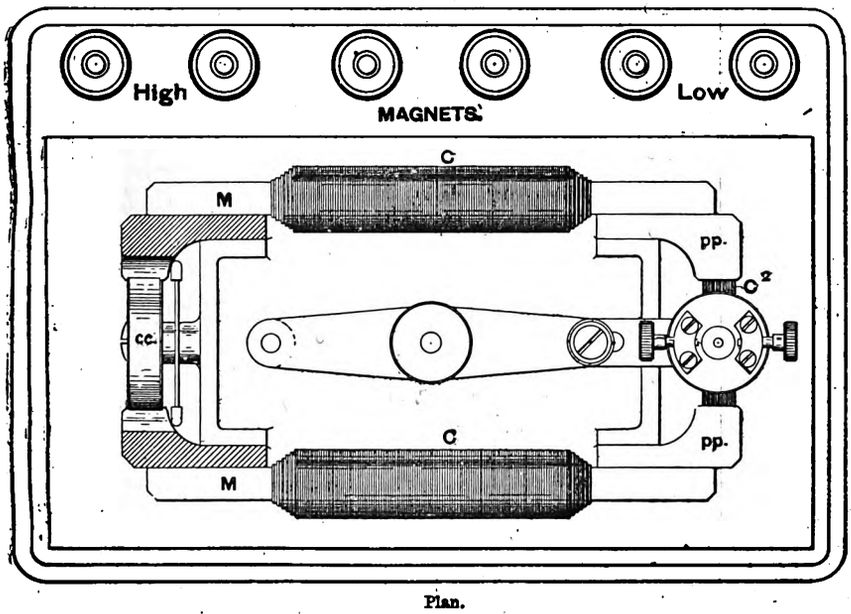
The question of vibration was one of considerable moment, inasmuch as it had to be entirely eliminated in order to obtain concordant and definite results, seeing the very minute forces that were at work, to say nothing of the effect on a delicately-balanced temper of a blurred mass upon the scale, amidst which might occasionally be seen—like the "Trotter" arc microbe—



Elevation.



Plan.

FIG. 13.

the bright image sought. The vibration chiefly to be guarded against was that due to the proximity of rapidly-rotating machinery, &c. Under such conditions, as might be expected, it was observed in the various instruments under test that coils of given weight with short suspensions more readily responded and got into step than when suspended and strained with longer ligaments. Such vibration was of a simple horizontal nature set up in the same direction as the parent vibration; it was possible at times, by altering the tension of the ligaments, to partially eliminate or even completely break up this vibration in the coil. This was, however, impossible in a coil having a short top suspension only without any bottom control; in such, a compound vibration is set up which is anything but pleasant, and which is best described by a glance at Fig. 16, in which it will be seen that in addition to a swaying vibration having the point of suspension as its centre, there is a very rapid oscillation about the centre of gravity of the coil. As might be expected, the vibrations being of different period, tend at times to break each other up; it is then that the coil so suspended has its sane moment, but an instant afterwards it is as mad as ever. A remedy, of course, is either a very long upper suspension, material alteration in the weight of the coil, or a strained bottom ligament. The latter alternative would entail a slight loss in sensibility, not sufficient, however, to influence it for practical work. It was therefore decided, in designing the special instrument required, to make it stiff in construction, to have a reasonably long suspension, and a coil of such shape, dimensions and weight which should be attached to the suspensions in such a manner as would entirely preclude any possible oscillation under the circumstances described. The result attained is all that could be desired, and the only vibration to which the instrument has been known to respond is a very slow one appearing at very long intervals of time, in some cases days passing without its being observed, and which is attributed to the slow oscillation of the house at the top of which it is at work.

For quick working, where great sensibility is not desired, a ready means of shortening the suspension was thought desirable; the vane already mentioned was therefore introduced, and is brought into action by being set at right angles with the vertical, or, in other words, placed horizontally, and lowered down the pillar between the bifilar suspensions until the requisite point is reached, where it is clamped, the point of suspension being practically transferred from the top turntable to the vane, which is wider than the slot in the former, through which the suspensions pass. In this manner it is possible to cut down the period of the coil to less than 25 per cent. and the sensibility to less than 35 per cent. These figures are, of course, dependent upon the characteristics of the coil.

The adoption of ebonite levelling screws of the shape indicated in drawing (Fig. 14), especially if the ledges be slightly undercut and occasionally wiped, has been productive of perfect insulation, which is still further increased by the insulation of both terminals and leads.

Coming to the fourth point enumerated in the necessary qualifications of a satisfactory galvanometer for potentiometer work—namely, that the coils be interchangeable, the reason for this will be explained later. In existing types of galvanometers the changing of a coil entails the removal of some part of the framework of the instrument as well, and the substitution of another framework with the new coil and *another* suspension of possibly very different characteristics. This method it was thought inadvisable to adopt, more especially as the massive construction of the instrument would not allow of its adoption economically. An easy method of attaching the coil itself to the suspensions—whose characteristics were known and remained constant irrespective of the various coils successively attached—in combination with the smallest weight

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possible, led to the form of attachment shown in Fig. 17, in which it will be seen that one end of the coil is attached to the end b of the twin-wire cradle F, the other end b' of which terminates in a loop. The second end of the coil is attached to a, which also terminates in a loop, a'. The twin wires forming the cradle are, of course, insulated from each other, and are braced on to the coil; each coil accordingly has its own cradle attached to itself. The suspensions $e\,e'$ terminate in a twin coupling, C, likewise duly insulated, and to which the mirror is attached; the ends of the coupling are bent, as shown, into hooks, which engage in the respective loops of the coil cradle; the changing of a coil is, therefore, a matter of small moment, being merely a question of hooking or unhooking, which is easily performed with ordinary care without injury to the suspensions, which, though delicate and fine, are double, and will stand an almost incredible strain without breaking.

In order to obviate the necessity of constantly changing coils, a double instrument, shown in Fig. 18, was devised. It consists of a rectangular base, supported upon insulating

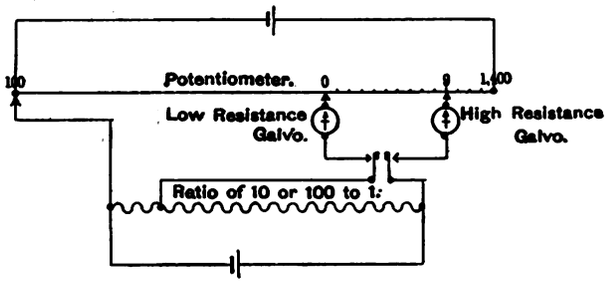

FIG. 19.

levelling screws, having two brackets cast upon it, upon which are fixed the compound permanent or electro-magnets, having suitable pole pieces and cores, as shown. The field may be regulated at will by means of the magnetising coils, and also, when necessary—by means of a yoke—the galvanometer might be made into a single limb instrument with one intense field.

The two coils, one of high the other of low resistance, are each suspended from turntables similar to that shown and described in Fig. 14. These are supported on adjustable arms attached to the cross head of the central pillar. It is of course apparent that the instrument is suitable for many purposes exterior to potentiometer work, but in conjunction with that instrument for ratio and other work it is well adapted, being connected up as in Fig. 19, from which it may be seen that

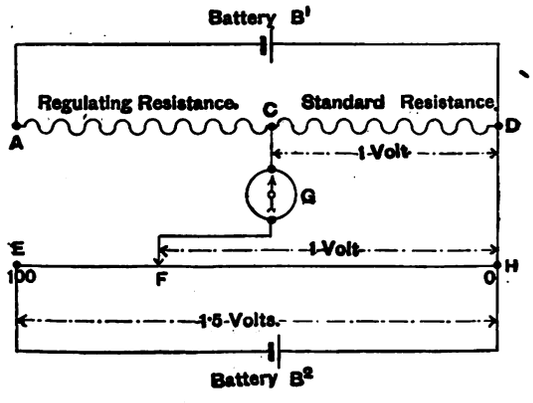

FIG. 20.

simultaneous readings may be taken if necessary. It might be pointed out that whilst these galvanometers were designed nominally for potentiometer use, they are pre-eminently adapted for ballistic work.

The necessity for changing the coils of the galvanometer may not be apparent to many, but observant operators will have noticed a considerable difference in sensibility and behaviour of the galvanometer under apparently identical conditions. The reasons for this are not far to seek when one ceases to think of potential only, and turns one's attention to what takes place when current flows through the galvanometer. Then one instantly sees that dependent rather on the characteristics of the test made, the conditions governing the deflection of the galvanometer are not equal with equal differences of potential in the *potentiometer*. That is to say, with a given galvanometer, and with identically the same E.M.F. at the terminals of the potentiometer, a given want of *balance* when measuring the E.M.F. of a Clark cell, and an entirely similar want of *balance* when

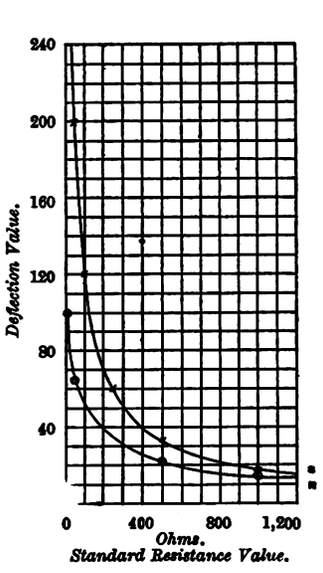

FIG. 21.

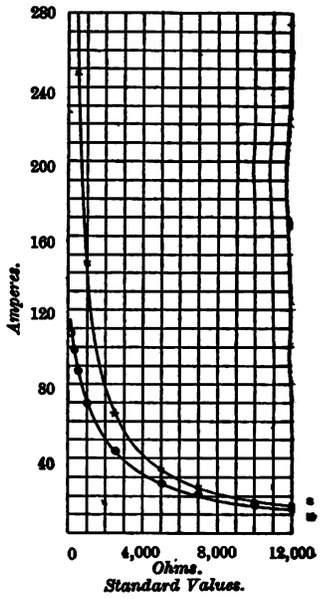

FIG. 22.

measuring the E.M.F. at the terminals of a low standard resistance is not productive of the same amount of displacement of the galvanometer spot. The same thing is apparent when comparisons of high and low resistances or E.M.F. over high and low resistances are made. Fig. 20 will perhaps more easily explain matters. In it we have the simple conditions under

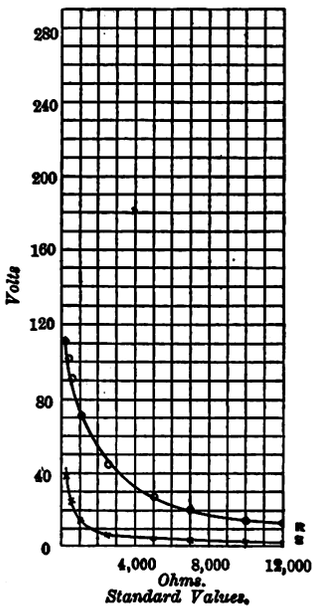

FIG. 23.

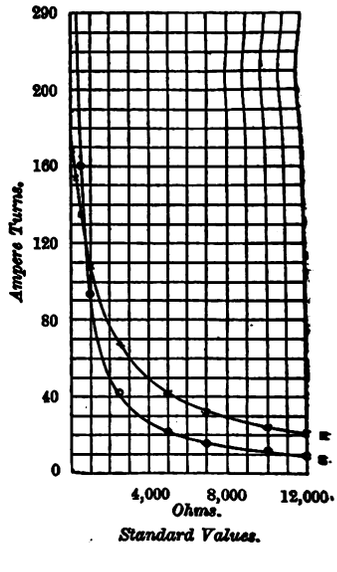

FIG. 24.

which two coils, one of low, the other of high resistance, were tested. As shown, the circuits consist of, first, the battery B', maintaining constant potential at ends, and consequently current through A C D.; second, the battery B^2, maintaining constant potentials across and current through the potentiometer E F H. The points H and D are connected together as shown. The points C and F are also connected together through the galvanometer G.

So long as one volt is maintained across C D and F H respectively, there is no flow of current through the galvanometer; but if the point F be moved we instantly have difference of

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potential set up between C and F, and consequent flow of current through the galvanometer coil, the volume of which, with given displacement of the point F, would roughly be dependent upon the resistance of the circuit G C D H F.

In the experiments made with the two coils mentioned—one of which was ten times the resistance of the other—a constant minute want of balance was maintained at F, whilst at C D, although a constant difference of potential of one volt was maintained—as was also the case at F H, with the exception of the minute difference mentioned—the value of the standard resistance C D was altered, and value of deflections produced by each alteration duly noted in the case of both coils. The curves given in Fig. 21 show graphically the deflections so obtained. The curve indicated by the letter S being that produced by the low resistance coil, and that indicated by R being that of the high-resistance coil, these symbols hold good throughout the series of curves. It will be observed that the greatest deflections, as might be expected, take place when the value of the standard is low and the current flow through the galvanometer consequently high, the deflection of S, for the same reason at these values being very much in excess of R; as the value of the standard was increased the deflections diminished naturally with increased resistance of circuit G C D H F, becoming approximately equal at the very high values of resistance. So much for the deflectional values. Unfortunately, however, the comparison does not end here, for the behaviour of the coils has to be considered. In the early

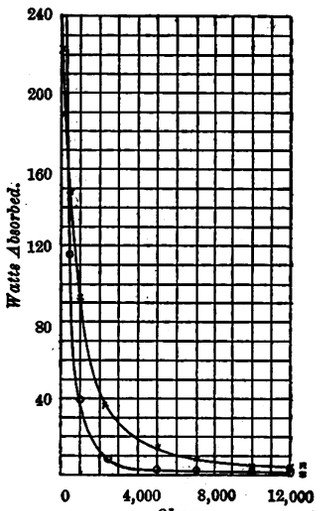

FIG. 25.

part of the curves, whilst the current flow was great, S, the low-resistance coil, sprang to its full deflection at once, whilst R moved very slowly, eventually creeping with difficulty to the points indicated. On the other hand, as the value of the standard resistance was increased and the other end of the curve attained by successive stages, we find R—the high-resistance coil—getting steadier and quicker, whilst the low-resistance coil becomes more and more erratic and uncontrollable, swaying about with little or no stability or decision. A study of the conditions and force at work in conjunction with diagram shown in Fig. 20 is productive of the following curves, which in themselves are sufficiently explanatory of the behaviour of the coils.

In Fig. 22 we have the current values plotted horizontally upon the vertical lines corresponding to the values of the standard resistance in circuit; as might be expected, the curves so produced are practically coincident with those of deflection, with high standard values being almost equal, and gradually increasing as the resistance in circuit is lowered, S attaining a far higher value than R.

In Fig. 23 are represented the curve of E.M.F. values at the terminals of the galvanometer coil; as is natural, the curves change places, R—the E.M.F. at the terminals of the high-resistance coil—being considerably above S throughout.

Fig. 24 gives the curve of ampere-turns in the coils, and it is at once noticeable that the two curves cross each other very quickly, the high-resistance coil R speedily attaining to double the number of ampere-turns in S, which was the predominant partner at the commencement of the curve. The ratio of convolutions in the two coils being approximately $2\frac{1}{2}$ to 1, a glance at Fig. 23 makes it very manifest that the curves must cross, for the higher current values of R, if multiplied by 2·5, will bring us slightly below the value of S at those points. On the other hand, when we multiply the lower current values of R by 2·5, we get very much above S.

The same thing is apparent in Fig. 25, which represents the curve of watts absorbed in the coils. The curve again crosses quickly, for whilst, by glancing at Figs. 22 and 23, we find at the commencement of the curves we have *one-fourth* the current, we have three times the E.M.F. in R that we have in S, whilst at the other end the current in both coils are approximately equal, but the E.M.F. at the terminals of R is 10 times that of S.

The above are but two examples of a series of tests made with different coils and from which certain deductions have been made and particulars obtained. Into these it is not the writer's intention to enter at present; it is only interesting to point out from the above that at the time when the low-resistance coil S is quick and decisive in its movement, and the high-resistance coil R is slow and creepy, it (S) has approximately 1·6 the number of ampere-turns, and 1·5 the watts absorbed in R. On the other hand, at the other end of the curve, when S is unstable and wavering, and R is quick and steady, it (S) has approximately but 0·5 the number of ampere-turns, and 0·1 the number of watts absorbed in R. From the above it is plain that for very accurate work it is necessary to have a coil suspended in the galvanometer which, under the conditions of test, is most suitable both as to sensibility and speed of working. For ordinary testing this is, of course, unnecessary, as the degree of accuracy is not so great, the forces at work are not so minute, nor need the galvanometer be so sensitive.

The writer has already mentioned the use of a millivoltmeter, and the partial success attendant thereon. It is upon this point that its weakness is apparent; the resistance usually of the coil itself is low, and whilst answering admirably when in use with a low resistance standard, the moment a Clark cell or high resistance comes into circuit its sensibility is gone.

HOUSE-WIRING.

DISCUSSION AT THE INSTITUTION OF ELECTRICAL ENGINEERS.

On Thursday evening, January 23rd, the discussion was commenced on the Papers on house-wiring read before the Institution of Electrical Engineers on November 28th last by Messrs. Sam Mavor and Fred Bathurst. The following is an abstract of this discussion:—

Mr. W[illegible]PEL said now that the existing rules of the Institution for wiring were on the point of revision, the two Papers under discussion had an additional importance, apart from the mere relation they had to the two particular methods advocated by their respective authors. He endorsed cordially the point urged by Mr. Bathurst as to the principal obstacle to the general adoption of electric lighting. It was undoubtedly the expense of wiring the building. Those of them interested in the supply of electricity were doing their utmost to reduce the cost of supply; the lamp manufacturers, as to the expense of lamps, were doing likewise, and yet, to judge from the tone of the remarks made at the recent Board of Trade Conference, an attempt was being made by some of them to increase this cost of wiring, through raising the standard of insulation to an unnecessarily high pitch. By all means let them protest against shoddy work, but do not let them put on needless refinement. Some of the rules of supply undertakings stipulated for as much as 75 megohms per lamp—quite an unnecessary standard. It was satisfactory to think that the persons really interested—namely, the insurance companies—were so far much less drastic. The Phœnix stipulation was 12·5 megohms per lamp, and twenty-five other leading companies stipulated that the leakage was not to exceed one twenty-thousandth of the total current, which at 100 volts equalled two megohms only per ampere. The present rules of the Institution were one five-thousandth of the total current, equal to half a megohm per ampere, or $\frac{1}{10}$th part of that first mentioned. This appeared to be quite adequate. He regretted to see, also, a tendency amongst the engineers of low-tension systems to force a 200-volt supply upon the consumer. Wiring contractors would do well to join the consumers and to protest emphatically against this practice; at any rate until such time as absolutely reliable and cheap 8 c.p.

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lamps were obtainable for this pressure. Meantime it was sufficiently difficult to get 100 volt 8 c.p. lamps which would stand burning at an economical efficiency. It must be remembered that for economical reasons the renewals of 8 c.p. lamps should be less frequent than lamps of larger candle-power, as there was a definite ratio between cost of current and renewals. The life of an 8 c.p. lamp should be about root two times that of a 16 c.p., assuming that each lamp cost the same. The first question occuring to all of them was, Did the methods advocated by the authors tend towards economy in first cost? He was afraid that that question was not answered by any reliable data, in fact there was a noticeable absence in both Papers of any figures as to cost. Perhaps the authors would give some data in their replies. In urging the advantages of his system Mr. Bathurst said that he saved on the insulation, which was half the cost of the wire. But did he maintain that his tubes were supplied and fixed for the same price as the much-abused casing or compo. tubing? He thought this could not be so, more especially as Mr. Bathurst spoke of the necessity of trained workmen. In his (Mr. Geipel's) opinion the extensive use of casing was largely due to the fact that there were always plenty of joiners to be had who did the work without special training. In speaking of the advantage of high insulation of his wires, he was afraid Mr. Bathurst forgot that the really weak points were in the switches, cut-outs and fittings. What Mr. Bathurst meant by the actual strain C^2R he could not understand. He could not follow Mr. Bathurst in his statement that rust in pipes was unfavourable to insulation. Rust was a better non-conductor than unoxidised iron. He had listened with great interest to Mr. Mavor's description of his well-thought-out system of concentric wiring, but he hoped that the members of that Institution and the Fire Insurance Companies would not be alarmed at Mr. Mavor's somewhat pessimistic remarks and warnings as to the necessity for greater stringency. He could not at all agree with Mr. Mavor as to the unsightliness of wiring in the present system; there were numbers of houses in London where not a casing was visible. It was useless to attack the existing method on the score of unsightliness; cost alone was its vulnerable point, and unless the cost of the concentric wiring was about 50 per cent. less than it was about a year and a-half ago, he was afraid that system was not ready yet to help them. It was possible that by abolishing the insulation of the outer conductor the concentric system might become cheaper than casing. Indeed, he was of opinion that the Board of Trade might go a step further and dispense with the insulation of the "outer" of all concentric low-tension distributing mains. It might be necessary to slightly insulate the outers of the feeders to obviate telephonic interference and electrolysis, but the difference of potential between any parts of the distributing network was so small that there appeared little necessity of insulation, especially as the "outer" was, even when insulated, invariably at earth potential. With such a system a considerable saving in first cost could be made, while Mr. Mavor's concentric system with uninsulated outer would work well in with it. As to the soldering of all contacts, that necessitated the use of a soldering iron whenever a fitting or switch required disconnection or connection to the circuit. Was not this an objection, as compared with the readily-made mechanical contact? He agreed entirely with Mr. Mavor's remarks as to the importance of what he described as grouping the branch fuses at distributing centres, and he considered that the method should be made compulsory with all systems of wiring, especially as it involved no increase in first cost. He also agreed with Mr. Mavor's strictures upon the bayonet-joint lamp holder so much in vogue, and he would ask if any of the members could second his experience, which went to show that the Edison screw socket was a better holder? It certainly appeared to overcome Mr. Mavor's objections. Mr. Mavor admitted that a fault might be caused in his wires by a nail for example, yet he proceeded to argue that he might sink his wires in the plaster, as it was never necessary to remove them. He could not agree to that. The compo. tube provided a means of repairing the wires in such cases without destroying any decorations.

Mr. HANCOCK said it afforded him great pleasure to see the prominence given lately to iron piping, and also that there was a general idea about that the time had come when they should make a move from their old friend casing. He ventured to think on examining the iron pipe system before them, that although it was a step in the right direction, it might possibly be carried a little further. His firm was not altogether sure that insulating the pipe and reducing the insulation of the cable was exactly the right thing. In the first place, by putting the insulation inside the pipe they reduce its capacity a great deal. In the second place, they were not at all terrified with the thought that, as some people said, the life of vulcanised rubber was but three years. If that were the case, he would like to ask Mr. Frank Bailey, for instance, whether, in the case of the hundreds, and even thousands, of pounds worth of vulcanised cable under his control he calculated that the depreciation was 33⅓ per cent.; and he would like to ask Messrs. Henley and the Silvertown Company the same thing. Without laying any particular claim to being the first to use iron-piping, he ventured to think his firm had been to a certain degree concerned in promoting its introduction. They were aware that for some years past there had been a feeling that there was room in the electrical world for more of an engineering spirit, so to speak. Casing was not entirely satisfactory; it did not apply to all the requirements they were justified in asking of it. They knew that there had been on the market for some time past various iron pipe systems, but somehow or other no one had cared to take the plunge. But they were gratified to know that since they determined to introduce it into the Commercial Union Buildings and the Guardian Buildings and other places, it had increased in favour. The point was, that in iron piping they found a system which gave them practically everything they asked for. First of all, it was a system which could be put in whilst the building was going up; if the builder liked he could make his mortar on top of the electric light installation. Also the ubiquitous carpenter could not drive his nails through the electric light pipes, which was a considerable advantage. They found that they had with iron pipes, although there were certain drawbacks, a system which enabled them to put in all the pipes while the building was going up, and which enabled them to draw in the cables the last thing, and so start with an installation which was perfectly new, and not one which was three-parts worn out before it came into use. They also found that if anything should happen to the wire the contractor could draw the cables out again. Coming to the question of insurance, he was very much afraid that the public had been under the impression that because an installation had been passed by an insurance inspector it was safe and nothing could happen. It was a pity it could not be made known, or at all events driven home to the public in some way, that the insurance companies did not undertake the functions of a consulting engineer. They considered that if the premium now paid covered the risk, well and good, if not it would be raised unless certain additional precautions were taken. There were one or two points he would like to mention in connection with the declaration they were usually asked to fill up. In the first place, in some of the Companies' forms they had to answer this question, "What excess of current will the conductors safely carry?" He ventured to say no two members of the Institution would have the same opinion on that subject. They generally evaded the question by saying the current density was so much to the square inch, and leaving it to the discretion of the inspector to say whether that was enough or not. He would suggest upon this point that the Institution should draw up clear and concise rules; the present method was unscientific and wasteful. In the smaller sized cables they might run up to 2,000 to the inch, but often it was not safe to exceed 500 to the inch. What they wanted was a definite table which could be referred to at once, and they might say the Electrical Engineers have gone into the matter and say for such-and-such sized cable you may put a certain amount of current through and no more. Naturally as they got up to the higher side of the scale they would be guided by the consideration of temperature, and as they got lower down the scale all they would have to consider was the fall in voltage for a given length. Another question often asked was the length of cut-out proportional to the E.M.F. That, too, was rather a difficult question to answer. In the first place no standard was laid down for them, and they had to choose an arbitrary standard of their own. Taking the Metropolitan Electric Supply Company as an example, they brought into the house 2,000 volts and transformed down to, say, 200. It was evident that if they considered a cut-out on the secondary should be three inches long, then the cut-out on the Metropolitan circuit should be 5ft. long. There was something wrong there. On the other hand if the Metropolitan cut-out represented a length of four or five inches, the cut-out on the secondary should be one-fifth of an inch. Passing on to what was a burning question of the moment were they to have 50 volts, 100 volts, or 200 volts in their houses? It was a question capable of being looked at from many points of view. If they looked at it from the point of view of the central station engineer they would say at once: have 200 volts. If they looked at it from the point of view of the ordinary contractor who had to take what fittings he could get on the market at the moment, and did not want to spend too much on cables, they would say 100 volts. If they looked at it from the point of view of the consumer, he thought they would say, probably, considering the life of the lamps and the question of convenience, 50 volts. Many people said the last-named was old-fashioned. He ventured to think it was in some points of view, but it had many advantages. With 50 volts under ordinary conditions it was amazing what the life of lamps was at the moment. There were many places where they had had lamps burning three or four years, going on and on, and never going out. He did not say they were in use every day. With 100 volts their experience was mixed. When they got up to 100, what might be called the limit of convenience was reached. That was to say, although the consumer might save a little at times by going up a little higher, he did not think any advantages counterbalanced the consideration of the life of the lamp. At the present moment they must run in London under very trying conditions. He thought that as yet it was rather premature to advocate 200 volts. They were told that when they had experience in the matter they would think rather more of it; they were told the life of the lamps was something remarkable; they were told they were portable and did not break in transit, and several other things. But he still maintained that 200 volts was in the experimental stage. It had to come, but the makers of fittings were not ready for it. Those who were using it at the present moment were doing a most useful service. There was another point. When they put up the voltage to 200, it was an admirable thing from the central station engineer's point of view; they increased the capacity of their mains and the efficiency of their lamps, but they were doing the consumer no good. With regard to the three-wire system, they were told it was impossible, or next to impossible, to get a shock across two outer wires. But, although station mains were in such wonderfully good condition, curiously enough the outer mains sometimes did go to earth, and also on many circuits people had not the confidence in the continuity of the supply that they should have. The result was that they would have a gas fitting somewhere in the neighbourhood, and it would happen sometimes the fittings themselves got in contact with the circuit. The result was that somebody took hold of the gas fitting and got a shock direct through to earth.

Mr. J. H. M'LEAN said he should like to speak from the point of view of the central station engineer. They had heard a great deal about details in connection with wiring, but his opinion was that even with the old-fashioned wooden casing they could have a great deal better wiring if more attention were paid to the work. The wiring affected them to a terrible extent; he did not think they half realised the extent to which it affected them. They (central station engineers) had to make their bread and butter by running out current to the consumers; it was not their place to look after the other side of the business, but they were expected to do it. They were expected to inspect and pass the wiring of the premises to which they were supplying current, and it sometimes happened in Oxford that six or seven

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STATEMENT OF CAPITAL EXPENDITURE IN ELECTRIC SUPPLY UNDERTAKINGS

To DECEMBER 31ST, 1895.

In the following Table the figures have been checked by the parties concerned, except where shown in *italics*, and in these cases a figure has been arrived at from the best available sources. † Indicates that the Supply Station is not in operation on 31st January, 1896. **N** Indicates that no information as to capital expenditure is obtainable, notwithstanding repeated applications, or that such information as is to hand is not suitable for this Table. Where a dash is inserted either no reliable figures can be given, or no capital expenditure has been incurred.

Date Supply commenced.	District supplied.	Owners of Supply Station.	Amount exp'nded to Dec. 31, 1895.	Owners of gas works in district.
			£	
1893	**ABERDEEN**	Local Authority	32,000	Local Authority
1894	**ABERYSTWITH**	Bourne & Grant Elec. Supply Co.	**N**	Local Company
—	†**ALDERLEY EDGE**	Electric Supply Co.	—	Do.
1895	**ALTRINCHAM**	Altrincham Electric Supply Co.	18,750	Do.
1896	**AYR**	Local Authority	20,000	Do.
—	†**BANGOR**	Local Authority	—	Local Authority
1889	**BATH**	City of Bath Elec. Lighting Co.	47,825	Local Company
1894	**BEDFORD**	Local Authority	22,000	Do.
1895	**BELFAST**	Do.	25,000	Local Authority
—	†**BIRKENHEAD**	Local Authority	20,000	Do.
1890	**BIRMINGHAM**	Birmingham Elec. Supply Co.	100,000	Do.
1895	**BLACKBURN**	Local Authority	32,000	Do.
1879	**BLACKPOOL**	Do.	50,000	Do.
1894	**BOLTON**	Do.	40,000	Do.
1891	**BOURNEMOUTH**	Bournemouth and District Co.	*55,000*	Local Company
1889	**BRADFORD**	Local Authority	*65,000*	Local Authority
1892	**BRAY**	Bray Elec. Light and Power Co.	10,000	Local Company
1894	**BRIDLINGTON**	Local Authority	**N**	Do.
1891	**BRIGHTON**	Do.	150,000	Do.
1893	**BRISTOL**	Do.	*90,000*	Do.
1888	**BUCKINGHAM**	Buckingham Elec. Supply Co.	3,500	Do.
1893	**BURNLEY**	Local Authority	22,150	Local Authority
1894	**BURTON-ON-TRENT**	Do.	30,000	Do.
1892	**CAMBRIDGE**	Cambridge Elec. Supply Co.	36,116	Local Company
—	†**CANTERBURY**	Local Authority	—	Do.
1895	**CARDIFF**	Do.	40,781	Do.
1891	**CARLOW**	Milford Electrical Supply Co.	15,000	Do.
—	**CHAGFORD**	Chagford and Devon Elec. Co.	*2,000*	Do.
1890	**CHATHAM**	Chatham, Rochester and District Electric Light Company	*19,500*	Do.
1890	**CHELMSFORD**	Chelmsford Elec. Lighting Co.	18,500	Do.
1895	**CHELTENHAM**	Local Authority	16,000	Do.
—	†**CHESTER**	Do.	1,000	Do.
—	**CHISWICK**	Bourne & Grant Elec. Supply Co.	**N**	Do.
1894	**COATBRIDGE**	Scottish House-to-House Co.	**N**	Do.
1895	**COVENTRY**	Local Authority	20,000	Local Authority
—	†**COWES**	Do.	—	Local Company
	COWPEN	Sanderson & Co.	**N**	Do.
—	†**CROYDON**	Local Authority	—	Do.
1893	**DERBY**	Do.	*30,000*	Do.
1894	**DEWSBURY**	Do.	20,330	Local Authority
1895	**DOVER**	Dover Elec. Supply Co.	*40,000*	Local Company
1892	**DUBLIN**	Local Authority	56,000	Do.
1893	**DUNDEE**	Do.	*35,000*	Local Authority
1895	**EALING**	Do.	35,000	Local Company
1882	**EASTBOURNE**	Eastbourne Elec. Light Co.	44,200	Do.
—	†**ECCLES**	Local Authority	—	Adjoining L. Au.
1895	**EDINBURGH**	Do.	122,072	Local Authority
1889	**EXETER**	Awaiting purch. by Local Auth.	*22,000*	Local Company
1891	**FAREHAM**	Fareham Electric Company	6,900	Do.
1889	**GALWAY**	Galway Elec. Light Co.	8,000	Do.
1893	**GLASGOW**	Local Authority	131,764	Local Authority
—	†**GUILDFORD**	Guildford Electric Supply Co.	1,000	Local Company
1894	**HALIFAX**	Local Authority	40,093	Local Authority
1894	**HANLEY**	Do.	32,363	Local Company
—	†**HARROW**	Harrow Elec. Light & Power Co.	—	Do.
—	†**HARROGATE**	Local Authority	—	Do.
1882	**HASTINGS**	Hastings and St. Leonard's Electric Light Company	52,770	Do.
1892	**HOVE**	Hove Elec. Lighting Co.	56,000	Do.
1893	**HUDDERSFIELD**	Local Authority	49,079	Local Authority
1893	**HULL**	Do.	45,300	Local Company
1893	**KELVINSIDE**	Kelvinside Electricity Company	*27,000*	Local Authority
	KESWICK	Keswick Elec. Light Co.	5,000	Local Company
1893	**KILLARNEY**	Killarney Elec. Lighting Co.	5,300	Do.
1893	**KINGSTON-UPON-THAMES**	Local Authority	23,000	Do.
1894	**LANCASTER**	Do.	25,000	Local Authority
1892	**LARNE**	J. E. H. Gordon & Co. (Limited) (in liquidation)	10,000	Local Company
1887	**LEAMINGTON SPA**	Midland Elec. Light & Power Co.	32,000	Do.
1893	**LEEDS**	Yorkshire House-to-House Co.	76,526	Local Authority
1894	**LEICESTER**	Local Authority	*35,000*	Do.
—	†**LEYTON**	Do.	—	Local Company
1884	**LIVERPOOL**	Liverpool Elec. Supply Co. (awaiting purchase by Corp.)	278,000	Do.
—	†**LLANNELLY**	J. C. Howell (Limited)	—	Do.
1894	**LONDONDERRY**	Local Authority	*15,000*	Do.
	LONDON:—		£	London Gas Co.'s
1890	**Brompton**	House-to-House Electric Co.	102,665	chiefly Gas Light and Coke Co.
1890	**Charing Cross**	Charing Cross and Strand Electricity Supply Corporation	*215,400*	Do.
1889	**Chelsea**	Chelsea Elec. Supply Co.	*118,785*	Do.
1892	**City of London**	City of London Elec. Light Co.	1,100,000	Do.
	County of London	on :—		
—	†**Clerkenwell**	County of London and Brush Provincial Company	—	Do.
—	†**Wandsworth**			
1893	**Crystal Palace**	Crystal Palace District Electric Supply Company	*69,000*	Do.
1894	**Hampstead**	Local Authority	50,000	Do.
—	†**Hackney**	Do.	—	Do.
—	†**Hammersmith**	Do.	7,200	Do.
1896	†**Islington**	Do.	70,188	Do.
1886	**Kensington**	Kensington and Knightsbridge Electric Light Company	200,000	Do.
1885	**London (S.E. & S.W.)**	London Electric Supply Corporation	300,000	Do.
1890	**London (W.C., W. & N.W.)**	Metropolitan Electric Supply Company	*650,000*	Do.
1891	**Notting Hill**	Notting Hill Electric Light Co.	83,982	Do.
—	†**Shoreditch**	Local Authority	14,000	Do.
1888	**St. James and Pall Mall**	St. James and Pall Mall Electric Light Company	237,897	Do.
1891	**St. Pancras**	Local Authority	156,000	Do.
1890	**Westminster**	Westminster Electric Supply Corporation	435,000	Do.
1893	**Woolwich**	Woolwich District Electric Co.	10,000	Do.
	LYNMOUTH	Lynmouth and Lynton Electric Light Company	**N**	Local Company
1893	**MANCHESTER**	Local Authority	210,000	Local Authority
—	†**MONMOUTH**	Local Authority	—	Local Company
1892	**MORECAMBE**	Morecambe Electric Light Co.	6,752	Do.
1892	**NELSON**	Local Authority	*9,500*	Local Authority
1890	**NEWCASTLE-ON-TYNE**	Newcastle-on-Tyne Electric Supply Company	58,500	Local Company
1890	**Ditto**	Newcastle and District Electric Lighting Company	53,060	Do.
1895	**NEWPORT (MON.)**	Local Authority	35,000	Do.
1891	**NORTHAMPTON**	Northampton Elec. Light Co.	20,586	Do.
1893	**NORWICH**	Norwich Electricity Company	32,150	Do.
1894	**NOTTINGHAM**	Local Authority	45,000	Local Authority
1892	**OGMORE VALLEY**	Ogmore Valley Elec. Light Co.	5,000	Local Company
1894	**OLDHAM**	Local Authority	30,780	Local Authority
1895	**OSWESTRY**	Oswestry Elec. Light Co.	3,335	Local Company
1892	**OXFORD**	Oxford Electric Company	65,330	Do.
1894	**PORTSMOUTH**	Local Authority	*80,000*	Do.
1891	**PRESCOT**	British Insulated Wire Co.	10,000	Do.
1892	**PRESTON**	National Electric Supply Co.	*70,000*	Do.
—	**READING**	Reading Elec. Supply Co.	30,000	Do.
1893	**RICHMOND (Surrey)**	Richmond Electricity Supply Company	*21,000*	Do.
1886	**ST. AUSTELL**	Veale and Co.	4,000	Do.
—	†**ST. HELENS**	Local Authority	—	Local Authority
1895	**SALFORD**	Do.	38,286	Do.
1888	**SCARBOROUGH**	Scarboro' Elec. Supply Co.	30,637	Local Company
1895	**SHEFFIELD**	Sheffield Elec. Light Co.	67,370	Do.
1895	**SHREWSBURY**	Shropshire Elec. Light Co.	—	Do.
1891	**SOUTHAMPTON**	Southampton Elec. Light Co.	*20,000*	Do.
1894	**SOUTHPORT**	Local Authority	42,131	Local Authority
—	†**SOUTH SHIELDS**	Do.	—	Local Company
1895	**STAFFORD**	Do.	15,000	Local Authority
1895	**SUNDERLAND**	Do.	25,000	Local Company
—	†**SWANSEA**	Do.	—	Do.
1887	**TAUNTON**	Do.	19,000	Do.
—	**THETFORD**	Thetford Elec. Light Co.	*4,000*	Do.
1895	**TUNBRIDGE WELLS**	Local Authority	25,000	Do.
—	†**WAKEFIELD**	Do.	—	Do.
1895	**WALSALL**	Do.	16,000	Local Authority
	WEYBRIDGE	Weybridge Elec. Supply Co.	**N**	Local Company
1893	**WHITEHAVEN**	Local Authority	19,000	Do.
—	†**WIGAN**	Do.	—	Local Authority
—	†**WIMBLEDON**	Do.	—	Local Company
1890	**WOKING**	Woking Elec. Supply Co.	15,000	Do.
1895	**W'LV'RHAMPTON**	Local Authority	35,000	Do.
1894	**WORCESTER**	Do.	52,000	Do.
1894	**YARMOUTH**	Do.	18,490	Do.
—	†**YORK**	Do.	—	Do.

The above shows that the amount of capital expended in Electric Supply Undertakings throughout the country is as follows :—

By **Companies**	5,618,336
„ **Local Authorities**	2,383,507
Total	£8,001,843

In our issue of January 18, 1895, the total was given as £7,189,173, showing an increase to date of £812,670. But it may be stated that the figures are now much more reliable than hitherto, and, in the case of the Supply Companies especially, the relation of subscribed capital to actual capital expenditure is now more clearly defined. In addition to the above large sum, schemes for the establishment of electric supply stations are under consideration by a number of Local Authorities and Companies (many of whom have already obtained the necessary Parliamentary powers), involving a large outlay, and a glance at the above list will show the number of stations which have come into operation all over the kingdom; and, therefore, what great progress has been made in the popularisation of electricity for lighting and power purposes since January 1, 1892, at which date only 4 Local Authorities and 17 Companies were supplying current.

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or a dozen installations were going on at the same time. If there were six or seven miles between each and 100 steps to climb, as was the case in some of the colleges, and they were expected to look at every bit of wiring that went in, it was clear they would not have much time to look after the Company's work. This was a serious point. If they neglected the work and a fire occurred, the credit of the concern was at once called into question. Looking at it from the personal point of view, he wanted to know where his credit came in. He would like to see the fire insurance companies paying a little more attention to their own business, and leaving the station engineers to pay more attention to theirs. It very often happened that the work was finished before they received the application form, and customers would not allow them to lift up their floors and pull about their walls and ceilings to look at the wiring, and they had to content themselves with a casual inspection and test. They had been shown all sorts of tubes and all sorts of joints and connections, but he could show them just as good things with the old wooden casing. How many of those joints and connections were behind the walls or under the floors? The previous speaker, who had spoken of 200 volts, said some things that were true, and some, he thought, which were not quite true. He should like to see 200 volt lamps, but he was inclined to think that in some cases if 200 volts were turned on the light would not be at the lamps. It would be somewhere else. He was glad to hear at the Board of Trade Conference that a little more power was to be put into their hands; at present they had only to be "reasonably satisfied" that all was right. He was glad to see one clause inserted, that if the insulation fell below a certain point they were bound to cut the installation off. He would cut them off! With regard to the insurance of buildings, at the present time the insurance companies were threatening to raise the premiums on central stations. He wished they would go to the consumers and leave the stations alone. They had spent a large amount of money on iron and steel buildings, with flagged floors and steel and iron supports, and perhaps had not as much wood in the stations as would equal his own weight, and yet the insurance people were going to increase the premiums to 2s. 6d. or 3s. 6d. They were insured at Oxford for over £20,000, and it would be a serious thing for them if the insurance were raised three or four times.

Major-General WEBBER said this question of insurance was one which was coming very close home to them, especially in connection with the fact to which the last speaker had referred, that the fire insurance companies were so irrational as to propose to raise the premiums on buildings which were constructed they might say practically incombustible, while they were overlooking the great fact that electric lighting, when properly carried out, was rendering fire risk much less than it was before. There was a very large field for the electric light which, on account of the practical prohibition of the insurance companies, had not yet been occupied. In all their seaport towns there were great warehouses where the fire insurance went up to from 7s. 6d. to 15s., and in consequence of the owners of those warehouses being told that if they displaced the present means of lighting and put in the electric light they would get no reduction, they did not care to go to the expense of changing. If the insurance companies employed as inspectors men who were thoroughly masters of the subject, no doubt they would reduce the risks on that great mass of buildings, and many of the owners would in that case adopt the electric light, but at present they had no object in doing so. He thought if the insurance companies did not take some steps to reform their ways and to reconsider and study the subject as they ought to do competitors would grow up who would take the trouble to understand the diminished risks due to electric light, and companies would be brought into existence who would insure at a premium considered from that point of view, and in that way as the spread of electric lighting installations proceeded they would get a very large business indeed. This was a matter which the financial and insurance world might well turn their attention to. In connection with all these systems of wiring, he might say that it was even possible to wire their houses in a more simple way than either by casing or tubes, and although it might be that he should be called old-fashioned, he would mention the case of his own house, where electric light had now been in full use for ten years. They carried it out by the conductors being stapled to the face of the wall with saddles 3in. apart, and wherever the lead of the conductor of the opposite pole crossed beneath or above it to reach a point it was simply supported by a little sheet of ebonite made in the shape of a saddle, which provided an insulation of not more than $\frac{1}{8}$ of 1in. These conductors has been painted over, and painted over, but of course had not been subjected to violence, and there had never been a short on any part of them. He did not mean to suggest that they should wire their houses in that way, but pointed it out as a good practical example of wiring which was at the time exceedingly economical, and was more so now. It came out at 18s. per point. The wires were not disfigurements; the decoration was over them and might at any time be removed and the wires replaced.

Mr. W. E. LANGDON said they were all indebted to the authors of the Papers for not only having brought under their notice the special systems advocated in those Papers, but what was more important, for having raised this very important question of wiring. He did not go so far as the authors in their general condemnation of wood casing. Where it was carefully employed it was, in his opinion, calculated still to be of considerable service. There was no question, he thought, that wires encased in metal tubing were safer than those in wooden casing. Still the wooden casing lent itself very conveniently to surface wiring where they had to deal with buildings which were already established. The "factor of cheapness" would always enter in, and hence the cheapest method would be employed to a greater or lesser extent. But there was one point with respect to this wooden casing which he would like to mention for consideration, and that was that the wooden casing was provided with two grooves, one for the positive and the other for the negative wire. These grooves were a certain distance apart. Now, the general practice was to place a screw or nail between these two wires, so that eventually, when the insulation might become impaired, these nails or screws would tend to assist any short-circuit that might happen to come across there. In his opinion the use of any metal between the wires in the casing should be most carefully excluded. A rule has been adopted by himself for the Midland Railway for some time past that where wires were placed above ceilings or under floors only wrought iron tubing should be employed, and that the wooden casing should be only employed subject to approval on the face of walls where it was under observation, and possibly that regulation adopted elsewhere might be of service. It occurred to him that this was not entirely a question of conduit or casing, but one perhaps that had a more important side to it in the question of wiring or joints. He had had pointed out to him recently some samples taken from a large installation. The wiring was carried out by a recognised, trustworthy firm, and one which had had a great deal of experience. A great many joints were dry joints, and he thought he might say that in every instance they were found to be insulated with nothing but adhesive tape. Now, if they got that condition of things with a firm which carried out a work, not a contract, but a work paid for at the cost with a certain percentage thereon, what were they to expect on cheaper jobs where there was a fixed price and where the contractor, of course, desired to keep the cost within the amount of his contract? It seemed to him that there was the crux of the question. How were they to insist on or obtain a better state of things? Mr. Mavor, in his Paper, if he remembered rightly, threw out a suggestion as to the inspection by the fire insurance company, that the several insurance companies should combine together, and should employ a man versed in the matter, who should be able to give his whole attention to it, and so exact a better state of things or cause the rejection of the consumer's connection. Well, let them consider: could that be carried out in all towns? He was afraid it would not be. It was an excellent suggestion, but there were many towns where he feared there would be a difficulty in securing the services of such a man, and, of course, such a man would require to be properly paid. But he would like to suggest whether it would not be more to the interests of the supply companies themselves to institute such a branch, to establish an officer competent for the duty who should be empowered to inspect every installation as it progressed. They might say the supply companies had the power now to reject any installation with which they were not satisfied; but the only means of satisfying themselves at present was by a cursory examination or by testing the connection.

Mr. H. C. DONOVAN said, so far as his experience went, every system was more or less good, if the persons who worked the system had an aptitude for detail. If in putting up an electrical installation proper attention were paid to detail then they would get a good installation; but if they neglected detail in any respect they were liable to create causes of loss of insulation.

Mr. B. H. ANTILL said he would like to be allowed to draw attention to what he believed was the most conspicuous example existing of "open-wiring"—viz., that which was to be found at the British Museum, where the wires were supported clear of the walls on insulators of porcelain. That wiring had, without question, given the fullest satisfaction ever since it was first put up. Referring particularly to Mr. Bathurst's Paper, he found that he deprecated the use of iron pipes for wiring purposes. Yet he admitted, towards the end of his Paper, that his insulating tubes would not be efficiently protected against mechanical injury, unless they were enclosed in iron or steel coverings. There was, so far as he could see, no real difference between such iron-covered tubes and iron pipes lined with insulating material. In either case, however, it would be highly improper to dispense with the employment of well-insulated wire. Concerning the concentric system of wiring advocated by Mr. Mavor, it appeared to him that the curve which Mr. Mavor published with his Paper was misleading. He quite saw the point which he (Mr. Mavor) wished to make regarding the irregular employment of "wiremen," but failed to see that the curve illustrated it. There was one paragraph in the Paper—referring to insulation resistance, which had his full sympathy. Mr. Mavor said: "It is of much greater consequence to obtain a moderately high insulation which may be relied upon to be durable than to have, as can easily be had in a dry building, an insulation resistance of many megohms, which will disappear on the approach of a charwoman and her wash-bucket, or is at the mercy of the first loose slate or a leaky water pipe." That was, he maintained, a principle which should be enforced not only in house wiring, in the wiring of shops, &c., but also in the specifications issued for the cable networks of central electric light installations. The practice of attempting to ensure good and lasting cables by specifying very high insulation resistance defeated its own ends, because a high insulation resistance, as was well known, could be obtained by other means than by quality or by thickness of insulating material. He did not wish to suggest that evening precise terms for a satisfactory cable specification, but his own opinion was that more reliance should be placed upon kind and quality of material and upon thickness of the insulating covering increasing with voltage, than upon hundreds and thousands of megohms. It could scarcely be insisted upon too strongly that a cable having a comparatively low insulation resistance was frequently a better and a more durable cable than one having a much higher insulation resistance, and also that conversely a high insulation resistance was not a proper criterion as to the permanent quality of a cable. There was only one point more to which he wished to allude. There was no doubt in his mind that the system of concentric wiring before them that evening was to all intents and purposes a development of the single-wire system which Mr. John Raworth worked out many years ago in connection with ship lighting, where he used either the ship as return or concentric leads such as described by Mr. Mavor. The experience of the last 10 years had shown them to be thoroughly reliable and satisfactory.

Mr. A. A. C. CAMPBELL SWINTON said that with regard to Mr. Mavor's paper, he thought that some people who were connected with

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the carrying out of electric wiring were of the impression that this concentric system, although very excellent from a mechanical point of view, and very suitable for warehouses and factories, was not suitable for highly decorated houses. He must confess that he was somewhat of that impression himself until recently, but a few months ago he was given an opportunity by Messrs. Mavor and Coulson to see a house in the neighbourhood of Dumbarton, where they had carried out an installation; it was an exceedingly highly decorated house, he might say over decorated, but undoubtedly this system lent itself exceedingly well to the wiring of a house, however much decorated it might be. There were certain advantages in respect to having only one wire practically, the other being insulated, which enabled them to have exceedingly small switches, and to make with great ease switches and fittings which were not unsightly. These points were of great importance where decorative effect was required. There was, however, one great difficulty with regard to the concentric system. It was impossible, in most cases, for contractors to maintain two separate staffs, two separate classes of workmen. If they were going to carry out their work in the ordinary way with wood casing, certainly if high-class work was to be done, a large portion of the staff ought to be of the house carpenter class; if, on the other hand, the work was to be done with the concentric system, they did not want carpenters at all, but something of the nature of a plumber, and men of the same experience were not quite suitable in each of the two cases. This concentric system was applicable to installations where a separate plant was used; it was also applicable where alternating currents with a separate transformer were used; but it seemed, at any rate at present, it was not applicable where the supply was taken from any ordinary continuous current system. He had at the present moment a case in point, where he was met with the difficulty that the Edinburgh Corporation were unable to sanction the use of the concentric wiring, which was otherwise highly desirable, for the reason that the Board of Trade would not allow them to have one of their conductors earthed except at the central station. If they would allow the conductor to be earthed at the feeding point it would meet the case. It appeared to him that where the concentric system was not admissible, wood casing, in the case of dry buildings, really answered very well. In the case of wires that had to be buried in wet plaster he did not think wood casings were advisable, and it appeared to him that iron pipes were worse; he was inclined to think Mr. Bathurst's tubing was an excellent arrangement for that purpose. With regard to the current that small wires would carry without danger, he had made a few experiments in this matter, and found that a No. 3/22 S.W.G. wire, the ordinary sized wire, when used for single lamps in better-class installations, insulated with vulcanised rubber and put in wood casing in the ordinary way, would carry 26 amperes; after running with 26 amperes for half-an-hour, the temperature was only raised to 107°F., and the current density was 13,700 amperes per square inch. He also tried a No. 3/25 wire for 55 minutes, and this, with 26 amperes, got to 242°F., only a little over the temperature of boiling water. He took it to the point at which the temperature did not rise any further. He was not advocating the employment of these things, but was only mentioning them, as he thought there was a great deal of nonsense talked on these points to the effect that they could not use those very high current densities because of the drop in volts. He did not recommend them; but about half those current densities he was quite sure would be absolutely safe. After current had been flowing in this wire for 55 minutes the temperature became permanent, and the current density was 28,900 amperes per square inch. He found that an ordinary flexible cord of 36/38 wire would carry 10 amperes, rising to 150 or thereabouts, quite comfortably; it never got any hotter so long as it was straight. The current density was 25,000 amperes per square inch. The fact was that with very small wires the cooling effect was so great that very high current densities were perfectly safe, but they were not advisable, because of the drop in volts.

Mr. G. S. CORLETT said, having been rather sceptical about this concentric wiring, he had used it on two or three important installations, and was agreeably surprised with one or two points in connection with it. The first was the little difficulty in training workmen to deal with the system. Secondly, the very cheap manner in which the whole job could be done. For example, a job embracing something like 600 16 c.p. lamps in a Lancashire cotton mill cost at an absolute prime cost figure, exclusive of dynamo and switchboard something like 17s. per lamp. He found that they had not the slightest trouble, that an ordinary plumber could in half an hour make a joint as well as the trained men whom they got down to show them all about it. It seemed to him that there was a great deal of unnecessary prejudice about burying their wires in casing. A great deal was said about the desirability of having their wires accessible, but a great many of them had to live in houses still fitted with gas pipes, and he never yet heard of a householder who complained of the inaccessibility of the gas pipes. As to the difficulty of nails being driven into the wire it seemed to him that with this system there would be no trouble at all from faults of that character. So far as his own experience of private installation work went, the present insurance system was little more than a farce. A representative of an insurance company recently called upon him, and something like the following conversation took place:—"I hear you have done an installation for Messrs. So-and-so." "Yes." "I want to know something about it." "What do you want to know?" "Well, I don't know, does it conform to the Phœnix rules?" "Yes, I think so." "All right, good morning! that is quite satisfactory." And the policy was endorsed. Mr. Geipel had alluded to the wickedness of central stations in shoving 200-volt lamps down people's throats. He had been using 200-volt lamps, and he had been waiting anxiously to hear in what the particular wickedness consisted. He never found the slightest trouble in keeping up the installation, and there were no more faults on the 200-volt circuit than on the 100-volt circuit.

The CHAIRMAN (Sir David Salomons) said as several other members wished to speak it would be necessary to adjourn the discussion until the next meeting, but before closing this meeting he wished to say a few words upon the subject before them. As they knew, he had personally very strong views on this question, but he need not express them now. He had always maintained and should continue to maintain that when a man purchased a horse he would not choose that animal except with special regard for the purpose to which he intended to apply it; if he wanted to run a race he would not buy a cart horse. In wiring they must choose their system with a view to the purpose to which it was to be applied, and it would be ridiculous to put down a hard and fast rule to be generally applicable. In some cases it might be perfect, in others it might be expensive and even unnecessary. Something had been said about the inspectors for the insurance companies, and he might give them an instance of an experience of his own. It was not so many years ago since electric lighting was introduced into this country, and he was probably one of the first to have it in his house. When the inspector from one of their greatest offices came down to see the fittings, and he (Sir David) made some reference to cut-outs, the inspector asked him the meaning of the word cut-out. When it was explained to him that the object was to prevent fire he was satisfied and went away. He (the speaker) did not think any inspector would be satisfied with such a brief explanation now; they had been educated, and by that Institution. The object of the Institution rules, now being revised in the most thorough manner, was not that they should be taken as examples for the world to follow, nor was it intended that no installation should be passed unless it complied with those rules, but to show what a perfect installation should be. He doubted if anyone could produce such a perfect installation, although it might be approached very nearly in the case of buildings of a very inflammable character. But they were doing a useful work in showing what could be done in exceptional circumstances. The idea which householders had that everything was right when an inspector has passed a building was quite erroneous because inspectors did not pretend to pass only those installations which were absolutely perfect. If the life insurance companies only passed those men and women who were absolutely sound it was quite clear that they would soon have to close their doors. What they had to consider was the average law of risks, and to assume that a certain number would die and a certain number would not, and that was the course which the fire insurance companies also had to pursue. The chief difficulty in connection with concentric wiring, good as it might be, in many cases, was that the householder should be a man capable of making up his mind in advance, a very difficult thing to do when he had had no large experience with other illuminants and could not foresee what alterations might afterwards be made. With regard to central station insurance he hoped very much that all engineers who had to do with central stations would join together and start some organisation which would deal in a fair way with electric lighting industry. To conclude he sincerely hoped they would be able to find a method of bringing about the good wiring without interfering with the liberty of the subject by fire office inspectors.

The discussion was adjourned until February 13th.

THE INSTITUTION OF ELECTRICAL ENGINEERS AND NATIONAL DEFENCE.

The following circular has been compiled by the Special Committee on National Defence recently appointed by the Institution of Electrical Engineers:—

The Council of the Institution of Electrical Engineers have resolved, "That steps should be taken to render available for purposes of national defence the technical skill of electrical engineers, and that a Committee be appointed with instructions to take such steps as it thinks fit to attain that end," and have appointed the following gentlemen as members of the Committee: The President (Dr. J. Hopkinson, M.A., F.R.S.), Sir Frederick Abel, Bart., K.C.B., D.C.L., F.R.S., Mr. R. E. Crompton, and Major-Gen. C. E. Webber, C.B. (Past Presidents), Mr. H. Edmunds, Mr. R. S. Erskine, and Mr. A. E. Mavor, to whom have since been added Sir Benjamin Baker, K.C.M.G., LL.D., F.R.S., and Prof. A. B. W. Kennedy, LL.D., F.R.S.

It hardly seems necessary to point out in how many ways a practical knowledge of electrical science could be made useful in time of war. Everyone knows that the acquiring of a knowledge of this science is a not unimportant part of the training of Military Engineers. This knowledge electrical engineers already possess, but they have at present no opportunity in time of peace of preparing for the practical application of that knowledge for the purposes of war.

In order to carry out their instructions, it is necessary for this Committee to ascertain what support it may expect from Members of the Institution, and others engaged in electrical industries. Hence the present communication and the following questions are addressed to you. One of the objects of this Committee is to ascertain if there are candidates amongst the electrical engineers to fill the vacancies in the list of Officers. In order to enable you to judge of the matter it may be well shortly to state the existing conditions of service in the various corps, particularly of Military Engineers, which now form part of the Reserve Forces of this country.

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These are divided between militia and volunteers, and are described, with a list of the names of the commissioned officers, in the Monthly Army List, which also gives the various places where those corps are located. With one exception (the Corps of Railway Managers and Engineers) they are formed in battalions and companies, having the usual military organisation. The Volunteer Force is composed of the following arms: Light Horse, Artillery, Engineers (fortress and submarine mining), Rifles, Medical Staff Corps.

The Corps of Engineers (Submarine Mining) is perhaps the arm to which electrical knowledge is most extensively applied at the present time. There exist divisions located on the Clyde, Forth, Mersey, Severn, Tay, Tees, and Tyne. The divisions are in general highly efficient, but there is a lack of officers. The preliminary training of officers requires in all about six weeks' work, which may be spread over two years. The duties of officers include attendance in camp at the headquarters of their division for not less than eight or more than 15 days, and at 48 drills, a full day's work counting as six drills. The advantages are—very interesting and healthful work and an allowance of 10s. a day employed in training or in camp.

In the other arms there is much less need for attendance at a camp which may be remote from the home of the volunteer. The corps of Fortress Engineers is recommended to those who cannot afford time for prolonged attendance at a distance from their residence. The following is a list of the existing regiments of Fortress Engineers: 1st Middlesex, 1st Lanarkshire, Edinburgh City, 1st Lancashire, 1st Newcastle-on-Tyne, Yorkshire (West Riding), 1st (Sheffield), 2nd (Leeds), Gloucestershire 1st (Cheltenham), Cheshire 1st (Birkenhead), 2nd (Railway) Crewe, Denbigh, Tower Hamlets 2nd (East London), Cumberland, Surrey, Hampshire 1st (Portsmouth), Glamorgan, Essex, Devonshire and Somerset 1st (Exeter), London 1st (North), Flintshire 1st (Buckley), Northamptonshire 1st (Peterborough), Durham 1st (Jarrow), Aberdeenshire 1st.

In the case of the militia longer attendance is required in camp than in the case of the volunteers; for example, the militia submarine miners have annually 55 days in camp, and during the first year four months' training. Of this arm there are divisions located at Portsmouth, the Needles, Plymouth, the Thames, the Medway, Harwich, Milford Haven, Western (Severn), the Humber, and Falmouth.

Special Corps.—The modern development of the uses of electricity is certain to lead to its extended application in war time. It is proposed, therefore, subject to the approval of the War Office, to organise and train a special corps of electrical engineers, whose duties will be defined at a later date.

It will further be the object of the Committee to ascertain if the Military Authorities will regard favourably the enrolment of electrical engineers on some such basis as was followed in the case of the railway engineers, by which the services of many who cannot afford the time for organised training, but who are willing to seek certificates of efficiency suitable to their attainments, can be promptly utilised by the War Office in case of national emergency.

This statement will, we believe, enable you to judge which branch of the force you could most usefully join. Will you kindly reply to the questions put on the accompanying form? Later, if you are disposed to take an active part in the movement, you may expect to hear from us further. If you occupy a leading position, superintending the work of artizans, will you also ascertain and inform the Committee how many of these in your employment would be willing to join such a special corps as has been suggested?—On behalf of the Committee,

J. HOPKINSON (President).

1. Are you willing as an electrical engineer to register your name as ready to undergo training, and to serve in case of urgent need?
2. Are you willing to begin training at an early date, and to accept a commission in the Reserve Forces if obtainable, or to join the ranks of a volunteer corps?
3. Which branch of the Reserve Forces do you prefer?
4. Would you prefer to join a special corps of electrical engineers?
   (*a*) As an officer.
   (*b*) In the ranks.
5. Are you at present a member of any volunteer corps?

Red Glass.—Photometrists and others interested in optical research will be glad to know that the firm of Putzler Bros., of Penzig, in Germany, have succeeded in making red pot glass which is very clear and bright, but is opaque to the whole of the blue side of the spectrum, down to the line of the wave length 628. There has hitherto often been trouble in obtaining good samples of red glass for optical-testing work and for obtaining non-actinic illumination.

PROF. RÖNTGEN'S EPOCH-MAKING DISCOVERY.

In the *Zeitschrift für Elektrotechnik* of January 15th, Prof. Boltzmann states his views on Prof. Röntgen's recent discovery under the above title. In a long introduction he reviews the fundamental laws of the wave theory, sums up what has been done in this branch of investigation, and after a *précis* of Prof. Röntgen's experiments (see *The Electrician* of January 24th) he proceeds as follows:—

"The hypothetical luminiferous ether, in which all these wave-motions apparently occur, exhibits a striking analogy to the behaviour of elastic and more especially of gelatinous bodies. These latter are always capable of transmitting longitudinal as well as transverse waves. Hence it has long been suspected that longitudinal ether-waves existed, though they had not been discovered. As neither the phenomena connected with Röntgen nor with cathode rays pointed to transverse vibrations, Röntgen gave it as his opinion, with all reserve, that the waves discovered by him might be the long-sought longitudinal-ether-waves. In all elastic bodies, and especially in gelatin, the rate of propagation of longitudinal-waves is far greater than that of transverse-vibrations. If this be the case also in the luminiferous ether, Röntgen rays, notwithstanding their small period, may be of considerable wave-length. The small period of the waves would explain their fluorescence-exciting property, which apparently becomes most powerful when the vibrations take place at a speed approximating that of the molecular vibration. The great wave-length would explain the ease with which these waves, like Hertzian waves, pass through most bodies. It is to be noted in this connection that the deep tones of the music in a house next door—those, that is to say, of the greatest wave-length—pass through the party-wall much easier than do the high tones. Cathode rays, on the other hand, would seem to be longitudinal waves of extremely short wave-length, resembling Röntgen in the first respect and ultra-violet light in respect of their absorption and wave-length.

"I have already pointed out many possible utilitarian applications of Röntgen's discovery. Its greatest importance, however, consists obviously in the fact that once again we have become acquainted with a new agency. The discovery of Hertzian and of cathode waves gave rise to justifiable excitement. Nevertheless the former are not appreciably different to light waves, and the latter are bound fast within the narrow region of the Hittorf tube, and are on this account but little accessible to science and practice. Röntgen rays, however, are a completely new large-scale phenomenon.

If we remember to what discoveries the investigation of the most insignificant new natural phenomena, such as the attraction of small bodies by rubbed amber, of iron by the lodestone, the convulsive twitches of a frog's leg due to electric discharges, the influence of the electric current on the magnetic needle, electro-magnetic induction, &c., &c., has led us, one can imagine to what applications an agent will be turned which a few weeks after its discovery has given rise to such surprising results. It makes one rejoice to think that in spite of all our discoveries in natural science, the stream of wonderful phenomena still flows on undiminished, and that just within the last few years new sets of phenomena and agencies have been discovered which should afford material for research for decades to come, and the useful applications of which will be witnessed by those who live to see the coming century."

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, January 31st.

KING'S COLLEGE ENGINEERING SOCIETY.

4:15 p.m. Meeting at King's College, Strand. Presidential Address by Magnus Mowat, and a Paper on "Railways."

INSTITUTION OF MECHANICAL ENGINEERS.

7:30 p.m. Annual General Meeting at 25, Great George-street, Westminster. Paper to be read: "Notes on Steam Super-heating," by William H. Patchell.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at the St. James's Hall Restaurant (Banquet Room), Regent-street, W.

MONDAY, February 3rd.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ENGINEERS.

7:30 p.m. Ordinary Meeting at the Royal United Service Institution, Whitehall. Presidential Address by Samuel Herbert Cox.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture III.: "Alternate Current Transformers," by Dr. J. A. Fleming, F.R.S.

TUESDAY, February 4th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "Developments in Gas Engines," by Dugald Clerk.

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The Electrician.

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THE NEW RADIATION.

Are RÖNTGEN'S rays a stream of material particles? or are they ultra-violet waves of extreme smallness? or are they a new kind of radiation altogether? These are the questions which are now being discussed in every physical laboratory in Europe, and probably also by this time in America, Australia, and Japan. A further question is likewise arising—viz., as to whether the rays are, indeed, anything in any sense new; whether they should not more properly be styled LENARD'S rays, if they are to have a name of the sort, for temporary—we hope only temporary—purposes.

How much do we know now that we did not know by the end of 1894? Apparently very little. We had then been told that rays emanated from highly exhausted vacuum tubes, that these rays excited fluorescence strongly, affected photographic plates, could pass readily through aluminium and other light substances, whether metallic or not, but were stopped by a sufficient thickness of sufficiently dense matter, whether it was ordinarily called transparent or not. Shadow photographs were taken of objects on a plate enclosed in a light-tight aluminium box, and differences of transparency were clearly exhibited. The rays were shown to proceed in straight lines, except in so far as objects placed in their path diffused them, as milk and other turbid media diffuse light. The rays were found to discharge electrified bodies upon which they fell, and thus to imitate one of the actions of very ultra-violet light. It was further known that the rays could get out of the vacuum tube not only through an aluminium window, but also, though in less quantity, through glass. On the other hand it was proved that the rays could be deflected by a magnet; and from this circumstance, chiefly, it was argued in this country that the LENARD rays were but an extension of the previously known cathode rays of HITTORF and CROOKES; that they were, in fact, electrified and radiant molecules of matter. This hypothesis was, however, vigorously contested by Dr. LENARD himself, who consistently urged that his rays were ethereal, not material, and that he had discovered a new kind of radiation, the properties of which he endeavoured

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to ascertain by a laborious series of accurate and skilful experiments. These results of LENARD received respectful attention from professed physicists, and the discoverer was vainly urged to come and describe them at the Oxford meeting of the British Association, but the general public took not the slightest interest in them, nor can it be said that the information was ever effectively conveyed to the general public.

A few weeks ago, however, Prof. RÖNTGEN, of Würzburg, happening apparently to possess a CROOKES tube exhausted to the precisely required degree, observed phosphorescence of a striking kind under extraordinary favourable circumstances. Most of the phenomena observed by LENARD were rapidly and independently repeated, and one of the shadow-throwing objects employed was the human hand. Both by immediate phosphorescence and by photography the bones were found less transparent than the muscles, and straightway an application to medicine and surgery was evident, and the daily papers promptly took the matter up and blazoned the discovery abroad.

Prof. RÖNTGEN, like Prof. LENARD, argues that the effects are due to a new kind of radiation; but he further argues that his rays are altogether different in kind from LENARD rays, inasmuch as they are not deflected by a magnet. Hence arises a most interesting scientific controversy, which will lead, in all probability, to much experimenting and to rapid progress, the outcome of which it would be rash at present to attempt to predict.

Meanwhile we must congratulate Prof. RÖNTGEN on the enthusiasm and interest his discovery has aroused amongst the general public—it was the *hand* that did it. A sensational result which at first sounds like a hoax, and which in any case it is safest at first to disbelieve, that is the sort of thing in which the public delights, and for the space of nine days, more or less, will flock to lecture rooms and soirées to hear about and see. And certainly the fact that such numerous applications seem opening out before this mode of prying though visually opaque screens is one of great importance. The discovery is not now a matter of the laboratory and the study, but is one in which the whole world may well feel interested. So long as individuals of the human race continue to professionally inject bullets into one another, it is well to be provided with easy means for inspecting the position of the injected lead, and to that extent aiding the skilled operators whose business and joy it is to extract it. Not only bullets, however, but dislocations, fractures, fragments of bone, needles, and other foreign bodies can no doubt before long be thus inspected *in situ*. With the stethoscope it has been possible to listen to the workings of the interior of the human frame; with the new radiation it is to be hoped that the human frame will become, to skilled vision, something akin to transparent, and that it may become possible to practically see into it as well. Engineers are hoping to be able to detect flaws in pieces of metal by the new radiation's aid, though whether so thick and massive a piece of metal as a screw-shaft will ever be got sufficiently transparent is a question at present unanswerable. Electricians may, perhaps, inspect the interior of standard resistance coils, and observe how the wire is getting on after lapse of time, though perhaps in their case the present electrical method of testing is, after all, the best. They have long been able to spy out faults in buried cables without any kind of visual aid, but it is just conceivable that an inspection of such windings as occur on armatures and the like might sometimes give useful information. Whatever may be the precise degree of novelty attending Prof. RÖNTGEN's discovery, there can be no doubt that he has succeeded in obtaining the rays in a much more powerful and effective manner, and thus providing us with an essentially new instrument of investigation. If the explanation of the rays really lies in the direction which the discoverer himself suspects, viz., longitudinal vibrations in the ether,—vibrations which have been long speculated on but never yet observed,—the discovery will be of transcendent importance. A whole new department of Physics will lie open for investigation—not a new chapter merely, but a new treatise—an unexplored territory comparable in extent with the already partially explored domains of Light and of Heat. It is almost too good to hope that such a discovery as this can be before us, but as we write we learn that Prof. BOLTZMANN leans the weight of his authority in that direction.

DR. HOPKINSON'S PRESIDENTIAL ADDRESS TO THE INSTITUTION OF ELECTRICAL ENGINEERS.

(Concluded from page 415.)

We have supposed that galvanic effects are measured by chemical change, and that the rate of galvanic effect—or, as it is generally called, the electric current—is measured by the rate of chemical change. From a theoretical point of view it would be possible to thus measure electric currents; but for practical purposes other means are adopted—electrometers, galvanometers, electro-dynamometers, and the like. With a description of such instruments and their methods of use I have not the time to concern myself this evening. We must assume that we have the means of measuring C, the galvanic or electric current so called, at any instant, and E, the difference of potential, whether these be great or small, and with any desired accuracy.

We should now be in a position to give a detailed account of galvanic batteries and of electrolysis, and the theory of the distribution of currents in systems of conductors of any form, and we are in a position to place the theory of thermo-electricity upon a thermo-dynamic basis without the introduction of any fresh idea. These, however, I leave on one side, and hasten to consider how the phenomena of electrostatics can be based upon what we have been discussing. There is a broad group of facts very familiar to the practical electrician engaged in laying telegraphic cables of which I have as yet given no account—I refer to the phenomena of capacity. Let us examine a little more closely the statement that I made that if a slip of paraffined paper were interposed between the two parts of a conductor no electrical action would occur. Suppose that, instead of paraffined paper interposed between the ends of a wire we have a very large number of sheets of tinfoil separated from each other by paraffined paper in such wise that we have a great area of tinfoil connected together, and separated from another great area of tinfoil by nothing more than the paraffined paper. If now these two areas of tinfoil are suddenly connected to the poles of a galvanic battery we find that it is by no means true that no galvanic effect will ensue; we find that a galvanic current exists, but that, whilst it begins with a large quantity, this quantity goes on diminishing until, barring the slight imperfection of insulation of the paraffined paper, it becomes *nil*. We find, then, that it is not true to state that paraffined paper cannot form a part of a galvanic circuit; it can form a part of a galvanic circuit, but it does so under completely different laws to the metallic conductor. With the metallic conductor the difference of potential at its two ends depends only on the current which then exists in that conductor, and not at all upon the currents which have previously existed; with paraffined paper, on the other hand, the difference of potential between the sheets of tinfoil depends not at all upon the then current, but entirely upon the currents which have existed since its two coatings were connected together, and the times for which they have existed. A galvanic current may be measured by the rate of electrolysis; being measured by a rate, its time integral will have a perfectly definite meaning, and will be measured by the total quantity of substance which would be decomposed in a voltameter in the circuit. We find that the difference of potential

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between the two coatings of the paraffin condenser is proportional to the time integral of the current since the time at which the coatings were connected together last. The constant ratio of this time integral of current to the difference of potential is called the "capacity" of the condenser. Suppose now that the condenser has been connected to a galvanic battery and the time integral of the current has been measured; let now the coatings of the condenser be disconnected from the battery and be connected together through any instrument for measuring the time integral of current: if this is accomplished with sufficient rapidity for loss by imperfect insulation to be negligible, we find that the time integral in the second case is equal and opposite to that which it was in the first. Here, again, is a difference from conduction in the ordinary sense. If a conductor in which a current has existed be disconnected from the source of current and be connected to any measuring instrument, no return current will be observed. Here, then, we have a new order of facts presented in an extreme case, but in fact, applicable to all kinds of insulators. Suppose we diminish the area of surface of the paraffined paper, we diminish *pro rata* the capacity of the condenser; but even when the paraffined paper is merely interposed between the ends of two copper wires it still will be a condenser having a definite capacity. There is no need to use paraffined paper to form a condenser. Two metallic plates may be insulated and placed parallel to each other; if they be connected one to one pole of a battery, the other to the other, a current will exist for a finite time; if they are now disconnected from the battery and connected to each other through a suitable instrument for measuring the time integral of current, a return current exists for a finite time. Consider now a condenser consisting of two parallel plates of very large area placed near to each other; its capacity varies as the area of the plates, and it also varies inversely as the distance between them—laws precisely analogous to those of conductors. It also, as might be expected, depends upon the material interposed between the two plates. Since the capacity of the condenser varies as the area, and inversely as the distance, whatever be the substance between the plates, there is a constant for every substance analogous to the specific conductivity of the material; this constant is called the "specific inductive capacity" of the material.

That the magnetic effects of the transient galvanic currents in insulators are the same as of corresponding currents in conductors, is a fundamental law at the basis of Maxwell's theory of electro-magnetism; it was, I believe, first definitely propounded by Maxwell, and it is one over which some of the most eminent minds have since contended. You will notice how, if the subject be arranged in the unhistorical, but not unnatural, way I have adopted this evening, this law drops so easily into its place, that its assumption would be almost unnoticed. Why should we assume that the magnetic effects of electric currents in insulators and in conductors are different? By far the most natural assumption is that they are the same.

Maxwell's electromagnetic theory of light—one of the great generalisations of the century—is directly based upon this law. What is this theory? It is simple enough in its character, broadly stated. Suppose you have an electrical disturbance, a transient galvanic current, in any dielectric, this disturbance—assuming the magnetic effects of currents in dielectrics to be the same as in conductors—will be propagated as a wave in directions perpendicular to the direction of the currents. The velocity of the wave can be calculated from purely electrical experimental knowledge; it is 3×10^{10}, if the dielectric be a vacuum. The velocity of light is 3×10^{10}. We know nothing of what light is; we do know that it is a wave, and that the disturbance is perpendicular to the direction of transmission of the light; but what is the ultimate nature of that disturbance we have no idea from the standpoint of the science of light. Is it not infinitely probable that the waves of light are none other than the electrical waves which we know must exist, and must be propagated with the observed velocity of light? And, mark, this theory demands no ether; it merely identifies the phenomenon of light with known phenomena of electricity and magnetism; it demands no knowledge of the fundamental nature of these phenomena, it demands only a knowledge of their laws. Surely Maxwell's generalisation is similar both in kind and in magnitude with the discovery of universal gravitation. Newton showed that the force which caused any body—an apple, if you like—to fall on our earth was the same as the force which kept the planets in their courses. He gave no theory of how that force was transmitted, nor of what, in its inmost nature, it was. He merely identified the two forces as one. So now Maxwell's theory may be shorn of all reference to an ether; it identifies as one the forces whereby light is transmitted and the forces with which we are familiar in our dynamo machines, and shows that they are measurably the same. It does not pretend to say what electricity and magnetism are, or what, if any, is the medium whereby the disturbances on which both depend are transmitted. Whether the postulate of an all-pervading ether be, or be not, a metaphysical necessity, surely it is well for the practical man and the physicist to leave the question to the metaphysician. My point, however, is that the hypothesis of two electric fluids and the ethereal theory of light have rather delayed than accelerated the acceptance of a great generalisation. Let us now return to elementary matters.

I have just stated that the capacity of two large plates near and parallel to each other varies as their area, and inversely as their distance. In what units are we to measure capacity? If we have already chosen a unit of resistance, a unit of capacity must follow from that through the units of potential and current. It would be the capacity of that condenser which, if brought to unit difference of potential, would discharge a galvanic current whose time integral was unit current for unit time. It would be quite natural to define as a unit of resistance the resistance between opposite faces of a cube of a defined substance at a defined temperature, in which case the dimensions of resistance would be the reciprocal of a length. Or, again, we might lay by a piece of wire and carefully preserve it, and say, let that be our unit of resistance. Then resistance would have no dimensions in terms of mass, length and time—it would be a fundamental unit. In either case we should introduce physical constants into our formulæ for electrostatic and electromagnetic phenomena, depending in the one case on the physical properties of the substance chosen, in the other on its actual dimensions. If the history of electrical discovery had followed the course adopted in this discourse, and it had become necessary to fix upon a unit of capacity at the point we have now reached, it would have been very natural to have taken the capacity per square centimetre of two plates at unit distance, the insulating medium being vacuum. We shall see shortly what is the actual electrostatic unit which has been chosen, but the fact is there is nothing specially natural, nothing specially absolute in the choice.

It is a matter of very great interest to know the capacities of condensers of various forms. Let us take, for example, the case of a sphere enclosed concentrically within another sphere. If r_1, r_2, be the radii of the two spheres, the result is that the capacity varies as $\frac{r_1 r_2}{r_2 - r_1}$; if r_2 be very great in comparison with r_1, the capacity varies as r_1. The electrostatic unit of capacity ordinarily adopted as absolute is the capacity of a sphere of unit radius enclosed concentrically in a very great sphere, with vacuum as insulator. From this, remembering that the product of a difference of potential and a galvanic current shall be power in ordinary mechanical units, all other units will follow. Thus time integral of current divided by difference of potential or capacity is a line; therefore conductivity is a velocity, and resistance the reciprocal of a velocity. Difference of potential multiplied by current is power, and has dimensions $M L^2/T^3$, but potential divided by current has dimensions T/L; therefore current squared has dimensions $M L^3/T^4$, and current $M^{\frac{1}{2}} L^{\frac{3}{2}}/T^3$, and so on.

Again, the capacity of two plates, area A, distance x, can be deduced from that of two concentric spheres at a small distance apart: it is $A/4\pi x$ in these units.

We may now prove that mechanical forces must exist between the plates of a charged condenser. Let a condenser be formed of two parallel plates of area A at a distance of x from each other, the distance x being capable of variation; let the condenser be charged to a given difference of potential and then insulated, and the position of the plates in relation to each other varied. If the condenser be then discharged, it is found, first of all, that

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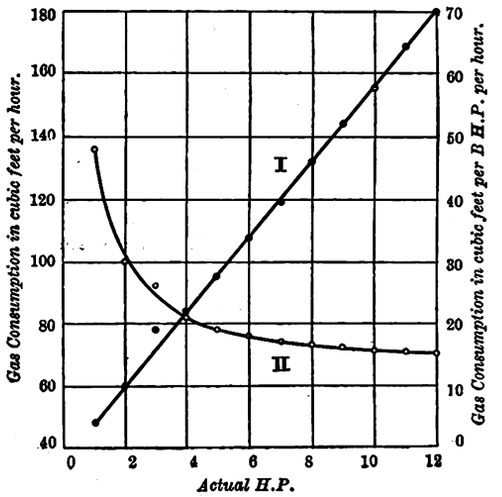
the total discharge is the same, however the position of the plates be varied. Suppose now that the condenser be charged to a difference of potential E, and a quantity, or time integral, of current Q, the work done in so charging the condenser will be $\frac{1}{2}$ E Q. Let now the condenser be insulated, and the distance of the plates increased to $x+\delta x$: the capacity of the condenser will be diminished in the ratio $x/(x+\delta x)$; and therefore, since the quantity remains the same, the difference of potential will have increased to $E(x+\delta x)/x$. Now discharge the condenser. The work done by the discharge will be $\frac{1}{2} E Q (x+\delta x)/x$, or an amount of work $\frac{1}{2} E Q \delta x/x$ greater than was done in charging the condenser. This work must come from somewhere. The only way in which it can be introduced is by the work done in separating the plates from each other. To increase the distance between the two plates by an amount δx therefore requires that we shall do mechanical work $\frac{1}{2} E Q \delta x/x$ upon the plates. This mechanical work is done through a distance δx, therefore a force must be exerted in separating equal to $\frac{1}{2} E Q/x$; hence it follows, as a matter of necessary consequence from the laws of the capacity of conducting surfaces in the presence of each other, that those surfaces shall when charged act mechanically upon each other; and the amount of mechanical force is determined.

Now $E \cdot \frac{A}{4\pi x}$ is equal to Q, hence the force between the plates is $2x\frac{Q^2}{A}$. Let us now suppose that matter is laid upon each plate of density $\frac{Q}{A}$, and that the matter on one plate attracts that on the other plate with a force varying as the inverse square of the distance: the resultant attractive force between the plates is exactly $\frac{2\pi Q^2}{A}$; hence we should accurately express the facts of attraction of two plates if we said there is on each plate a charge of electric substance, and every particle of substance on the one plate attracts every particle on the other with a force varying inversely as the square of the distance. But that the facts can be so expressed is no evidence that any such electric substance exists.

I do not propose to touch on electromagnetic and magnetic phenomena; I would only point out this: Just as electrostatics has been based on action at a distance between hypothetical electric fluids, so magnetism has been based on the action at a distance of hypothetical magnetic fluids. There can be no doubt that the science could be easily rearranged, and that the phenomena of electro-magnetism could be made fundamental, and that the facts concerning permanent magnets could be made subsidiary thereto, exactly as we have deduced this evening the facts of electric attraction from the phenomena of current-electricity. I believe that in the future this is the way the science must be arranged for practical men. They are but little concerned with the attractions between charged spheres and the like, and very much concerned with the laws of currents and differences of potential and capacities. The theory of permanent magnets has for the modern electrical engineer only a general interest, but the laws of magnetic circuits and induction therein are all-important. It would seem that the subject needs rearranging, and that that which is most important should be put most prominently forward. I even venture to think that this would be no loss to pure science; we should see with increased clearness how little we know what electrical phenomena really are, and how much we know of how electrical laws work. We should see how much there is that is arbitrary and conventional, and by no means absolute, in the system of units we have adopted. The science of electricity is so essential to the practical electrical engineer that it should be arranged so that he can learn in logical order what he most wants to know. In what I have briefly indicated, there will be something which is trite to all, and something, perhaps, not easy to comprehend when stated too shortly. My aim has been rather to excite in your minds discontent with the way in which the science of electricity is usually arranged, in the hope that such discontent may take an articulate form and become a demand for something more convenient for your particular purpose. When the demand becomes clear, it will not be long before it is supplied.

THE ECONOMY OF GAS ENGINES.

The accompanying table and the diagrams plotted from it are based upon particulars of a series of gas engine trials, which were published by Mr. Nelson W. Perry in a Paper on "The Storage Battery or the Gas Engine as an Auxiliary," read before the American Institute of Electrical Engineers. The interest in the trials lies mainly in the fact that they furnish a complete account of the consumption of a small gas motor for all loads below that at which it was rated. Unfortunately, the type of engine is not stated in the Paper, nor the manner of reducing the consumption at reduced loads. In the diagram, Curve I. shows the total consumption of the engine, in cubic



feet of gas per hour, and Curve II. gives the gas consumption in cubic feet per brake horse-power per hour. The observed results are shown by the circles on the curves. It will be seen that the results are somewhat below the rates of consumption which would be obtained in ordinary practice, but the general types of the curves are probably not altered on that account.

Trials of a 12 B.H.P. Gas Engine.

Actual horse-power.	Gas Consumption.	
	Cubic feet per hour.	Cubic feet per brake horse-power per hour.
12	180·0	15·0
11	168·3	15·3
10	155·0	15·5
9	144·0	16·0
8	132·0	16·5
7	119·0	17·0
6	108·0	18·0
5	95·0	19·0
4	84·0	21·0
3	78·0	26·0
2	60·0	30·0
1	48·0	48·0

THE ELECTRIC LIGHTING OF MELBOURNE.

To the September, 1895, number of the *Cosmos Magazine*, an Australian literary journal, Mrs. Charles Bright contributes an interesting little article on "The Electric Lighting of Cities," in which she has taken the lighting of Melbourne as a text upon which to express her advocacy of municipal control of such matters. Incidentally, we learn a good deal of the peculiarities of electric-lighting systems at the Antipodes, and it is interesting to contrast these with our boreal methods. We are assured that, so far as the southern hemisphere is concerned, Melbourne has led the way; and it must be gratifying to the ratepayers of the Victorian capital to hear that the balance sheet shows that they "have not only a light of six times the power of the superseded gas, but at this early stage, with an assured saving of almost £1,000 a year over the

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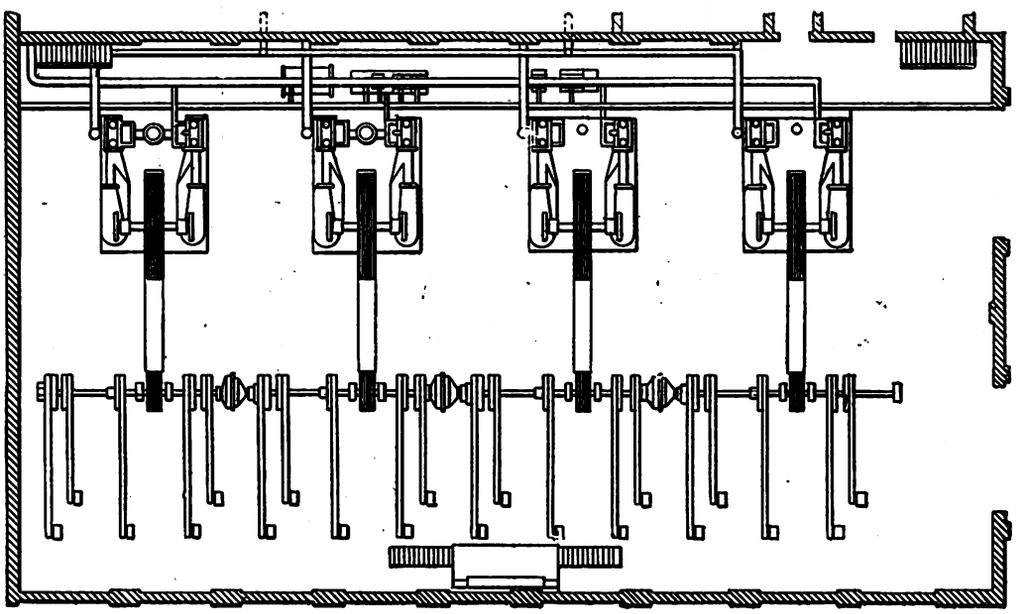
former gas bill." This success should be all the more gratifying from the fact that it is obtained with a type of station which every central-station engineer in this country would characterise without hesitation as antiquated; and we may point out that, however less costly than gas the Melbourne station may be, by comparison with the modern type of English station it cannot but be sadly inefficient. To make this point clear, we will turn for a more detailed description of the station to a Paper read by Mr. A. J. Arnot, the electrical engineer to the Melbourne City Council, before the Victorian Institute of Engineers, in 1894. The accompanying plan of the machinery room will also enable an idea of the Melbourne system to be obtained. The following is an abstract of Mr. Arnot's description :—

"The buildings consist of an engine and dynamo room, 138ft. by 78ft., boiler house and stokehole 84ft. by 37ft., coal bunkers, testing room, stores, offices, fitters' shop, and apartments for resident engineer. The system adopted for lighting the streets of Melbourne is known as the continuous-current series arc and incandescent, favourably known and well tried in America and in some parts of Great Britain. The streets to be lit are those within the city limits, which embrace an area of 4,700 acres. Arc lamps of 1,200 nominal candle-power are used in the main thoroughfares, while incandescent lamps of 20, 25, and 32 c.p. are erected in the lanes. The generating station is situated at a point nearly equi-distant from the two main extremities of the city. The site is high enough to be well out of the reach of floods, and at the same time not too far from the river Yarra to prevent its water being used for condensing purposes, and is also conveniently situated to wharf and railway for the delivery of coal. A plan of the generating station is attached, of which the following particulars may be interesting: The plant is laid out in four sections, each complete in itself. Three of these are sufficient to light the whole of the city, the fourth being at all times a stand-by in the event of any part of one section failing. A section consists of one 250 H.P. boiler, one 300 I.H.P. engine, one 30ft. length of shafting, five 50-light arc dynamos, and one 2,000 8 c.p. incandescent lamp dynamo (this last to be erected). The boilers consist of four water-tube, Babcock and Wilcox manufacture. The heating surface of each boiler is 2,823 sq. ft., and the grate surface 51 sq. ft. These boilers are now so generally and favourably known amongst engineers, that a description of them from my pen would be out of place. They are fed by steam pumps of the direct-acting duplex type two in all, each of 3,000 gallons per hour capacity; one pump being, therefore, sufficient to feed three boilers. There are two independent delivery pipes, each boiler being connected to both of them, and the connections to pumps are so arranged that by a manipulation of valves either pump may be connected to either delivery pipe. The suction pipe may be fed from three distinct sources: 1st, hot well; 2nd, storage tank of Yan Yean water, capacity 48,000 gallons, situated under the coal bunkers; 3rd, from Yan Yean direct. The feed water is forced through an economiser situated in the flue, having a total heating surface of 3,750 sq. ft., or may if necessary be forced direct to the boilers. The economiser is divided into two parts, so that either half or whole may be used. Before the flue gases enter economiser, and after they leave same, the temperature is recorded by pyrometers. A draught gauge is fixed in the flue, as is also a test-tube connection for sampling the gases. On the feed-water pipes on either side of the economiser thermometers are attached. The main steam pipe is on the principle of the ring of steel, 10in. and 8in. diameter, cast-iron flanges, copper bends and expansion pieces. Branching into the main pipe on the boiler side are four supply pipes, and on the other or engine side are four connections to high-pressure cylinders. Each branch has its own valve. The ring has two valves between the supply-steam and delivery-steam connections, for use in the event of a part of the steam-pipe service becoming unusable. The exhaust main, which consists of a 12in. cast-iron pipe, runs the whole length of the building under the floor, as shown by sectional drawing. Branching into it are the exhaust pipes from the four engines. This exhaust main is connected by valves to two surface condensers, each capable of condensing the steam of three engines. The main exhaust is also led into the smoke stack, when by the opening of a valve, should necessity arise, the steam may exhaust into the atmosphere. The condensers are situated below the engine-room floor. Alongside each condenser is a separate circulating and air pump. The circulating pumps take their supply from two large tanks underneath the dynamo room, each tank being capable of holding 125,000 gallons of water. This water is pumped up from the River Yarra by a compound duplex direct-acting pump of 50,000 gallons per hour capacity. The pump is situated in the Corporation Fish Markets, taking steam from the refrigerating plant boilers, and is attended to by the engine driver in charge of that plant. The distance from the lighting station to Fish Market is 900 yards, and the difference in elevation of low-water mark and level of tank is 39ft. The depth of water in storage tanks is indicated by floats connected to electric alarms, which ring when tank is full or contains only 2ft. of water. The overflow from surface condensers is into the main drain, which to the station is gas tight, as are also the walls of storage tanks. The storage tanks are ventilated by pipes in outer wall of building. The air pumps deliver into a hot well situated over the flues. The engines, which are four in number, are of the horizontal compound surface condensing type, fitted with the Rowland and Richardson's patent trip valve gear. The high-pressure cylinder is 15in., and low pressure 26½in. diameter, the stroke being 3ft., and the number of revolutions 12 per minute. The flywheel is 14ft. in diameter. Each engine drives on to its own section of 6in. shafting by seven 6¼in. ropes. The receiving pulley on shaft is 5ft. 7in. in diameter. Between each section of shafting is a patent friction and claw clutch combined, so that, should occasion arise, any engine may drive any section of shafting. There are at present ten dynamo pulleys on each set of shafting, five being fast and five loose. These pulleys are 5ft. 7in. diameter with 8in. face. Double leather belts 7in. wide are used to drive the arc machines. On each section of shafting space is left for 100 H.P. high-tension alternating-current dynamo, for which tenders are now about to be called. These alternators will be sufficient for the present demand for light, and it is proposed, with an increased demand, to extend the building for alternating plant, and then erect engines and alternators coupled direct for incandescent lighting, and the spare 400 H.P. on the arc-light plant could be used for further extensions or increased lighting in the streets, when the cost of maintenance will permit of it. The arc dynamos are of the well-known Thomson-Houston type, of 50 arc light, or 250 20 c.p. series incandescent. The armature is of the new type lately introduced by the manufacturers known as the sectional coil armature, and is a great improvement on the old style of spherical armature. There are 30 coils on each armature, 10 being coupled together in series. The dynamos, 20 in all, were bedded on top of the large storage tanks used for condensing purposes. The roof of these tanks consists of 4½in. brick arches, with a layer of concrete varying in thickness from 4in. to 18in. The cables from the dynamos are led beneath the flooring in 'compo' pipes, which are filled in with bituminous compound, to the controllers on the wall opposite each dynamo, and from these controllers along the wall to the switchboard. The switchboard is at an elevation of 8ft. from the floor, access to which is by a two-way staircase.

"As is too well known, the overhead system of conducting the cables has been adopted throughout. The great cost of undergrounding the whole of the reticulation was prohibitive, although in the near future I look forward to the placing of both the electric light leads and telephone wires underground in the principal streets. The poles used for the carrying of



Melbourne Electric Supply Station.—Plan of Machinery Room. Scale, 1in. = 24ft.

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the cables are all of box or red iron bark of two sizes, 30ft. and 35ft. long. The 30ft. poles are fixed five arms in some cases, and two in others, the 35ft. poles having generally seven arms, with the exception of a few close to the lighting station, which have nine and ten. The maximum distance between the poles is 53 yards. The spanning of the streets by steel cable and suspending the lamp in the centre was objected to by the Electric Light Committee as unsightly, the erection of wrought-iron girder work as too costly, and the use of extension brackets as undesirable, owing to the necessity, if that system were adopted, of placing all the lights on one side of the street to prevent contact with the telephone wires. The system adopted was the only one left that was possible—viz., the placing of the arc lamps on top of lighting pillars on alternate sides of the street.

"The incandescent lamps are of the Sawyer-Mann type, taking in all cases the arc current of 6·8 amperes. They are so constructed that, should the filament break, the current may pass on by either the fusing together of the platinum wire of the lamp, or the burning through of a thin piece of paper inserted between the two poles of the lamp within the socket. The height from the ground of the incandescent lamp is 14ft. Some circuits in the city have as many as 120 32 c.p. incandescent lamps and 10 arc lamps in series."

Here we have a station which, whatever its striking merits, consists of no less than 20 dynamos driven by four steam-engines, not merely by belts and ropes, but also with intermediate counter shafting. We hope this is not a fair sample of antipodean supply stations; indeed, we are sure it cannot be, for the colonies are as well aware as engineers in this country of the enormous reduction in efficiency which such a primitive system must inevitably involve, not to mention the equally enormous increase in the cost of labour and repairs. We can only hope that the Melbourne authorities will apply the annual surplus of £1,000 to a scheme for promptly replacing their present antiquated plant by machinery of an efficient modern type. "The Melbourne City Councillors," we are told, "have erected an electric lighting station of so complete and extensive a character that there is nothing like it, so experts say, in the Southern Hemisphere." Perhaps the Southern Hemisphere ought to be very glad.

NOTE ON THE MEMOIR OF HERR JAUMANN, ENTITLED "LONGITUDINAL LIGHT."*

BY H. POINCARÉ.

Herr Jaumann has recently published in the *Proceedings* of the Vienna Academy† a work full of ingenious ideas, in which he attributes cathode rays to longitudinal vibrations in the ether. The experimental foundation of his theory has given rise to a polemical discussion, in which I do not wish to take part. I only desire to make some remarks on the subject of his calculations and the consequences he thinks can be deduced from them. Herr Jaumann assumes that in rarefied gases the dielectric power ε is variable, and he thus arrives at the following equations, representing the electric oscillations in such a medium, and which I reprint in Hertz notation :—

$$A\left[\varepsilon_0\frac{dX}{dt}+X_0\frac{d\varepsilon}{dt}\right]=\frac{dM}{dz}-\frac{dN}{dy},$$

$$A\left[\varepsilon_0\frac{dY}{dt}+Y_0\frac{d\varepsilon}{dt}\right]=\frac{dN}{dx}-\frac{dL}{dz},$$

$$A\left[\varepsilon_0\frac{dZ}{dt}+Z_0\frac{d\varepsilon}{dt}\right]=\frac{dL}{dy}-\frac{dM}{dx}.$$

A is the reciprocal of the speed of light, X Y Z and L M N the components of the electric and magnetic forces; ε is the dielectric coefficient, ε_0 the mean value of this coefficient; X_0 Y_0 Z_0 the mean values of X Y Z; dX/dt is very small compared with X_0 and $d\varepsilon/dt$ with respect to ε_0. The variations of ε are given by the equation :

$$k\frac{d\varepsilon}{dt}=\frac{d\varepsilon_0 X}{dx}+\frac{d\varepsilon_0 Y}{dg}+\frac{d\varepsilon_0 Z}{dz}=0,$$

where k is a constant.

The equations then become :

$$A\left[\frac{d\varepsilon_0 X}{dt}+\frac{X_0\theta}{k}\right]=\frac{d}{dz}-\frac{dN}{dy},$$

$$A\left[\frac{d\varepsilon_0 Y}{dt}+\frac{Y_0\theta}{k}\right]=\frac{dN}{dx}-\frac{dL}{dz},$$

$$A\left[\frac{d\varepsilon_0 Z}{dt}+\frac{Z_0\theta}{k}\right]=\frac{dL}{dy}-\frac{dM}{dx}.$$

If we differentiate the first with regard to x, the second with regard to y, and the third with regard to z, and add, noting that

$$\frac{d\theta}{dt}=\frac{d}{dx}\frac{d\varepsilon_0 X}{dt}+\frac{d}{dy}\frac{d\varepsilon_0 Y}{dt}+\frac{d}{dz}\frac{d\varepsilon_0 Z}{dt},$$

we get

$$A\left[\frac{d\theta}{dt}+\frac{1}{k}\left(\frac{dX_0\theta}{dx}+\frac{dY_0\theta}{dy}+\frac{dZ_0\theta}{dz}\right)\right]=0.$$

This equation shows that cathode rays, instead of being propagated in straight lines, should follow the lines of force. On the other hand, they would not be deflected by a magnetic. Herr Jaumann has indeed shown that the direction of the plane of the wave should be deflected by a magnet; but it would not be the same with the direction of the ray. In any case, therefore, Herr Jaumann must modify his hypotheses if he wishes to take all the facts into account.

* From the *Comptes Rendus*, No. 23, 1895.

† See *The Electrician*, January 24, p. 417. Abstract

CORRESPONDENCE.

THE BERRENBERG VACUUM PUMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the note in your Editorial columns for January 26, 1896, you asked the question how far a first-rate vacuum was necessary for commercial glow lamps. Well, as a filament glowing in the open air takes 31 watts per candle, one enclosd in a chamber from which 90 per cent. of the air had been pumped out, takes 15 watts per candle, and when the pressure has been reduced to about $\frac{1}{100000}$th of an atmosphere it only takes 4 watts per candle, it appears obvious that increasing the vacuum increases the efficiency of the glow lamp, and thus reduces the cost for power during the whole of its life. This is so far recognised that it is usual for manufacturers of 16-c.p. lamps to expend 15 per cent. of the cost of construction in producing the vacuum, while in the case of 50, 100 and 300 c.p. lamps the cost of pumping is as much as 50 per cent. of the total cost of manufacture. Of this I am certain. I have been engaged for years in exhausting lamps on a commercial scale with various kinds of mercury pumps.

Only one, therefore, who is quite unfamiliar with the details of glow-lamp construction could have written the following sentence in your "Editorial Note": "If a philanthropic inventor came round and exhausted lamps for nothing it would make little or no perceptible difference in the price of the lamps."

Prof. Ayrton is quite familiar with the difficulties of using the McLeod gauge, and that is why in his report the readings of the McLeod gauge are translated into "Approximate pressures in atmospheres." He is also well aware that opening a lamp bulb under mercury only gives a rough idea of the goodness of the vacuum in the lamp, but he feels certain, from the precaution he took in making the tests, "that the combination of pumps, as erected at No. 4, Huggin-lane, is capable, in 15min., in creating a vacuum as *good* as that in the best, and *much better* than that in the worst, of the glow lamps he examined; and that it is capable, in 20min., of creating a vacuum *much better* than that in *any* of the lamps he had broken under mercury."

What other means of testing vacua do we possess? The spark test is but a very rough one at the best, and cannot be applied to lamps exhausted by different methods, as the residual gases are of different natures, and therefore give different colours to the sparks. Another test is the coolness of the globe while in use; well, lamps exhausted on my Metallic Vacuum Pump are much cooler than those exhausted by mercury pumps.

Perhaps, however, the writer of the note in *The Electrician* will indicate exactly how *he* would test the vacuum in a commercial glow lamp and compare it with the vacuum in another lamp.

The writer's statement that "metal is impervious to air" is also quite contrary to my experience, for I have found that all metals, even hammered steel, allow air to pass through them. Therefore, an oil jacket throughout the whole system is absolutely necessary if a high vacuum is to be produced and maintained in metallic pipes.

With reference to the suggestion on the part of the writer that the pump is not novel, I am satisfied to abide by the

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independent reports of Mr. Fletcher Moulton, Q.C., and Prof. Ayrton.

For the last sentence I must give *The Electrician* credit. It says: "To exhaust lamps well is far more important than to do them cheaply." But I have shown by four years' actual working that with the aid of my pumps incandescent lamps can be exhausted *both* well and cheaply.—Yours, &c.,

ADOLPH BERRENBERG.

[Mr. Berrenberg quite fairly asks us to state how we should make comparative tests of very high vacua, since we cannot put our trust either in the McLeod gauge method or the air-bubble method. Had we known of a really reliable method, we should have given Mr. Berrenberg the benefit of our knowledge last week. The point is that, as lamp-makers well know, the high vacua given by the McLeod gauge are as often as not more apparent than real, and cannot, therefore, be brought forward as irrefragable evidence of the vacuum-creating power of one pump as compared with that of another.—ED. *E.*].

LEGAL INTELLIGENCE.

Hall v. Alabaster and Co.

This was an action brought in the High Court before the Lord Chief Justice on Monday last, by Mr. Henry Cuthbert Hall, electrical engineer, against Messrs. H. Alabaster, Gatehouse and Co., to recover damages for an alleged libel in the *Electrical Review* (of which they are the proprietors and publishers) on April 26th, 1895, in an article headed "Storage Battery Testing Extraordinary," which discussed a report by the plaintiff upon a certain type of storage battery.

The plaintiff alleged that the defendants meant and intended to convey by the article referred to that he was ignorant and incompetent as an electrical engineer, and that he was not capable of testing a storage battery, or of making a reliable report thereon; that he was not an expert electrical engineer, and that his report was not made honestly, but contained untrue, reckless and misleading statements, made by him with a view to persuading persons to take up the manufacture to which the same related, and with the object of disparaging the manufacture of a rival invention.

The defendants, by their defence, while admitting the printing and publishing of the words complained of, denied the plaintiff's contentions. They also alleged that the words complained of, in so far as they consisted of matters of opinion, were fair and *bonâ fide* comments upon matters of public interest which did not exceed the limits of fair criticism, and which were printed and published *bonâ fide* and without malice. They also further pleaded that, in so far as the words complained of consisted of matters of fact, they were true in substance and in fact.

Mr. Lawson Walton, Q.C., M.P., Mr. Scott Fox, and Mr. Oppé appeared as counsel for the plaintiff; while Mr. H. H. Asquith, Q.C., M.P., and Mr. Eldon Bankes represented the defendants.

Mr. LAWSON WALTON, Q.C., in opening the case, said that the plaintiff was an electrical engineer, and the defendants published the *Electrical Review*, and the plaintiff by his action sought to recover compensation against the defendants for a publication which reflected both on his professional conduct and upon his professional integrity. The issues sought to be raised were (1) whether the criticism to which the defendants had subjected the plaintiff was fair, and (2) whether the statements on which they founded the criticism were true in relation to the plaintiff's action and in relation to the experiments which he described. Mr. Cuthbert Hall was a young man who had been for some years qualified as an electrical engineer. He had given considerable attention to electrical storage, and he had pursued his researches with such success as to obtain some degree of eminence in his profession. He was one of the arbitrators attached to the London Chamber of Commerce in connection with the electrical department, the editor of an electrical trade journal, and he had acquired a professional connection which was to him the source of a professional income on the continuance of which his commercial prosperity depended. In 1894 Mr. Hall was invited by Mr. Higgs to conduct certain tests of a new storage battery which Mr. Higgs was interested in, and he undertook to investigate the scientific claims and merits of this battery, which he would call the International Electrical Storage Battery. For that purpose he was furnished with I.E.S. batteries and had placed at his disposal the works of the I.E.S. Company. These experiments lasted for a considerable time, and while they were in progress Mr. Higgs was furnished with the results. After some little time Mr. Higgs suggested and Mr. Hall accepted the suggestion that the battery of the Electrical Power Storage Company, known as the "E.P.S." battery, should form the standard of comparison. That was convenient and fair; convenient because the E.P.S. battery was known to every engineer, and fair because the capacities and various powers of the E.P.S. batteries were all published in the catalogues of the E.P.S. Company, and, therefore, ready to the hand of anyone familiar with the subject. It became necessary to tabulate the results obtained, and Mr. Hall having arrived at certain figures, at the request of Mr. Higgs embodied the results of his experiments in a letter, or report, which he sent to that gentleman. The learned counsel read the report, and went on to say that it was given to Mr. Higgs, and was not a public report. How it got into the hands of the defendants Mr. Hall could only speculate. Mr. Higgs had it and said he sent copies to a few friends of his. By some means the defendants got hold of this memo., and having got it, they thought it afforded an opportunity for smart writing at the expense of the youthful engineer who had made these experiments. It was a communication intended to be read by and guide the action of certain gentlemen who had engaged Mr. Hall, and who had themselves seen the way these tests were being carried out. The defendants having got hold of this report, proceeded to indulge in a little smart and slashing writing, in which Mr. Hall's reputation as a man of honour and a scientific man were scarified, as would be seen from the libel. The learned counsel then read the libel, and contended that it suggested that Mr. Hall did not possess the most ordinary capacity for conducting a professional investigation; that he was reckless and unskilful; that his results were worthless, and that the mode in which he stated them would damn any invention, and that he had unscrupulously allowed himself to be the tool of a man who was seeking to foist on the public a worthless invention.

The PLAINTIFF, examined by Mr. Lawson Walton, said that he was a consulting engineer in connection with electricity and electrical appliances; an associate of the Institution of Electrical Engineers and editor of *Electrical Industries*, and one of the arbitrators in the London Chamber of Commerce in the Electrical Section. Although he had only been in practice since 1892 as a consulting engineer, his experience dated from 1886. He had paid considerable attention to storage batteries. In 1894 he had a conversation with Mr. Higgs with reference to a battery in which he was interested, and Mr. Higgs made various statements to him with regard to its capacity and the fall of electrical pressure. He thought it very improbable that the cell had the capacity which Mr. Higgs stated it to have, and upon his telling Mr. Higgs his opinion the latter told him that he would send cells for him to test. In May, 1894, Mr. Higgs sent him two cells to test. After he had made a preliminary test, in May, 1894, and finding that the cell had very extraordinary capacity, it was arranged that he should make a series of elaborate tests, and the tests so made should be made the subject of a Paper which he proposed to read at the Institution of Electrical Engineers. His remuneration was to be 25 guineas. Having made these arrangements 11 cells were provided for him at the works of the I.E.S. Company, at Euston-buildings, London, N.W. That was about the beginning of November, 1894. The 11 cells were all arranged in series, each cell having three plates in all, one positive and two negative. Before he began he found that the cells were in working order. He began with low rates, and charged and discharged at those low rates some considerable time, and then the rate was raised step by step. The result was that the cell bore the high rate. He kept notes of the tests, and Mr. Higgs was shown some of the curves from time to time. Mr. Higgs then wished a comparison made with some existing battery in the trade. The battery he took was the "L" type of battery referred to in the catalogue issued by the E.P.S. Company, which was the most favourable in the point of high rate of discharge and high capacity combined. In response to Mr. Higgs' wish he made out figures showing the results of the work of the new battery as compared with the published capacity of the old battery. In comparing these two batteries he did not consider that it was an essential or important feature to give the absolute size of the old battery with which the comparison was made. He furnished Mr. Higgs with the results of his tests in a letter which he wrote to him on March 21, 1895. For the purpose of comparison he reduced the areas of the I.E.S. cells to square inches, and the areas of the E.P.S. cells to square inches, and having done so, he compared the rate per square inch of the one with the rate per square inch of the other. He considered that perfectly intelligible and perfectly fair. There was no ground for the suggestion that the I.E.S. cells suffered injury at the high rates. The discharge showing the result was not an isolated experience. The discharge was repeated over and over again until the same conditions were reproduced. After that he felt justified in saying that the cell had a certain capacity at those rates. He tried the E.P.S. at 10 times the maximum allowed by the makers. He did not force the I.E.S. cells to their utmost maximum. He kept to the 10 per cent. for the potential, because he was accustomed to consider that the maximum at which the cells should be discharged. The report was dictated by him and type-written and then sent to Mr. Higgs. It was not prepared by him with a view to general publication He knew that Mr. Higgs was interested in the cell from the beginning.

By His LORDSHIP: He did not know that Mr. Higgs wanted the figures for the purpose of showing them. Mr. Higgs did not tell him that he was going to show them. At the time that Mr. Higgs asked him for the results he thought they were only for his own personal information. In addition to the figures which appeared in the report he had his own notes and own curves and own data he had kept for the purpose of preparing a report on the subject. He did not continue the tests beyond a certain time because the works were removed to Woking. When he first began the experiments he had meant to make very elaborate tests. He gave Mr. Higgs such results as he thought reliable up to that time. He had meant to test the resistance of the cell and make the report of scientific interest. He was not called upon by the defendants to show the results to them, and he received no communication from them to the effect that they were going to criticise the report, nor did they ask his permission to do so. He had no knowledge that Mr. Higgs had parted with it or shown it to anybody. He did not wish the report to be published as a scientific report. Mr. Higgs was familiar with the tests he had employed. He emphasised to Mr. Higgs that isolated tests were valueless. He explained to him that he had taken repeated charges and discharges. The size of the cell was absolutely immaterial. There was no ground for the suggestion that he had suppressed the fact that the cells had been damaged. The cells were not damaged. The experiments lasted altogether, continuously, for three months. He had absolutely no sort of interest in the success of the battery in question. It was untrue to say that his results were erroneous or reckless.

Cross-examined by Mr. Asquith, WITNESS said that his report was intended to convey an idea to commercial men of the value of the I.E.S.

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cell. He thought Mr. Higgs wanted it for his own information, but if he had been asked whether it was likely that Mr. Higgs would show it to other people he should have said it was. It was always intended that the results of his experiments should be published, but witness did not ask for remuneration until the appearance of the article complained of as a libel. The report was intended as a report to Mr. Higgs, and not as a public report. The cells and materials used by him were placed at his disposal by the I.E.S. Company. Asked if it was in reference to the use of the battery for traction purposes that his experiments were conducted and his report made, witness said No, but it had a particular value for traction purposes. At the present moment the application of electricity for traction purposes was one of the most difficult and important matters for the consideration of electrical experts. E.P.S. cells had been used for traction purposes. The three things essential for traction purposes were high capacity, mechanical durability, and light weight. Upon every one of those points he said and thought the I.E.S. cell was the best now before the world. There were 11 cells in the battery, and three plates in each cell. He could not say whether there was such a thing known to the market as a cell of the E.P.S. type used for practical purposes containing as few as three plates. The E.P.S. cells had to have a great number of plates, because their capacity was low. The number of plates was a question of capacity. In connection with his experiments in this instance he did not test an E.P.S. cell, but he had tested E.P.S. cells over and over again, and his reference to the makers would, he thought, prevent a commercial man from drawing the inference that he had experimentally contrasted the results given by the E.P.S. and I.E.S. cells. He was aware that there were a great many types of E.P.S. cells, but he took the L type instead of the K type, because that was recommended by the E.P.S. Company, and his experience was that at a higher rate of discharge than 4 amperes there would be injury to the plate in the way of reduction in capacity. It might be that the E.P.S. cells were in practice discharged at five or six times their normal maximum capacity, but that was contrary to the directions of the makers. He selected the L type of the E.P.S. Company because what was wanted for traction purposes was a high rate of discharge and a high capacity; and at any rate of discharge, the L type had a higher capacity than the K. The E.P.S. Company themselves recommended the L plate where these things were wanted in combination. He did not think he ought to have stated in his report the type of E.P.S. cell he had selected. His experiments were carried out by his assistants, he himself going to the works four or five times. The measuring instruments were supplied by the I.E.S. Company. He had discharged E.P.S. cells at about five times the rate allowed by the makers, with the result that there was a remarkably low capacity, and the peroxide was loosened. He believed the plates of the I.E.S. cells were encased in celluloid for the purpose of giving mechanical support, but such encasing was unnecessary.

WITNESS then gave, categorically, reasons for the statements in his report, and said that he did not know of an I.E.S. battery ever being used for traction purposes. He did not report on the merit of such a battery for traction purposes in every respect. When a battery was used for locomotive purposes it was exposed to vibration and shocks which would not occur in a laboratory, and all these things involved irregularities in the rate of discharge, and very great mechanical strains. Under these circumstances the mechanical structure of batteries of this kind for traction purposes was very important. A cell which was constructed to a large extent of celluloid was mechanically stronger than one of lead, because in acid the lead underwent chemical changes. In reporting on the capacity he did not consider the durability of the plates. At that time he could not pass an opinion on the durability of the cells; durability would be shown by experience in working on prolonged experiments. In his report there was nothing to indicate that the E.P.S. batteries were in boxes lined with lead, which weighed nearly two tons, while the I.E.S. batteries were in light ebonite boxes. In his opinion ebonite boxes would stand the wear and tear of tram-car life.

In re-examination, WITNESS said he was not invited to report on the actual operation of these batteries in use for traction purposes, and was not concerned with whether they were practicable for the purpose or not. His report did not purport to record any tests of durability, and none would be efficient except tests of actual and lengthy use.

Prof. AYRTON, electrical engineer, and Past President of the Institution of Electrical Engineers, examined, said that he had had many years' practical experience in secondary cells. He had had his attention called to the report in question, which had been the subject of criticism in the defendants' paper. He should have thought that if Mr. Hall had imagined that his report was going to be published in a technical paper, he would have entered into more details. He (witness) understood Mr. Hall's report quite well. He had heard the descriptions which the plaintiff had given in evidence of the methods of comparison which he had adopted, and he (witness) considered them quite fair. From personal tests which he had made to satisfy himself, Mr. Hall's "results" were not "reckless" or "erroneous"; he should say that they were substantially correct.

By His LORDSHIP: He did not test the E.P.S. cells to see what rates they could discharge at without injury. He assumed that the list rate of the makers gave that information, otherwise there was no object in giving the list rates at all.

Cross-examined by Mr. Asquith: The list rate was the rate the makers guaranteed the cells to give if long life was desired. What a business man wanted to know was the relative value of the two types of plate, and therefore it did not matter so long as it was correct.

Mr. LIMBREY HIGGS, a solicitor, in giving evidence and corroborating the evidence of the plaintiff, said that he had a few type-written copies of the report in question made to send round to some of his friends, but he did not know how the defendants got possession of it. The defendants did not ask his permission to use it.

Cross-examined, the witness said that he supplied copies of the report to Mr. Mayne, of the firm of New and Mayne.

Mr. J. BIRNIE EVANS, an Associate of the Institution of Electrical Engineers, and carrying on business in Palace-chambers, Bridge-street, Westminster, examined, said that for five years he had made a special study of secondary electrical cells, and was familiar with the different types of cells in the market. His attention was called to the new I.E.S. cell, and he tested it for his own satisfaction. He conducted the tests independently of Mr. Hall and in the ordinary scientific way. The results he arrived at corresponded with those arrived at by Mr. Hall, but some of them were slightly better. Substantially the results of his experiments agreed with the plaintiff's; but where they differed the difference was in favour of the I.E.S. cell. He heard Prof. Ayrton's evidence, and agreed with it in the main.

Mr. Conradi, an electrical engineer, corroborated Prof. Ayrton's evidence.

Mr. Benn, an electrical engineer, having given evidence to the same effect, the plaintiff's case closed.

Mr. ASQUITH, in opening the case for the defendants, said that it had been almost impossible for his learned friends who represented the plaintiffs, or himself, in the conduct of the case, not to give it the appearance of a contest of rival claims between two competing batteries; because it was impossible to examine and cross-examine the witnesses who had been called without trenching at any rate on that question. That was not in any sense the issue which the jury had to try. The only question that they (the jury) had to consider was, first, whether the article in question conveyed the imputation which the plaintiff suggested it did, and secondly whether that article in its fair and natural sense went beyond the limits of fair criticism in a technical journal in a matter of technical interest. He (the learned counsel) should show that the matter was brought before the defendants in the most legitimate way. Mr. Higgs, as they now knew, had a number of copies made of the report, and distributed them amongst his friends in order to induce them to join the Company, and in particular gave a number of copies to the firm of New and Mayne, who were jointly interested with him in the venture, and were the makers, in fact, of the battery. It happened that a gentleman wishing to purchase some form of accumulator from New and Mayne, sent an agent of his to negotiate about it, whereupon Mr. Mayne, one of the partners, having a pile of Mr. Hall's type-written reports before him, handed one across to the gentleman—the agent who had nothing whatever to do with the *Electrical Review*. That document having been handed over to a customer in the ordinary way, that customer brought it to the paper and therefore the document was obtained in the most legitimate manner possible.

His learned friend had made another suggestion equally unfounded—namely that inasmuch as the E.P.S. Company was an advertiser in the *Electrical Review*, it was in some way to its interests—a damaging comparison having been made with this rival battery—to get rid of that comparison and to carry the war into the enemy's camp. That suggestion was made upon imperfect knowledge, because not only the E.P.S. Company, but the I.E.S. Company were advertisers in the columns of this paper. What the defendants did when Mr. Hall's report came into their possession was to send it to a gentleman who they believed to be thoroughly competent, who was undoubtedly a practical expert in matters of this kind, and who was entirely independent of the Companies in question, and lived in Bradford, for him to comment upon it. What appeared in the paper was written by Mr. Rankin Kennedy under these circumstances, he having no personal acquaintance with the plaintiff. What struck Mr. Kennedy—as it struck a great many other people—was, that this report, framed in the manner it was framed, and inducing its conclusions by the process of reasoning which appeared on the face of it, was a report upon which the commercial public for whom it was intended would think they could safely act. He should submit that the article did not and never was intended to convey any imputation upon the honesty or good faith of the plaintiff. As far as he knew the newspaper never had any ground for making any such suggestion, and did not make it upon a fair construction of the article. He thought they would come to the conclusion that what they did say was that there was not on the face of the document sufficient data to support the conclusions the plaintiffs sought to erect upon it. Being of that opinion, they thought it was right that the public should have pointed out clearly to them the respects in which the report was deficient. The report was a comparison between the I.E.S. battery and the E.P.S. battery for traction purposes. The E.P.S. battery had the advantage of having been used for traction purposes. The object of the article was to institute a comparison between the batteries for that use, and the points of comparison were (1) capacity, (2) mechanical structure, (3) duration of life, and (4) weight. Those were the points it was necessary to establish in favour of the I.E.S. battery if its superiority over the E.P.S. battery was to be held to be established.

Proceeding to deal with the alleged libel, the learned counsel said it was natural that a journalist dealing with this question should point out that the report was vitiated by no mention of the type of E.P.S. battery used, and contended that, though the I.E.S. battery had never been on a tramcar, it might have been exposed in the laboratory to longer and more continuous tests than it was. It was true the E.P.S. Company's catalogue warned users of their cells not to exceed the normal rate of discharges, but in connection with the L type they said that under certain conditions the rates of charge and discharge specified might be increased on reference to the advice of the Company, and he should show that E.P.S. cells of every type were almost every day discharged at four or five times the maximum listed rates without the least injury to the plates. He did not think the writer could be said to have gone beyond the limits of fair criticism when he said that the plaintiff's was a reckless comparison, and his evidence would show that the E.P.S. cells stand the comparison. The statement in the report that the plaintiff was unable to make a comparison of the capacity of the I.E.S. Company's cells with the E.P.S. cells at the same

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rates of discharge, because the E.P.S. cell would not stand such heavy discharges, the learned counsel asked the jury to say was a sanguine and reckless statement with reference to a cell which had only been tested in the laboratory and had never been applied for the purposes of traction at all. Lastly, weight was most important. Surely it was not the act of a careful man to make this comparison without warning his readers that wooden boxes lined with lead were used by the E.P.S. Company, while the I.E.S. Company used ebonite boxes, which he thought was one of the flimsiest substances that could be used for this purpose. These were the matters which occurred to the writer of the article and the conductor of the journal to call for strong and severe comment. The report did not give the information it ought to have given, and it omitted to give data which was absolutely necessary to enable the readers to test the justice of the writer's conclusions. If that were so, his clients were strictly within limits, and it was their duty as journalists to do what they could to point out the defective reasoning of this report and to warn the public not upon such materials to put their money into such a concern as this. He should submit that in doing that they were acting in no improper way, and that they had not exceeded the limits—necessarily wide and elastic—of fair comment on a matter which concerned the public

Mr. L. EPSTEIN, an electrical engineer and the inventor of the Epstein cell, said he thought the listed rate of the E.P.S. cells was a practical result, and the report unfairly compared practical results in the case of the E.P.S. cells with theoretical results in the case of the I.E.S. cells. In practice durability of construction and mechanical strength were the first considerations in cells. E.P.S. cells could be discharged for a certain number of times without injury at rates up to three times the normal rate. Epstein cells might be discharged to zero without taking any harm within a reasonable time. The mention of the Waddell-Entz cells in the report was misleading, because that was a different type of battery. His experience of celluloid was that it was a most uncertain material, and his firm had discarded it. In his opinion it was premature to recommend such a plate to the public. To a certain extent, to discharge E.P.S. cells at a higher rate than that which appeared in the catalogue was taking a liberty with them, and he would not specially recommend it. He was clearly of opinion Mr. Hall was not justified in drawing the conclusions he did as to practical results for traction purposes from the results of his laboratory tests. There was nothing in the report which had reference to anything but laboratory tests. Witness admitted that he published a report by Prof. Ayrton on his cells, which related to laboratory tests, but said he did not go so far as to say that on account of these tests his batteries were the most valuable for traction purposes. He put his batteries in ebonite boxes, and they answered in the majority of cases.

Mr. FRANK KING, manager of the Electrical Power Storage Company, examined, said that he had had a long practical experience of electric storage cells, and had read the report which Mr. Hall made. In his opinion the value of a cell for mechanical purposes was its mechanical strength. He did not see that the report dealt with the mechanical strength of the cell. Assuming that four discharges of the cell were made it would not give the plaintiff any idea of its durability, at least 20 discharges would be necessary; for that. Discharging at high rates must produce high rates of temperature in the cell. In that particular plate an increase of temperature would soften the celluloid and render it useless in giving additional strength to the plate. It got no advantage, therefore, from the use of celluloid. He had had a very large and distressing experience in the use of celluloid in the cells. He had used a great number of tons of it. Celluloid had been discarded as giving an additional mechanical strength to those plates. In his opinion a report was not justified which recommended the plates for locomotion purposes which did not deal with the durability or strength of them. His chief criticism on the cell in question was its deficiency in mechanical strength.

Mr. R. E. B. CROMPTON said he had for 15 years considered the application of electricity for traction purposes. The most important point to be considered in judging of the capacity of a battery for traction purposes were, first, durability and mechanical strength; and second, high rate of discharge. If the first were sacrificed to the second, the batteries were of no use for traction purposes. He had read Mr. Hall's report, and he agreed with the evidence which had been given by Mr. King. With regard to the employment of celluloid in secondary batteries, he said that he had used it largely, and had been a great sufferer from its continuous failure after it had been exposed for a considerable time to the action of the battery. That celluloid was absolutely useless in a battery was well known to everybody. He had not analysed the particular celluloid in use in the I.E.S. battery. If it were generally known that celluloid was of no use in this connection, he should account for the I.E.S. Company using it by saying it was due to their ignorance. The action of the battery on the celluloid began about nine months from starting. The type of lead cell which he had used from the beginning was being taken up by the largest users of accumulators. Assuming the durability of two cells were equal, the fact that one cell could be worked in practice at high rates of discharge would constitute an exceedingly valuable cell for traction purposes. If you were comparing two cells with equal durability, the usefulness would vary with the capacity for high rates of discharge.

Mr. T. E. GATEHOUSE, one of the editors of the *Electrical Review* said that Mr. Hall's report was sent to his newspaper in the ordinary way. It was brought by Mr. Schanschieff, an electrical engineer, who informed him he brought it from Mr. Ward, another electrical engineer. He read the report and sent it to Mr. Kennedy, a contributor to his paper, whom he knew as a thoroughly competent electrician. He had no interest in the I.E.S. or E.P.S. cells on any other electrical firm.

The LORD CHIEF JUSTICE: You thought it was a matter of interest in the particular line of industry with which you deal?—Of very great interest.

If these results were reliable it would show there were considerable advantages in this arrangement?—Yes.

He saw Mr. Kennedy's review before it was published, and inserted it after he had read it. He decidedly agreed with the criticisms Mr. Kennedy passed upon it. Witness produced a diagram showing how irregular was the rate of discharge of a battery during a 19min. run on a tramcar. He knew Mr. Hall by name, but he did not know that he was an associate of the same Institution as himself, though Mr. Hall described himself as such and gave his address. The report purported to be furnished to a private gentleman, but as it was not marked "private and confidential" he assumed it was a public document. He was afterwards informed by Mr. Higgs that it was a private document, but he thought it was all the more justifiable to criticise it because Mr. Higgs stated it was a report for commercial men. In his opinion the vital point was that Mr. Hall made no experiments on the life of the cell. There was nothing in the report to show that the I.E.S. battery was fit for traction purposes at all. With regard to the suggestion that the alleged libel charged Mr. Hall with foisting a worthless thing on the public, witness said a consulting engineer did not do that, though his report might be used for that purpose. Mr. Higgs' letter was published by him after the issue of the writ. Mr. Hall did not represent, nor did his solicitor represent, that this report was a private document.

Mr. ARTHUR SHIPPEY said that he was employed by Mr. Ward to obtain a light accumulator for him, and in consequence he called upon Messrs. New and Mayne. He saw Mr. Mann, the manager, who referred to the report of Mr. Hall, and witness was offered a commission to sell I.E.S. batteries.

Mr. LAWSON WALTON said that Messrs. New and Mayne were making for the I.E.S. Company, and Mr. Higgs sent them 15 or 20 copies of Mr. Hall's report.

WITNESS said Mr. New gave him a copy of the report in order that he might use it for obtaining orders. He took the report to Mr. Ward, who, being a practical man, asked him for curves.

Mr. RANKIN KENNEDY said that he had had 18 years' experience in electrical matters, and was a pupil of Lord Kelvin. He had been a contributor to the *Electrical Review* on technical matters, and wrote the article in question. He did not know Mr. Hall, and had no interest in the I.E.S. or E.P.S. cells. The report was sent to him, without any communication, to treat as he thought proper. He commented on the report, not on the engineer or the batteries. He treated the report as a public document. He had never seen an I.E.S. battery, but he had seen one which was equivalent. Asked what was his ground for saying that the figures in the report were transparently erroneous, witness said that any engineer would know that 5 H.P. batteries would be useless for traction purposes, because three times the normal horse power of the batteries had to be provided for. The statement that the I.E.S. cell could be discharged to a lower capacity than any other cell was erroneous, because he knew many cells which could be discharged to zero without injuring them. The main error in the report was that there were no details given. If he had been informed that Mr. Hall had furnished Mr. Higgs with details, that would very much have modified his opinion. There was nothing in the report to support the statement that the I.E.S. battery was the best for traction purposes.

This concluded the evidence.

Mr. ASQUITH, in summing up the case for the defence, said the question, and the only question, was whether this report, understood in the sense which an ordinary reader of average intelligence would put upon it, did contain imputations upon the character and competency of the plaintiff, which were in excess of fair journalistic criticism. His learned friend opened the case as a case in which a newspaper had, by illegitimate means, got possession of a private document and had utilised its columns, not for the purpose of fairly criticising the information it contained, but for the purpose of puffing the products of a rival company, which was a large and lucrative advertiser in its columns. The facts made it abundantly that this was nothing of the kind.

Mr. LAWSON WALTON having replied,

His LORDSHIP, in summing up, said that there was no class of cases in which the functions of the judge were so limited, and the functions of the jury so wide, as in actions of that kind. The first point was whether the plaintiff's report was or was not a fitting subject for criticism. The plaintiff, by his counsel, said it was not, and that it was a private document; also he alleged that it was a matter which did not concern the public, and with which a public journal dealing with those subjects had no legitimate concern. He (his Lordship) had no doubt in his own mind that the plaintiff must have known, as a man of common sense and experience, that Mr. Higgs was not paying for the report in order to put it in the waste paper basket or lock it up in a drawer. His Lordship then referred in detail to the evidence, which showed how the report came to the defendants' hands, and was handed by Mr. Gatehouse, the editor, to Mr. Kennedy for criticism. If the matter was one for legitimate criticism, as he (his Lordship) thought it was, having regard to the fact that the question of storage batteries was of great importance in the electrical world, the jury had then to consider whether the defendants had gone beyond the bounds of fair criticism. To his mind the most important part of the article complained of was that in which reference was made to attempts by so-called expert reports to foist upon the public a certain manufacture, and it was for the jury to say whether that meant that the plaintiff lent himself to an attempt to foist on the public a worthless invention. There was no evidence for saying that such an imputation could be sustained, and it was without justification; in fact, the learned counsel for the defendants had disclaimed that there was any intention of making it. The question, however, was not the meaning of the writer, but what the words meant to ordinarily reasonable men.

The Jury, after a short deliberation, returned a verdict for the plaintiff for £100 damages.

Judgment accordingly

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Digby v. Wyatt.

This case came before Mr. Justice Grantham on Friday last, brought by Mr. T. J. Digby, electrician, against Mr. Frank Wyatt and his wife, proprietors of the Duke of York's Theatre, London, to recover damages for the detention of certain electrical appliances.

The plaintiff's case was that under an agreement with Mr. Horace Sedger, lessee of the theatre, he supplied the electric light appliances for the stage during the performances of "Baron Golosh," the piece being produced under an agreement by which the expenses were to be borne by Mr. Sedger and the defendants. The plaintiff said Mr. Sedger thought that he had been released from liability under his arrangement with the plaintiff by the agreement with the defendants, and as he (the plaintiff) had failed to come to any arrangement with the defendants with regard to the lighting of the theatre by electricity, he applied to Mr. Sedger for permission to remove his appliances. The defendants, however, refused to allow the removal to be effected, and the result was that when he was asked to supply the necessary electrical apparatus for the staging of "The Artists' Model," at another theatre (the Lyric), he was compelled to make new arc lamps at a cost of £63.

The defence was that the plaintiff was not entitled, at any time before May 25th, to any of the plant in question. Moreover, the defendants further pleaded that when the plaintiff produced Mr. Sedger's authority to remove the plant they permitted him to do so.

In the result His Lordship gave judgment for the plaintiff for £10, with costs on the higher scale.

Fareham Electric Light Company (Limited) v. Fareham Urban District Council.

In the Queen's Bench Division on Wednesday, before the Lord Chief Justice, Mr. Channell, Q.C., who appeared for the Fareham District Council, said: Your Lordship will remember that in this case, which was tried last sittings, my learned friend, Mr. Robson, appeared for the plaintiffs. Your Lordship recollects that the question in the case was as to whether or not the contract should be carried out. What the local Council did afterwards was this. They thought the best thing they could do would be to go to the ratepayers again and ascertain their opinion as to the course that should be adopted, that is, whether they would carry out the contract or pay the damages. The Council accordingly took a poll of the ratepayers, with the result that there was a small majority in favour of carrying out the contract instead of paying the domages. Some time was of course wasted over these proceedings, and then my clients got into communication with the Lighting Company again, when it turned out that there was a little misunderstanding as to what the offer was. There were apparently two points of difference. In the first place the Urban District Board thought that the offer was to the effect that proposal that they should carry out the original contract was conditional upon their getting the sanction of the Local Government Board to the proposed loan. My friend's clients, however, said they never intended anything of the sort, their offer being that we should either purchase the works or pay the damages. That is the first point of difference. The next point is as to the payment of interest. The plaintiffs say that if the contract is carried out they ought to have interest from some antecedent date upon the purchase money. On this point there had been some dispute, and about a fortnight ago I was consulted by my clients about these disputed points, and I suggested that the first thing to do was to go to the Local Government Board and see what they could do about getting the sanction of that Board to a loan; they would then know whether a loan could be obtained or not. My clients acted upon that advice, but at present they have not received any definite answer. I understand, however, that they have received a letter from the Local Government Board this morning, in which it is stated that the Board are prepared to sanction a loan for part of the amount, but that the other part of the loan asked for requires further consideration. Under these circumstances, I suggest that we should be granted a little more time to consider our position.

Stay of execution for fourteen days granted.

Fraser v. South.

This case was heard yesterday (Thursday) in the Westminster (London) County Court, and was a claim for £13 for two arc lamps supplied to the defendant, Mr. Harry South, electrical engineer, of Garrick-street, W. The defendant was stated to have sent in November last two arc lamps on approval, and a month was allowed in which to try them. The lamps were not returned. The defence was that plaintiff's late partner offered to lend the lamps to one of defendant's customers on approval, and that defendant merely acted as the agent of the manager of the music hall at which the lamps were to be tried.

Judgment was given for the amount claimed with costs, the judge (Mr. Lumley Smith) holding that the defendant had kept the lamps too long.

Long-Distance Telephone in Russia.—According to reports received, the Russian Government has resolved to erect a telephone line between St. Petersburg and Moscow. The line will consist of four copper wires, and as all preliminary work has already been done, the completion of the line is expected by May 1, 1896. The line will at first be used exclusively by the Government.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK will be ready in a few days, Subscription Orders (5s. 9d. post free, abroad 6s. 6d.) must be sent in by Wednesday next. After that date the published price of the Directory and Handbook will be (as usual) 7s. 6d., post free 8s. 3d., abroad 9s.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES can be obtained of the Booksellers or direct from the Publishing Offices:—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

'THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

TENDERS INVITED.—The Vestry of St. John, Hampstead, require tenders for works and materials for one or three years for (1) coals and coke, (2) oils for machinery at electric lighting station, (3) tools, implements and other electrical engineers' stores, (4) carbons, lamps and other stores for electric lighting station, (5) removing ashes from electric lighting station. Some further particulars are given in our advertisement columns. Tenders must be sent in to Mr. Arthur P. Johnson, Vestry Clerk, by 4 p.m. of February 12th.

——— The Corporation of Huddersfield invite tenders for two steam boilers, four mechanical stokers and one surface condenser with air and circulating pumps. Specifications, &c., may be obtained of Mr. A. B. Mountain, Borough Electrical Engineer, St. Andrews-road, Huddersfield, and tenders must be sent in to Mr. F. C. Lloyd, Town Clerk, Town Hall, Huddersfield, by Tuesday, February 4th.

——— The Great Indian Peninsular Railway Company invite tenders for the supply of stores, including telegraph materials, iron telegraph wire, &c. Tenders to the Secretary, 43, Copthall-avenue, London, E.C.

——— Tenders are invited for the concession for the electric lighting of Sainte Croix de Teneriffe, Canary Islands, for 35 years. Tenders to the Ministère de la Gobernacion, Madrid, by Feb. 29th.

LIGHTING SCHEMES INVITED.—It will be seen by our advertisement columns that the Urban District Council of Eston, Middlesboro', invite schemes for lighting the district by electricity. A plan of the district can be seen and particulars obtained on application to Mr. F. W. Stainthorpe, A.M.I.C.E., District Surveyor, Grangetown, Yorkshire, to whom schemes must be sent in not later than May 1st next. Mr. Jno. T. Belk is clerk to the Council.

TENDERS ACCEPTED.—Messrs. Siemens Bros. and Co. (Limited) have received an order from the Gas and Electricity Committee of the Edinburgh Corporation for the supply of additional engines and dynamos for their electric lighting station. The contract for the supply of boilers has been awarded to Mr. Sinclair.

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SALE BY TENDER.—Messrs. Wheatley Kirk, Price and Goulty announce the sale by private tender (by direction of the Court) of a portion of the plant and machinery, the whole of the utensils, office furniture, stock and stores, &c., on the premises known as the Smithfield Works, New Road, Blackwall, London, E., formerly occupied by Messrs. D. W. Forbes and Co. (Limited). In our advertisement columns some further particulars will be found. Tenders should be sent by post to Mr. W. C. Hewlett, chief clerk, at the Chambers of Mr. Justice Kekewich, Royal Courts of Justice, Strand, London, by Wednesday, February 5th. Particulars and conditions of sale, forms of tender, orders to view, &c., can be obtained of the firms mentioned in the advertisement.

SALE BY AUCTION.—Messrs. Hepper and Sons have received instructions from the Corporate Property Committee of the Leeds City Council to sell by auction at the Municipal Buildings, Leeds, on Thursday, February 13th, at two o'clock, a large quantity of electric lighting plant, including engines by Willans and Robinson and Crossley, boilers by McLaren, dynamos by Mather and Platt and Paterson and Cooper, E.P.S. accumulators, and a quantity of apparatus and instruments, forming the complete installation which was some time ago erected at the Municipal Buildings, and which is now dispensed with as current is taken from the local Electric Supply Company's mains. Some further particulars are given in our advertisement columns. Catalogues are now ready, and may be obtained of the auctioneers, East-parade, Leeds.

REMOVAL.—The National Telephone Company (Limited), notifies that the "Sale Outright of Instruments and Lines Department" has been removed from Falcon-avenue, Aldersgate-street, to the City District Offices, London Wall, E.C.

BUSINESS CHANGES.—Messrs. Swinburne and Co. (Limited) inform us that arrangements have been made to amalgamate their business with that of the Nalder and Harrison Construction Syndicate (Limited), the new firm's title being "Nalder and Harrison (Limited) and Swinburne and Co. (Limited)," the works of the combined firm being situate at Bow Common-lane, London, E Mr. Holt, late General Manager of Swinburne and Co., joins the Board of the amalgamated companies.

APPOINTMENT VACANT.—The Electric Lighting Committee of the Edinburgh Town Council, at their meeting on Wednesday, resolved to advertise for a resident electrical engineer in succession to Mr. E. W. Monkhouse, at a commencing salary of £400 per annum.

LIQUIDATIONS.—We have received a letter from Mr. Sydney F. Isitt, Liquidator in J. C. Howell (Limited) (in liquidation), calling a meeting of creditors, to be held at 6, Old Jewry, London, E.C., on Wednesday next at 12 o'clock, when Mr. Isitt proposes to report on the progress of the winding-up. The circular states that the Liquidator has been informed by Mr. Howell that some of the creditors have been paid. In the event of its becoming possible by Monday next to continue the payment of the liabilities as they become due, in accordance with the terms of the original arrangement, creditors will be advised, and in that case no meeting will be held.

——— By an order of the Sheriff's substitute of the county of Renfrew, J. W. Weens and Alexander Wylie, engineers, &c., of Johnstone, Scotland, notify that they have presented a petition to be finally discharged of all debts contracted by them before the date of the sequestration of their estates.

——— At a meeting of the proprietors of the Merveilleuse Electric Arc Lamp Syndicate (Limited), on December 31st, it was decided to wind up the Company voluntarily. This resolution was confirmed on January 16th, and Mr. A. Conder, accountant, was appointed liquidator.

——— A meeting is to be held at the offices of Messrs. Owston, Dickinson and Simpson, solicitors, 23, Friar-lane, Leicester, on February 26th, at 3 p.m., to receive an account of the winding-up of the English Electric Manufacturing Company (Limited).

BERLIN INDUSTRIAL EXHIBITION, 1896.—Some concern is evidently felt by the organisers of this exhibition at the tension existing between England and Germany at this moment. In a letter just to hand Englishmen are asked not to allow "the unfortunate irritation recently prevailing in both countries" to in any way mar the success of the forthcoming exhibition, with which considerable progress has been made.

CATALOGUE.—We have received a copy of Messrs. Easton, Anderson and Goolden's (Limited) latest catalogue of electric, steam, hydraulic and general engineering machinery. The work is divided into sections, each copiously illustrating one department of work undertaken by this firm. The first section is on "Waterworks," a branch of engineering equipment in which this firm has done some first-class work at home and abroad. Particulars of various forms of electrically-driven pumps are included in this section. The second section deals with "Pneumatic Machinery," and the third with miscellaneous plant. We notice some good illustrations of the Grafton high-speed enclosed steam engine, and particulars of this serviceable motor. Following these is a section on "Boilers," a class of work for which Messrs. Easton, Anderson and Goolden (Limited) have made a good reputation, both in and out of electric supply stations. Hydraulic and electric lifts, cranes, travellers, &c., occupy considerable space towards the end of the book; and later still comes a section specially devoted to "Electrical Machinery," in which all classes of lighting, mining, coal-cutting, signalling and traction plant, driven by electricity, are included. The catalogue is strongly bound in cloth boards, and both in the style of its get-up and in the character of its contents is a credit to a firm of high standing.

PRICE LIST.—Messrs. Beanland, Perkin and Co., of Leeds, forward a price list of "B. P. C." dynamos and motors.

ABERDEEN.—The Electric Lighting Committee have just presented their accounts for the year ended December 31st. The revenue for this period amounted to £3,611. 8s. 9d., and the expenditure was £1,356. 18s., or a balance of £2,254. 10s. 9d. The sum of £1,819. 10s. has been set aside for interest and depreciation, leaving a clear net profit of £435. 0s. 9d. The Corporation has had authority to borrow £32,000, and has already exercised its power in respect to £29,800 of this sum. It is understood that the Committee will shortly recommend considerable extensions of the present electric lighting area, and it is also probable that they will reduce the price of current from 6d. to 5d. per unit.——At the last meeting of the Docks and Pilotage Committee of the Harbour Board the question of lighting the quays by electricity was under consideration, and the matter was referred to a Committee, consisting of Messrs. Murray, Sangster, Connon and Meff, who are to act with the engineer in collecting information as to cost, &c. The Committee are to consider and report upon the question whether it would be cheaper to take current from the Corporation mains or to put down an independent generating plant.

BIRMINGHAM.—In reference to the application of the Birmingham Central Tramways Company for permission to introduce the overhead electric traction system on their Nechells route, the Public Works Committee of the Corporation have just decided to recommend that permission be given to the Company to employ this system on the tramways between Albert and Nechells Park-roads (a distance of about 2¼ miles) for a period of six months, subject to the approval of the Board of Trade, and also to such conditions as the Board and the Committee may think fit to impose. Should the Corporation decide not to grant a renewal of the consent the Company are to remove the posts and wires and reinstate the roads and footpaths at their own cost. It is stated that the Directors of the Company have agreed to these conditions.

BRECHIN.—Owing to the inferior quality and the high price of the gas supplied by the local gas company, many of the principal shops and business establishments in this town have already put down independent electric lighting plants. The Brechin Paper Mill has adopted this course. Current is supplied by a Mather and Platt dynamo, driven by a Shanks engine. About 110 incandescents are used.

BRADFORD.—The Gas and Electricity Supply Committee have appointed Mr. Thomas Barker, architect, to draw up plans for the proposed extension of the Corporation electricity works.

BURSLEM.—Messrs. Crompton and Co. have recently fitted for the electric light the extensive baths erected by the Corporation of Burslem. The erection and fitting of the baths has cost £10,500. Messrs. Crompton's representative at Burslem for this work was Mr. G. Heath.

CHELMSFORD.—Messrs. Crompton and Co. have written to the Town Council offering to dispose of the undertaking of the Chelmsford Electric Lighting Company to the Council, one inducement held out being that the additional capital thereby accruing to Messrs. Crompton and Co. would be used in the extension of the works now in process of erection, in this way contributing to the increased prosperity of the town. Messrs. Crompton's letter states that it is now an accepted principle that Corporations should have the public lighting arrangements under their own control, and that the present is a fitting opportunity to consider this important question. The terms of purchase were not mentioned in the letter, and some discussion arose as to whether, before referring Messrs. Crompton's communication to a Committee for consideration, the terms upon which the purchase could be effected should not be given. It was finally decided that the Committee should confer with Messrs. Crompton and Co. as to the terms of their offer, and then consider the proposal generally.——It is stated that Messrs. Crompton and Co. have in contemplation the aquisition of a new site for their works near the railway.

EDINBURGH.—For some time on Wednesday the Electric Lighting Committee of the Corporation discussed the subject of the contemplated extension of the electric lighting area, and finally authority was given for the acceptance of offers for boilers, super-heaters, mechanical stokers, dynamos, and other plant, estimated to cost over £20,000. It was also decided to recom-

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mend that opposition be offered to the petition presented by Dr. J. Hopkinson and the Westinghouse Company to the Privy Council, praying for an extension of time for their patents in connection with the three-wire system.

ELECTRIC TRAMWAYS.—An interesting series of articles on the present and prospective developments of electric tramways is appearing in the *Belfast News Letter*.

FENTON.—The District Council at their last meeting instructed the Clerk to act in conjunction with the local authorities of Stoke, Burslem and Tunstall, in making objection to the application of the promoters of the Provisional Order for the construction of electric tramways in the district.

GLASGOW.—The Committee of the Police Department have appointed a sub-committee, consisting of Messrs. Primrose, Guthrie and Cleland to visit Edinburgh and inspect and report upon the system of electric lighting in that city.——It is stated that the Glasgow office of the Silver-town Company have secured the contract for a complete installation of electrical machinery for the Glasgow Subway Company (Limited), including engines and dynamos, electrically-driven pumps, the lighting of 15 stations and trains, and the supply of electric power for elevators, &c.

HACKNEY (LONDON).—At their meeting on Tuesday last the Vestry decided to adopt the combined electric lighting and refuse destructor scheme, particulars of which were given in our issue for December 13th. The scheme is estimated to entail an outlay of about £80,000.

HASTINGS.—Mr. F. Bruce, of Hastings, has been entrusted with a contract for the wiring of the new wing of the Victoria Hotel, St. Leonards. The convent at Church-road is also being fitted up for the electric light by Mr. Bruce.

ISLINGTON (LONDON).—Current for private lighting lighting will be available from to-day. The street lighting, however, will not be started until March, after the formal opening by the Lord Mayor.

KINGSTON-ON-THAMES.—At the last meeting of the Town Council a letter was read from the Surveyor to the Hampton Wick District Council stating that he had no instructions from his Council with respect to the proposal to extend the electric light mains to Hampton Wick, but he offered no objection to a circular being sent by the Corporation to the inhabitants of the district for the purpose of ascertaining the quantity of current that would be required. The Town Clerk recently wrote to the Surbiton District Council suggesting that it should re-consider the question of entering into an arrangement with the Corporation for the supply of electric current, but the Surbiton Council has just replied stating that they had appointed a consulting electrical engineer, and that electric lighting tenders were under consideration.

LEEDS.—At last week's meeting of the Highways Committee of the Corporation, Dr. J. Hopkinson's recommendations with regard to the electrical equipment of the Leeds tramways was approved. The scheme is for the construction of an electrical tramway from Kirkstall to Roundhay, with the Westinghouse closed conduit system in Boar-lane. The following is Dr. Hopkinson's estimate for the rolling stock, plant and apparatus required in the installation :—

Trolley wire erected with insulators, 14 miles at £190 ..	£2,660	0	0
Poles for two trolleys, seven miles at £1,196 per mile ..	8,372	0	0
Bonding rails, at £150 per mile of single track	2,100	0	0
Seven miles of 0·15 square inch cable, at £317 per mile	2,219	0	0
Closed conduit for 310 yards of double rail, at £1. 12s. 6d. per switch.....	251	17	6
20 cars at £750	15,000	0	0
Two boilers, each 200 H.P., with steam pipes and economisers, at £700	1,400	0	0
Two condensing engines, at £1,400	2,800	0	0
Two dynamos, at £600	1,600	0	0
Switchboards and instruments.....	740	0	0
Two batteries, at £500.....	1,000	0	0
Instruments and switches, at £70 each station	140	0	0
Total	£37,882	17	6

LLANDRINDOD WELLS.—The Urban District Council has just decided to accept the proposal to light the public streets with incandescent electric lamps at an annual charge of 58s. 6d. per lamp per annum. There is to be a minimum of 70 lamps, each of 32 c.p., and the agreement is to continue in force for seven years. The maximum charge for current of 8d. per unit is to be reduced to 7d. when the equivalent of 3,000 16 c.p. lamps are installed.

LLANELLY.—At the meeting of the Estate Committee of the Town Council on Wednesday last it was decided to accept the offer of Mr. J. C. Howell for the purchase of the Council's Provisional Electric Lighting Order.

MANCHESTER.—It is stated that, undeterred by the abortive example of Glasgow, a number of leading business men in Manchester are signing a requisition calling upon the Corporation to inaugurate an independent telephonic system for the city. It is stated that a committee has been formed, and that the requisition has already received over 1,000 signatures. The requisitionists complain that the National Company's system is much too expensive, and that there is reason to apprehend a further increase in its charges.

MIDSOMER NORTON.—The Surveyor reported at the last meeting of the District Council that he had received two applications from electric lighting companies to light the town electrically. The Council, however, decided to advertise for lighting tenders.

PEMBROKE.—At the last meeting of the Town Council a deputation, consisting of Messrs. Ford and Baker, had an interview with the Council on the question of lighting the town by electricity. It was decided that Mr. H. A. Jones-Lloyd, Chairman of the Gas Committee, should confer with Mr. Baker upon the details of the scheme, and the result of their conference is to be reported at the next meeting. A meeting of ratepayers is to be convened for the purpose of protesting against the Corporation entering into any agreement with a syndicate about to be formed for lighting the streets electrically. The *South Wales Daily News* states that it understands the syndicate will consist of local men, "some of whom are members of the Corporation, and they expect to realise a profit of not less than 25 per cent." The ground of opposition is that the Corporation should retain the lighting of the streets in their own hands.

SHEFFIELD.—A special meeting of the City Council was held on Tuesday to discuss the tramway question. The lease of the existing Tramways Company expires in July next, and there is a strong feeling against renewing it, as it is considered the lines should be under the management of the Council. The Sheffield District and Rotherham Tramways Company is promoting a Bill in Parliament for power to construct an improved system of tramways on the overhead system. The Parliamentary Committee recommended the Council to oppose the Bill, and, after a long discussion, it has been decided to adopt this course.

SOUTHPORT.—The Town Council have sanctioned an expenditure of £4,000 for putting down additional plant at the electricity station.

STOURPORT.—A meeting of ratepayers was held at the Town Hall last week for the purpose of considering the resolution which had been passed by the District Council with regard to the construction of an electric tramway between Kidderminster and Stourport. The matter was discussed at considerable length, and a resolution in favour of the scheme was adopted.

WREXHAM.—At the meeting of the Town Council on Tuesday it was resolved that it was not desirable to grant any further extension to the Wrexham Electric Light Company under the provisions of its Electric Lighting Order.

SMOKING CONCERT.—To-night (Friday) at eight o'clock, at the St. James's Hall Restaurant, Regent-street, London, W., a smoking concert of the Electro-Harmonic Society takes place ; an excellent programme is provided under the musical direction of Mr. T. E. Gatehouse and Mr. A. E. Izard. The artistes include Mr. Malweyn Humphreys, Mr. Albert James, Mr. David Hughes, and Mr. Edward Kent, in addition to the popular directors of the concert.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

January 10th, 1896.

710. A. C. MILES and B. F. DE MORGENSTERN. London. Improvement in and relating to electric accumulators.

711. A. C. MILES and B. F. DE MORGENSTERN. London. Improvement in and relating to arc lamps.

712. A. C. MILES and F. F. DE MORGENSTERN. London. Improvements in and relating to electric motors.

719. B. WILLCOX. London. Improvements in electrical accumulators and storage batteries. (La Societe l'Accumulateur Fulmen France.)

722. J. T. THORNYCROFT and J. E. THORNYCROFT. London. Improvements in electric arc lamps.

January 11, 1896.

736. W. B. EDGAR. Glasgow. Improvements in electric tramways or railways.

778. H. W. HEADLAND. London. Improvements in secondary batteries.

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780. H. Leitner. London. A new or improved method of manufacturing electrodes for secondary electric batteries.*
791. W. Walker, Jun., F. R. Wilkins, and J. Lones and O. Vernon London. Improvements in primary voltaic batteries.
793. H. J. Dowsing and H. S. Keating. London. A new or improved electrical lamp.
794. H. J. Dowsing and H. S. Keating. London. A new or improved electrical lamp.
810. G. Carey Fricker. London. Improvements in apparatus for automatically controlling the supply of electricity and gas, water or other fluids.

January 13, 1896.

842. S. O. Cowper-Coles. London. Improvements in and connected with the manufacture of electric conductors
845. D. Weisz and E. Epstein. London. Improvements in electrical appliances for automatically preventing railway collisions.*
868. C. Raab. London. Improvements in electric meters.
879. Eversheds and Vignoles (Limited) and S. Eversheds. London. Improvements in electric measuring instruments.
880. G. Ewart and J. Vaughan-Sherrin. London. Improvements in electric heaters*.
888. A. U. Alcock. London. An improved secondary battery or accumulator.

January 14, 1895.

915. E. Scott. Wolverhampton. Improvements in electric transformers for alternating currents.
916. E. Scott and E. T. Cochrane. Wolverhampton. Safety non-sparking switch.
931. J. K. Semple. Glasgow. Improvements in and relating to electrical devices for igniting gas.
964. C. J. Schwarze. London. Improvements in telephonic apparatus.*
976. H. J. Fisher. London. Improvements in and relating to electric arc lamps.
977. H. F. Parshall. London. Improvements relating to the synchronising of alternating-current motors for electrical power transmission.*
981. G. M. Gibson. London. Improvements in apparatus for printing telegraphic messages in type.
986. J. C. Graham. London. Improvements in the electro-deposition of metals.

January 15, 1896.

1,005. M. Zinner, Jun. Manchester. Improvements in electrical resistances.*
1,054. D. G. Fitzgerald and W. C. Bersey. London. Improvements in voltaic batteries.
1,068. J. C. Graham. London. An improved electrical process for recovering metals from weak solutions and for concentrating the electrolyte.
1,069. C. Pollak. London. Improvements in or connected with electrical condensers.

January 16th, 1895.

1,123. T. Pilkington. London. Improvement of "iron-clad" field magnets.
1,144. W. Herabus. London. Improvements in electrodes for electro lytical purposes.

January 17, 1896.

1,198. J. W. Darley, Jun. London. Improvements in electric railways.*
1,218. G. Tolmie. London. Improvements relating to electric railways.
1,228. D. M. Hawes. London. Improvements in the manufacture of battery cells or vessels to contain acids or other chemicals.
1,230. E. H. P. Humphreys. London. Improvements in apparatus for measuring electricity.
1,237. C. J. P. Robertson. London. Improvements in and relating to electric incandescent lamps.
1,238. P. A. Newton. London. Improvements in the manufacture of electric batteries. (C. Willams, United States.)*
1,249. H. F. Parshall. London. Improvements in synchronising mechanisms for alternating-current generators.
1,256. W. J. Davy. London. Improvements in electric choking or impedance coils.

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1894.

24,541. Kellner. Effecting electrolysis.
25,048. Nisbett. Junction boxes or fittings for cables.
25,221. Atkinson. Dynamo-electric generators, &c.
25,066. Atkinson. Dynamos and motors.

1895.

541. Eckstein and Eidsforth. Electric bell and indicator.
831. Quin and Symmons. Arc lamps.
1,262. Davy. Arc lamps.
1,265. Menges. Galvanometers.
1,405. Barrière. Arc lamps.
1,611. Preston and Gill. Electric lighting, heating and ventilating vehicles.
3,066. Newington and Hewlett. Electric switches.
3,582. Reason. Electric conductors.
3,633. Parker and Others. Distributing electricity.
3,685. Edmunds. Insulating electric conductors.
3,701. Bersey. Vehicle electric driving gear.
5,041. Siemens Bros. and Co. (Limited) and Grimston. Electric steering gear.
8,967. Gentzsch and Others. Insulating material for cables.
11,528. Whitaker and Treharne. Electric insulators.
13,164. Wise. (Maschinenfabrik Oerlikon). Dynamos.
19,947. Moradelu. Electric contact devices.
20,028. Chaplin, F. J. and R. Dynamos.
20,883. Justice (Nixon). Telephonic, &c., systems.
22,004. Cummings and Gawkey. Electrical conduits.
22,066. Drake and Gorham. Switches.
22,120. Allan and Others. Storage batteries.
22,337. Edison and Swan United Electric Light Company (Limited) and Hill. Incandescent electric lamps.
22,600. Kitsée. Telegraphic communication.
22,696. Thompson (Mathiesen). Arc lamps.

COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Company (Limited).

The forty-seventh half-yearly ordinary general meeting of this Company was held on Thursday, January 23, 1896, under the presidency of the Most Hon. the Marquis of Tweeddale (the Vice-chairman).

The SECRETARY (Mr. George Draper) having read the notice convening the meeting and the minutes of the last general meeting, which were confirmed by the present meeting and signed by the Chairman as correct,

The CHAIRMAN: Gentlemen, I regret very much to say that our respected Chairman, Sir John Pender, is confined to his house to-day. I hope the indisposition from which he is suffering will pass away speedily, and I believe that a little rest from his arduous labours, and, perhaps, a visit to a more genial climate, will restore him to his usual good health. Fortunately for me I shall have, I believe, very little difficulty in recommending the approval of the report and accounts. The half-year which is under review to-day is the most satisfactory one that this Company has ever experienced. It is distinguished by two very satisfactory features. One is the large increase in the receipts, and the other is the decrease in the expenses. In the figures which I shall now refer to this will be fully borne out.

The gross revenue for the half-year under review amounted to £409,780, as against in the corresponding period of 1894 £362,557, or an increase of £47,223. An analysis of the message receipts from the various sources shows a satisfactory increase in nearly all classes of traffic, but the principal increase is in the traffic with West Australia and South Africa, which is due to the activity which has taken place in the gold-mining markets. With regard to the traffic with South Africa it is satisfactory to note that, notwithstanding the large reductions made in the tariff, an increase has taken place on the value of the traffic at the former rates, but as this is entirely due to special circumstances we can hardly count upon its being maintained.

The total ordinary expenses for the half-year ended September 30, 1895, amounted to £96,704, as against, in the corresponding period of 1894, £97,533, or a decrease of £829. The details of increases and decreases in the various headings of the accounts are as follows: The general expenses in London were £8,888, as against, in the corresponding period of 1894, £8,493, or an increase of £395. The principal increase will be found in salaries, rent, and fuel and light, and repairs and renewals of furniture, due to the additional number of staff and increased office accommodation required to cope with the greater volume of business. The working expenses at stations were £80,400, as against in the corresponding period of 1894 £79,316, or an increase of £1,084. Many satisfactory decreases are shown in several of the items under this head. Increases are mainly due to the salaries, lodging allowances, and other accounts more directly affected by the additional traffic which had to be carried. We have given the usual annual promotions to the permanent members of our staff, in accordance with the principle laid down by the Board, and this is an increase which I am sure that no one here will begrudge to those gentlemen. The number of staff at the stations in September, 1895, was 746, as against in September, 1894, 726, or an increase of 20. So long as we can show an increase in the revenue of the Company, and at the same time keep the total ordinary expenses within reasonable limits, I think you will agree with me that it is a very satisfactory position to be in.

Notwithstanding, as I have already pointed out, a considerable increase in the revenue this half-year, the total ordinary expenses actually show a decrease, as I have said, of £829. Although every care is exercised in controlling the working expenses, you must not be surprised if at some future date the figures are increased. Our business, in fact, is growing rapidly, and the increase is so large that an augmentation in the expenses must be contemplated by you.

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Turning now to the expenses attending repair and renewals of cables, they amounted to £47,165, as against in the corresponding period of 1894, £43,709, or an increase of £3,456. This, as you all know, is a very uncertain item in the accounts of a submarine telegraph company. It is a very fluctuatitem. Some half-years the cost of repairs is larger than at other times. This half-year these expenses have been slightly larger, but perhaps in the coming half-year they may be less. As regards our ships, we believe that the greatest economy is achieved by keeping them in a state of the highest efficiency, but you cannot keep ships in a high state of efficiency without spending a good deal of money. We are enabled by this means to restore communication in the shortest possible time, thus saving the Company in many cases loss of traffic, and at the same time maintaining a good and efficient service to the Government, the Press, and the telegraphing public generally. I think the repair to the Eastern and South African Company's Cable between Aden and Zanzibar, which was so promptly effected by one of our ships during the late crisis in the Transvaal, affords a satisfactory proof of the efficiency of our service, if any proof were required. As another example of the energy with which the Company deals with the restoration of communication in the event of interruptions of traffic, I may mention a case which has lately occurred near Delagoa Bay. The cable steamer "Great Northern," which is usually stationed at Cape Town, was ordered to Zanzibar with instructions to call at the various ports *en route* in case of any break occurring during these troublous times. The ship arrived at Delagoa Bay on the 18th inst., and the cable became interrupted the following day. The ship, however, being within 29 miles of the break, the line was promptly repaired, and communication by the cable restored. The traffic in the meantime passed over the land lines to and from Delagoa Bay.

Full details of the work done by our ships during the half-year will be found on page 6, Abstract C, and I think a perusal of those details will justify the immense importance we attach to maintaining our ships in a high state of efficiency and ready for any emergency. With respect to that expenditure on the ship "Amber," I may mention that notwithstanding the extensive repairs and general overhaul which that vessel required, the expenses of which are included in this half-year's accounts, the total expenses of the ship are little more than they were in the corresponding period of 1894.

The next item with which I have to deal is the depreciation of spare cable, which amounted to £3,423, as against in the corresponding period of 1894, £4,815, or a decrease of £1,392. As previously explained, this item must vary according to the stock of cable in our tanks from time to time. After providing the usual amount for interest on debentures and debenture stock, and the usual two quarterly dividends, we are enabled to carry £10,000 to the maintenance ships' reserve fund, £50,000 ot the general reserve fund, and the balance of £49,352 is carried forward to the next half-year—a result which I think justifies what I have said with reference to the prosperous condition of your Company. We have applied a further sum of £50,000 from reserve fund in reduction of the cost of the Aden-Bombay No. 3 cable, leaving a balance of £70,000 still to write off; but I am glad to say that the cost of this cable will have been wholly applied to reserve fund when we put before you the accounts to the end of our financial year up to March 31st next.

The value of our investments on account of reserve fund at September 30th last amounted to £423,000 but they showed an appreciation of nearly £60,000, so that altogether the accounts presented to-day may fairly be considered as very satisfactory. With respect to the condition of our cables, I am glad to be able to say that, generally speaking, they are in good working order; but they are, as you know, of all ages and all lengths, and in seas differing very much in their condition with respect to cable-laying. You are also aware of the numerous breaks and interruptions that occur in them. All this, taken together, should warn us that we should add—we are, in fact, bound to add—to our reserve fund, which is still, in the opinion of all whose opinion is worth having, in a very inadequate condition. The general reserve fund amounts to £472,786, but it ought to be something like double that before we can consider it in a satisfactory state.

And now, gentlemen, I think it will interest you to know the actual facts with reference to our recent interruption on the east and west coasts of Africa. On December 24th the Aden-Zanzibar cable became interrupted. We had two ships available for its repair—one belonging to the Eastern Company, which had just left Suez and was on its way to Aden; the other one, belonging to the Eastern and South African Company, was stationed at Cape Town. The Eastern and South African Company found that by hiring the Eastern Company's ship a saving of about a week in restoring the cable would be effected, and orders were immediately given for the Eastern Company's vessel to proceed to the spot. The Aden end was hooked at the second sweep, and communication was restored via the East Coast on the evening of Saturday, January 4th. Meanwhile events had happened in the Transvaal of which you are all well aware, and our West Coast route had been called upon to perform, not only the whole of the ordinary traffic, but also of an enormous amount of additional traffic. Until the morning of December 30th the West Coast line was able to keep up to the work, but on the news of Dr. Jameson having crossed the Transvaal frontier, the line was occupied almost entirely by telegrams sent by and to European Governments. It may not be generally known that Governments have the right under the International Telegraph Convention, of priority of transmission for all their messages, and this particular traffic was transmitted without exceptional delay. Immediately the East Coast route was restored the delay began to diminish, and on January 10th we had completely recovered our normal working, which was owing not only to our having two lines available, but also to the cessation of the special Government traffic. It was a time of great anxiety for us, as you may easily suppose. We desired, above everything, to be absolutely fair, and to treat the whole of our traffic in accordance with telegraph law, and I cannot help saying that I think we succeeded (hear, hear). At any rate not a single complaint, as far as I am aware, has come from our own Government. On the contrary, I have reason to think our own Government is highly satisfied at the way in which their business was done. We have also not received any complaint from any other Government, foreign or otherwise, who, of course, have very large and important interests in connection with South Africa. I think I have said all that is necessary to recommend to you the adoption of our report and accounts. I think we may look forward to the coming half-year with confidence. The war clouds are lifting in every direction, and traffics continue good, reflecting, I believe, the greatly improved condition of business and commerce. With these observations I beg to move the adoption of the report and accounts.

Lord SACKVILLE A. CECIL: I second that.

The CHAIRMAN: It has been moved and seconded—

"*That the report and accounts be received and adopted.*"

Before putting the motion I will invite any observations which gentlemen opposite may wish to offer to the shareholders.

Mr. BAINES: Brother shareholders, before making any remarks on the report I must express my regret at hearing that Sir John Pender is unwell. I trust that this will be of a very temporary character, and that he will soon be among us once more. I daresay the entire meeting will only be too ready to ask some gentleman on the Board to convey to Sir John Pender our expression of sincere regret at his indisposition. We have again to congratulate ourselves on having had a very good half-year—better than ever. In fact, that has been the tenour of our reports for some little time, but I regret to say that notwithstanding that our dividend never increases. I have been connected with this Company for a quarter of a century or more, and I notice that the dividend is very stationary. You are doing very considerable business, and are rendering great services to the public, and after such a length of time, and after doubling, triplicating, and quadrupling our cables, it stands to reason that we shareholders, who have borne the brunt of the battle, ought to look to getting some benefit ourselves. The Preference shareholders are well secured, and so are the Debenture holders, and we have to bear considerably more burden than appears on the surface. There are certain benevolent funds to which we contribute which come entirely from the Ordinary shareholders. I do not think that the Debenture holders or Preference shareholders have ever been called upon to subscribe to that fund, which is thought to be a very necessary one. The large sum of £50,000 is carried to the reserve fund, and a very large sum is carried forward, but I think that the Directors ought to have taken the interests of the Ordinary shareholders into consideration. I regret that his Lordship has not said anything touching on their interests either in the present or the future. I think that that is a matter of regret. There are several items of satisfaction brought to our notice on this occasion. The reduction in the expenditure is a good feature, and I wish to impress on the Board, as I have done before, the necessity of taking into consideration the interests of the Ordinary shareholders. I think that the Company has such an amount of money at its disposal that it might do something for them. We see our stock standing in the market at 17, or a trifle over. Perhaps the Directors find themselves in some difficulty as regards increasing the dividend on account of clamour from the Press or from those who do business with us, but I should think that they might devise some scheme by which the increase of dividend would not be apparent (laughter). I think that in a commercial enterprise such as ours 6½ per cent. is not such a very brilliant return. There is, however, that point which I have just mentioned to be guarded against. I would therefore suggest to the Board a scheme something of this character. We see our Ordinary stock standing at something like 17. Would it not be possible for them to give an additional share for each of the Ordinary shares, and thus let us have some benefit from the position which the Company has attained to? If the Board find that they cannot do that, there is a sum of about £3, the difference between £7 and £10, which each shareholder might be called upon to pay. That might be carried to the reserve fund, which would in that way be strengthened very materially. What would it matter if we got 4 per cent., as, it being on two shares instead of one, we should be getting 8 per cent., which I think is only a fair return doing the work which the Company does not only in serving commerce, but other interests. This is really the crux of the whole question. I as a shareholder am not altogether satisfied with the present state of things. I do not say that what is paid is a small or despicable dividend, but I say that a company like this, doing the work it does, having the capital it has at its command, and serving the public as it does, the shareholders certainly are deserving of a better return than 6½ per cent. Why, some ordinary banks of very recent formation pay dividends of 8 per cent. and 10 per cent., and a commercial company, considering the risks we run, ought to have more than 6½ per cent, which is not enough. I trust it will not be necessary for me to propose a resolution, which, however, I think I shall do, unless some notice is taken at a future meeting of the observations I have now made. I hope that it may not be necessary for me to do so, but that the Board will themselves take this matter into consideration, and deal liberally with the Ordinary shareholders.

After a few observations from Mr. W. GOODSALL on the subject of the reserve fund and of increasing the dividend,

Mr. JOHN NEWTON said: I am afraid I shall be contrary to the general sense of the meeting, judging from the remarks which have been made, as regards the question of the dividend. I do not consider it a small one, but a very good one (Oh!). I want, however, in the first place, to give expression to the universal sentiment of regret felt by us at not having our own chairman with us. He has been with us so long that we miss him very greatly. It is, however, to be hoped that he will soon be among us again restored to health. Reverting to the question of dividend, I think the Company presents to the investor such a remarkable career of success that we can well afford to leave the management of the business and of its

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finances to the Board. Certainly I trust that there will be no manipulation of the stock in the direction of "watering" it and trying to obfuscate and deceive foreign Governments. As if such a thing were possible! If you were to give me an extra share for every share I hold, do you think that the Government or the public would not know what you were doing and that you were really paying me 8 per cent. or 10 per cent. if you gave me 4 per cent. or 5 per cent.? It would be well known to the experienced men who attend the Telegraph Conference, who are certainly impelled in their action by the large dividends which are talked about and paid. It is very remarkable that the gentleman who has occupied our time, and done so for much longer than I, should try to put me down by calling out "Time." He ought to know that I should not think of sitting down for any such cry (laughter). I think the position of the Debentures and Preference shares in the market is an indication to the shareholders that they are very well served, and they see their Ordinary shares standing at 17, or 70 per cent. premium. Bear in mind that you have to deal with competitors if you show a very large dividend. What is the use of doing anything that would induce others to establish other cables which would compete with us? What has been the case with the Anglo-American Telegraph Company through showing such large earnings in the past? What has been the result except that of bringing about a competition which is as severe as it is possible to find in any business, keen as competition is in everything? I therefore say leave well alone, especially when that well is being attended to by such successful Directors as we have. Surely when the Chairman tells you that it is necessary to increase your reserve fund you will take advantage of exceedingly good years to make the increase which is necessary in order to ensure your dividend being maintained. As solid quarterly dividend-paying companies there are none to equal the Eastern and Eastern Extension, I trust that there will be no attempt to split or "water" the stock, as it would be thoroughly well known what that would mean.

Mr. WOOD: I think that our friend hardly understood what Mr. Baines said; but I understood that his idea in doubling the shares was to carry a larger amount, if necessary, to the reserve fund, which would place us in a better position even than we are now in. Shareholders in the Aerated Bread Company often have shares issued to them in proportion to their holdings. I think that if £3 a share were transferred to our reserve fund it would be a considerable help to us. All these shares would be taken up and the shareholders would derive a benefit, whereas at present they cannot get any benefit unless they sell out, and they do not want to do that. I think that the idea of Mr. Baines is a very good one; but it is merely a suggestion. We have a right on this side to suggest what we like, and what Mr. Baines has suggested would improve the position of the shareholders and strengthen the Company in the direction of the reserve fund.

The CHAIRMAN: Gentlemen, let me assure you that I shall take an opportunity of conveying to our Chairman the kind expressions which have fallen from the speakers who have addressed the chair to-day, and whose remarks have been so cordially received by the whole body of shareholders (hear, hear). Mr. Baines has repeated the remarks which he made on a former occasion, and complained that the dividend is not sufficiently large; but I would remind him, in the first place, that this is the half-yearly meeting, and that at the half-yearly meetings the dividend is always very much less, or it is always expected that the dividend at the close of the financial year will be larger than that for the first half of the year. His remarks and suggestions, however, will, of course, receive, as they have always received, the careful consideration of the Board, and if we can see our way to meet his wishes on the subject of dividend without interfering with the policy which has been pursued over since this Company has been formed, we shall be very glad to do it. That policy may be stated in very few words—namely, in the first place, to keep our capital account as low as possible; in the second place to pay a fair dividend, and in the third place to build up an adequate reserve fund. I think we have fulfilled the first two conditions—that is to say, we have kept our capital practically stationary for a great many years, and we have paid, I think it must be admitted even by Mr. Baines, a fair dividend ever since this Company was started. It might be described as a liberal dividend. The third condition, however, has not been fulfilled; our reserve fund is not adequate, and it will take some time before it is. You must not suppose that this large gross revenue will always remain as large as it is at present. Suppose, for instance, a cable or cables are laid across the Pacific, that would affect our traffic very considerably. It is not impossible that that may happen in a shorter time even than we should like. When it does come off, which it is bound to do some day or another our traffics will be certainly affected, and it would take us all our time to compete successfully and profitably with our rivals in the Pacific. With respect to the suggestion to issue copies of the proceedings at the general meetings, we did at one time issue copies to the shareholders, but it was given up on account of the cost. It is not a very large sum, I quite admit, and probably it was given up at a time when we were not in so flourishing a state as we are in now. If we find that the shareholders generally would like a copy sent to each of them, we shall be very glad to meet their wishes in that respect, and with reference to the frequent breaking down of the Tangiers-Gibraltar cable, it is not due to want of care or trouble that the breaks take place. We do not like breaks because they cost us money. I do not think I have anything to answer with respect to the remarks made by Mr. Newton; in fact Mr. Newton has really done what I have attempted to do, and I believe he did it much better. He answered the criticisms in a very satisfactory manner, a manner very agreeable to the Board, because we take the same view as he does with respect to the matters commented on. Mr. Wood, I think, endorsed Mr. Baines's opinions, but, as I said before, Mr. Baines's opinions and suggestions will be considered by the Board, and shareholders must suspend their judgment until the close of the financial year. I think it is a peculiarity in this Board that the re-election of the Directors takes place in the middle of the year, or in the first half-year, instead of at the close of the year. Perhaps that led gentlemen to suppose that this was the closing half-year, but it is not so. The end of our financial year will be six months hence. I think I have answered all the questions which have been addressed to me, and I will now, with your permission, put the motion for the adoption of the report and accounts. That has been seconded by Lord Sackville Cecil. Those in favour of it will signify the same in the usual manner by holding up their hands. On the contrary. Carried unanimously. I have now to propose—

"*That Lord Sackville A. Cecil, who now retires, be and he is hereby re-elected a Director of the Company.*"

Sir ALBERT J. LEPPOC CAPPEL, K.C.I.E.: I beg leave to second that.

The CHAIRMAN put the motion in the usual way, and declared it carried unanimously.

Lord SACKVILLE CECIL: I am much obliged to you, gentlemen, for this renewal of your confidence.

The CHAIRMAN: I have now to move—

"*That George Garden Nicol, Esq., who now retires, be and he is hereby re-elected a Director of the Company.*"

I regret to say that Mr. Nicol is also indisposed, and not able to be present among us to-day. He has been attending our meetings regularly up to a very recent period. I only hope that his indisposition is merely temporary. As you know, Mr. Nicol, Sir John Pender, and myself are the three original Directors of this Company. I beg to move the resolution.

Lord SACKVILLE CECIL: I second that.

The CHAIRMAN put the motion in the usual way, and, having declared it carried, said: The only other business now is the election of auditors. That will be done by gentlemen in the body of the hall.

Mr. BAINES: It is my duty to move the re-election of the auditors. Generally speaking, I have had some remarks to make with respect to the audit of the accounts, because this is a matter of importance to shareholders to look after. Occasionally we see the false impression which auditors' certificates convey. The certificate of our auditors is certainly characterised by its brevity, for it simply says "Audited and found correct." Now that is very concise, and I hope it is satisfactory. I now beg leave to move the re-election of the auditors, Messrs. Deloitte, Dever, Griffiths and Co., and Messrs. Welton, Jones and Co.

Mr. WOOD: I have much pleasure in seconding that.

The CHAIRMAN put the motion, and having declared it carried, said: Gentlemen, that constitutes the business of the meeting.

Mr. NEWTON: It is not usual for these meetings to separate without passing a vote of thanks to the Chairman and his colleagues. I think they are entitled to a vote of thanks in this Company far more than they are in the case of some other companies. I therefore have much pleasure in proposing a vote of thanks to the Chairman and Directors for the successful way in which they have managed this Company throughout its long career.

Mr. GRIFFITH: I have much pleasure in seconding the resolution.

The motion was carried unanimously.

The CHAIRMAN: On the part of my colleagues and myself I beg to thank you, gentlemen, and I hope that we shall continue to deserve the confidence which you have been good enough to express towards us.

The proceedings then terminated.

City and South London Railway Company.

The twenty-third ordinary general meeting of the proprietors of this Company was held at Winchester House, Old Broad-street, on Tuesday under the presidency of Mr. Charles Grey Mott.

The SECRETARY (Mr. W. F. Knight) read the notice calling the meeting, and the seal was affixed to the register of shareholders.

The CHAIRMAN said: I now have to move the adoption of the report and statement of accounts. We have again, I am glad to say, to report that we have carried over three millions of people with perfect safety, and with almost absolute punctuality, during the past half-year. You will notice that there has been a decrease in the number of passengers, as compared with the corresponding period of 1894, of 103,000, but there is an increase in the numbers as compared with those carried in the June half-year of about 60,000. The decrease, as compared with those carried in the December half of 1894, is explained by two or three reasons. More than a year ago we increased the fares in order to diminish the overcrowding on the railway, and that had a very decided effect in decreasing the number of passengers. Then we had during the first three months of this half-year very fine weather, and it was exceptionally hot. As you are aware, this always has a prejudicial effect on the traffic of this line. The decrease at that time induced us to consider the question of revising the fares we had raised before, and we lowered them at one of the stations down to their old level. The result was that we immediately got an increase in the number of our passengers, and this compensated us for the loss we had had in the previous quarter, and resulted in our having a decrease only in the receipts for the half-year on passengers other than season-ticket holders of £350. On the other hand, the number of season tickets increased by 62, compared with the corresponding period of 1894, and the receipts from that source were £290 more. This gives us a net increase in our passenger receipts of £240 in the half-year. You remember that our object in raising the fares was to lessen the overcrowding which took place in the early morning trains especially. It had that effect, and the overcrowding decreased, but, unfortunately, as you know, it reduced our revenue in consequence. We have now partially recovered that decrease, and I hope that in the present half-year we shall show a decided increase both in number of passengers and receipts, but it has increased again the overcrowding of the trains. In order to meet that we have made an alteration at King William-street. It has proved a very difficult piece of work

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but by the devotion and ability of our engineer, the difficulties have been got over, and those alterations, I am glad to say, are completed and are brought into use. The advantage there is that we can have two trains at once in the station, as we have at Stockwell, and therefore there is no waiting for the train. The passenger at once proceeds into the train without any delay of that kind, and we are already enabled to run several additional trains in the hour; and when all the appliances are in good working order, we hope to increase the number still further. This will enable us again to diminish the overcrowding, I hope, and give some better accommodation for passengers in the morning. Unfortunately at the present moment we have often to turn away a large number of passengers, and frequently delay those who travel, and that injures our traffic very considerably, because, as you know, people coming to the City want to be absolutely certain of the time at which they will arrive, and delays of that kind lead them to make fresh arrangements, so that they do not travel by us at all. It also affects the increase of the residential population on our line, because without these facilities they seek some other neighbourhood where they will obtain them. We have now, I think, done everything we can, with our present line, to meet the traffic and to provide accommodation for it. We hope that these new arrangements will enable us to keep pace, as far as we can, and to prevent any very great overcrowding for perhaps another twelve months; but it is only a temporary provision, and we feel that the time has now arrived when we can no longer delay proceeding with the additional accommodation we propose to provide to enable us to deal with the traffic. We have been very careful and cautious in not going on with this work while we could avoid doing so, and our experience at the present moment, I fear, is that we have been over cautious, and have delayed the matter too long, It is evident that no time should be lost in proceeding with our extension and in providing sufficient accommodation to deal with the traffic; and in our report we ask for your authority to proceed at once with that portion of the Islington extension which lies between its connection with the existing line and Finsbury Pavement, adjoining the Moorgate-street station of the Metropolitan Railway. To meet the additional trains we are now beginning to run, we have ordered new carriages, which have all been delivered, and they appear to be giving general satisfaction so far as they have been used. We have turned our attention especially to see if we could not possibly reduce the cost of working the line still further, and we have introduced a small new engine and dynamo into the engine house for that purpose, so as not to use so much current during the less busy hours in the day. By using this small engine we are able to save the expenditure of electric current and the consequent expenditure of fuel required to produce it. We are also about to erect a large condensing apparatus at Stockwell, which we are assured will save us considerably in the fuel consumed, and I trust that before we meet again we may be able to say that that has been the case. The condenser is now being made, and I hope will be fitted up before the summer. The new sidings at Stockwell are completed, and are just being brought into use. They will economise to a certain extent in not requiring the trains to be taken up and down the incline for their ordinary repairs. These are all the points, in connection with which we have been doing our best to decrease the cost of working the line as far as we can, and I hope that these new trains, on the other hand, will enable us to earn a little more revenue than we could otherwise get. We cannot, however, make this line a success until we get the extension carried out so as to enable us to convey the traffic, which is there ready for us when we are prepared to carry it. If you will turn to the accounts you will see in the case of the capital account that we have paid off the old terminable Debenture bonds to the amount of £9,400 in the half-year, and we have spent on capital account, on the new carriages, new engines and other matters £6,683, making a total on that account of £16,083. To enable us to do that we have issued Preference shares to the amount of £4,690, and have received in premiums on those shares £2,237, or a total of £6,927. In addition to that, as we were getting very poor interest on the balances at our bank, we reduced them as low as we could, and they are less by £6,740 than they were a year ago. We have other balances which have been increased, which give us a credit of £2,416, this making a total of £16,083, which is exactly the amount of the bonds and the expenditure. In turning to the revenue account you will see that the receipts from passengers are increased by £240, from parcels by £29, and from rent by £105. There are decreases, on the other hand, in transfer fees of £4, and in sundry receipts of £68, making a net increase of £302. With regard to the expenditure, the maintenance shows a decrease of £65, locomotive expenses £85, traffic expenses £50, general expenses £42, law charges £17, and rates and taxes £9. On the other hand, there is an increase of £97 in carriage repairs, and of £47 in passenger duty, making a net decrease in expenses of £124. The final result is that we have a net increased receipt of £302, a decreased expenditure of £124, and a decreased debenture interest of £337, or a total credit of £763. We have, however, a decreased bank interest of £20, and there is an increase in the preferential dividend—owing to the issue of these Preference shares to replace debentures—of £70. We are, therefore, better off by £673 in the half-year, which is very nearly equal to the increased dividend of ¼ per cent. You will naturally ask why we do not pay an increased dividend of ¼ per cent. The answer is that last year at this time we brought forward from the previous half-year a much larger balance than usual, and we took £417 to pay a dividend of 1¼ per cent. at that time. We have not that balance this half-year, and we have to find out of the receipts the £417 in order to give the same dividend as we paid last time. But we have done more than that. Instead of taking out of this fund £417 we have added to it £256, so that those two items together make the £673 which we have of increased receipts, and, therefore, although we appear as if we had made very little progress this half-year, we have really had a satisfactory increase in the relative earnings of the two half-years, which is nearly equal to ¼ per cent. Our working expenses this half-year have been 59·62 per cent., as compared with 60·9 per cent. in the corresponding period of the previous year, so that that is a definite decrease of more than 1 per cent. If you take off the cost of working the lifts, the railway expenses are 51½ per cent., against 52 per cent. in the December half of 1894. The receipts per train mile were 2s. 2d., or an increase of ¾d. per train mile, and the receipts per passenger were 1·80d., against 1·77d. a year ago. The locomotive expenses per train mile were 6·02d., against 6·03d. last half-year; and if you take off the cost of the carriage of coal, which other companies do not charge, it brings this item down to 4¾d. per train mile. I think I have already explained the reason why it is absolutely essential that we should go on and construct the extension of the railway. I am glad to say that we have made, so far as we can at the present moment, such satisfactory arrangements as regards the sites of the stations, which was the most important question at issue; and these arrangements make us pretty certain that we can carry that line through and complete it for the amount we stated this time last year as the estimated cost—namely, £280,000. Of course, it is absolutely impossible to say within a few thousands either one way or the other, but we hope we may carry out this work for less than that. We have taken the best estimates we can from engineers and others, and we believe that that extension can be carried out for this amount, and remembering that the length of the line is considerably over a mile, it will be done very cheaply if we do it for that figure. Seeing that we shall pass through and have to deal with the very busiest traffic in the world, perhaps, almost along its route, we cannot doubt for a moment that that extension will not only enable us to pay the interest on the Preferential shares we propose to issue to carry it out with, but will also leave us a large surplus to increase the dividend on the ordinary stock. I am sorry to say that we have lost the services of the engineer of this Company. Mr. Basil Mott has been with us ever since the line was making and ever since it has been opened as our engineer, and we are very sorry indeed to lose his services. At the same time we are also glad that he leaves us to take up a most important work in connection with the great Central London Railway which is now starting, and although we cannot but feel that we owe very much to his ability and devotion in the past, we feel that we must give him every good wish in the work he has undertaken. During the whole of the time he has been with us as engineer he has had under him a very able assistant in Mr. P. V. McMahon, and we felt that we could not do better in the interests of the Company than to appoint Mr. McMahon to succeed him. I trust that in the future I may be able to speak of Mr. McMahon in the same terms in which I am able to speak of his predecessor. As regards the Bill which we have introduced into Parliament, the powers under the Bill of 1893 for the extension to Islington will expire next August, making it necessary for us to introduce a Bill to extend the time, as we do not propose to proceed with the extension beyond Finsbury-pavement to the Angel, and it is for the purpose of obtaining an extension of time for the land required for that part of the line which we are not proceeding with at present that this Bill is introduced. It will not affect the proceedings we propose to carry on now, because we shall exercise the powers which now exist with respect to the sites we require for the proposed extension. We find also that in order to avoid interfering with the traffic of the streets in the High-street, Borough, and at the same time to enable us to get at and deal with the somewhat difficult junctions between the proposed new line and the existing line, which must be carried out without interfering with the traffic, it is desirable to sink a special shaft at that point of junction, and we have taken powers in this Bill to acquire a site for the sinking of that shaft in order to prevent our having to sink it in the street. We shall be able to get a site which will enable us to sink this shaft on property of our own. We also take power to sink a shaft a little further on in a corner of the street where there is no traffic passing. We have also certain other requirements in the Bill. We want to alter slightly at one of our City stations the mode of construction of the shafts for the lift. The Bill will come on afterwards at the special meeting. He concluded by moving the adoption of the report and accounts.

Mr. SAMPSON HANBURY seconded the motion, which was carried unanimously, and resolutions were afterwards passed declaring the full dividend of 5 per cent. on the Preference shares and a dividend at the rate of 1¼ per cent. per annum on the Ordinary stock, and re-electing the retiring Directors, Mr. Charles Seymour Grenfell and Mr. Edwin Tate—and the retiring auditor, Mr. James L. Oliver.

An extraordinary general meeting was then held.

The CHAIRMAN proposed—

"*That the additional capital sanctioned by the City and South London Railway Act, 1893, be, and the same is hereby created in 55,000 new Ordinary shares of £10 each, and 20,000 Preference shares of £10 each, bearing interest at the rate of 5 per centum per annum, and that the Directors be and they are hereby authorised to issue such shares in such amounts at such times, and on such terms and conditions as they may think fit. The holders of the Preference shares hereby created shall be entitled to vote on the same scale of voting as the holders of Ordinary shares.*"

This, he said, would create the 20,000 Preference shares which they proposed to use as set out in the Directors' report, which they had approved. They had very carefully considered the best mode of raising the money, and after discussing various reasons for and against, they thought it would not be desirable to create the capital at the present price of the Ordinary shares. The Preference shares of the Company were now selling at 50 per cent. premium, so that the Company would really only be paying about 3¼ per cent. on the money obtained by this issue, and they thought that they could not raise the capital they required at a lower rate than that. They would not think, while all this work was going on, of interfering in any way with the dividend on the Ordinary share capital until the line was opened and paying its own way. They therefore intended to issue the Preference

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shares, payable by instalments, or such portions as they wanted, for they would only require the money gradually over a period of two or two and a-half years. They therefore proposed to issue these Preference shares in such a way that the dividend would not come before the time estimated for the opening of the line and its being worked for some time. That was their general idea. He then moved the resolution.

Mr. BARCLAY HEWARD seconded the motion.

Mr. THOMAS HANBURY, in the course of a lengthy speech, opposed the proposal. He went into a calculation, showing the time it would take to get by omnibus or on foot from the corner of Lombard-street to London Bridge in comparison with the time it would take to travel by the projected line, and maintained that one could walk the distance as quickly, or by going by omnibus could save three minutes by not using the line. Since the past year the Ordinary stock had fallen from about 50 to 41, and he held that this was attributable to the confidence of the public having been shaken by the expenditure which the Directors proposed. By the resolution now proposed £10,000 a year would be placed before the £7,500 a year, which was all that the Ordinary shareholders had to go upon for a dividend. He contended that the so-called extension was really a new undertaking, and that it should be so constructed, if it were constructed at all, the public being asked for the capital in the usual way. The Brighton Company would virtually have nothing to do with the proposed extension. Opposition would also be given to the Directors' proposal on account of its involving the removal of the ancient church at the corner of Lombard-street for the site of a station. He concluded by proposing the following amendment:—

"*That the placing of £10,000 per annum in front of £7,500 per annum, the only income at present available for the ordinary shareholders, is unjust to them, and therefore the proposed issue of £200,000 of 5 per cent. preference shares be not authorised.*"

Mr. J. T. MIDDLETON said that having consistently opposed the extension at previous meetings, and as his opinion remained unchanged, he would second the amendment. He thought the Directors should avail themselves of the powers they had under their Act, and make the proposed extension a separate undertaking, as he opposed the placing of such a large number of Preference shares in front of the Ordinary stock.

Mr. DRAKE pointed out that at the last meeting the Directors were authorised to proceed with the scheme, and he had no doubt that most of the points which had been raised by Mr. Thomas Hanbury had been considered by the Board.

Other shareholders having addressed the meeting,

The CHAIRMAN stated that as they had adopted the report, he could hardly deal with the question of the desirability of the construction of the line. The question before them now was as to the best mode of raising the money. Mr. Middleton thought that it ought to be raised by a separate undertaking, but this matter had been very carefully considered, and they believed that it would be very undesirable in the interests of the Company to do anything of the kind. It would lead to extremely complicated working, and might result in the separate undertaking running away with the whole of the profit and leaving this Company with the risk besides. The more they looked into the matter the more they were satisfied that the extension should be carried out by the Company themselves, and the Directors were quite satisfied that the proposal would result in a very satisfactory addition to the ordinary dividend. It must be remembered that this was not an ordinary steam railway, but an electric railway worked on totally different principles. There was one definite generating point, and the extension of an electric line did not mean the extension of the expenses of working in the same way as it did with an ordinary steam railway. That was a most important point. They could not stop safely as they were. Mr. Hanbury's calculations were quite wrong as to the time taken in going by the proposed railway as compared with doing the journey on foot or by omnibus. They were going to make a station for the Brighton and South-Eastern Companies' traffic at London Bridge, and they would have there an underground connection up to the platform of the Brighton Company. He had not the least doubt that they would get a very large traffic there. With reference to the church at the corner of Lombard-street, it was only within the last two or three days that any opposition had been expressed to their taking it. The opposition came from the City Church Preservation Society, which did not represent the Ecclesiastical authorities, who had no objection to the Company taking the church. So far as the spiritual wants of the metropolis were concerned, it would be an enormous advantage, because the money paid for the site would be used for constructing churches in poor and populous districts on the outskirts of London, where churches were required. With regard to the architectural aspect of the question, opinions differed, and his own view was that a great improvement would be effected by removing the church and placing on the site a much more handsome building. It was, however, too late to discuss this question now, for all their arrangements were completed. The Preference shares would be of the same kind as those already issued, and the shareholders must leave the Board to do their best to carry out the arrangements on the best financial conditions possible. He then put the amendment, which was lost, and the original resolution was afterwards carried by an overwhelming majority. Continuing, he proposed—

"*That the Directors be and are hereby authorised to exercise the borrowing powers of the Company authorised by Section 82 of the City and South London Railway Act, 1893, by the creation and issue of Debenture stock.*"

The motion was seconded and carried.

A special general meeting was afterwards held, and

The CHAIRMAN proposed a resolution approving a Bill to extend the time for the purchase of land for the purposes of the City and South London Railway Act, 1893, for completing the underground railway and works thereby authorised, empowering the Company to acquire additional lands, and for "other purposes."

The SOLICITOR (Mr. Donald McMillan) explained the salient features of the Bill.

Mr. D. YOUNG seconded the resolution, which was carried.

On the motion of Mr. DRAKE, seconded by Mr. MIDDLETON, a cordial vote of thanks was passed to the Chairman, Directors, and the General Manager, Secretary and staff.

St. James' and Pall Mall Electric Light Company (Limited).

The report of the Directors for the year ended December 31st last, which will be presented to the shareholders at the ordinary general meeting to be held at the offices, Carnaby-street Central Station, Golden-square, London, W., on Tuesday next, at 12.30 p.m., states that the Directors are pleased to state that the business shows a steady increase, and that the position of the Company has been considerably strengthened during the past year. The building extension in Carnaby-street has been completed and the station equipped with its full plant, and the working of this and of the supply generally has proved most satisfactory.

The actions instituted by the Attorney-General on behalf of the Parish and by the Windham Club, alleging nuisance from the plant at Mason's yard Station, have been arranged. The Directors have disposed of the greater portion of the engine plant at Mason's-yard Station and are replacing it by machinery of a similar description to that in use at the Carnaby-street Station, and it is believed that the alterations have had the effect of putting an end to the annoyance complained of. The exceptional expenses incurred in the actions, and by the consequent change of machinery have been charged to revenue.

Certain negotiations have been in progress between the Directors and holders of Founders' shares with a view to the consolidation of interests, but no definite arrangement has been arrived at. In November, in accordance with the intimation given in the report of last year, a further issue of £20,000 Debenture Stock was made to the shareholders at 2½ per cent. premium, making a total of £50,000 already issued.

The net earnings of the Company during the past year have amounted to £14,580. 7s. 9d. Of this sum £5,498 was distributed in July last in payment of the interim dividend for the half-year ended June 30th, on the Ordinary shares, and 7 per cent. on the Preference shares. The balance of £9,082. 7s. 9d., together with £95. 3s. 7d. brought forward, leaves £9,177. 11s. 4d. now to be dealt with. The Directors propose to divide as follows:—

Dividend at the rate of 7 per cent. on the Preference shares for second half-year	£3,500	0	0
Dividend at the rate of 10½ per cent. for the second half-year on the Ordinary shares, making with the interim dividend 7½ for the year	5,244	15	0
Dividend of £2 19s. 6d. per share on the Founders' shares	297	10	0
Carried forward to Ordinary shareholders' undivided profit account	134	13	3
Carried forward to Founders' undivided profit account	13	1	
	£9,177	11	4

Mr. Walter Leaf and Mr. Bennett Fitch offer themselves for re-election as Directors, and Messrs. Deloitte, Dever, Griffiths and Co. as Auditors.

Yorkshire House-to-House Electricity Company (Limited).

The following report of the Directors of this Company for the year ended December 31st last will be presented to the ordinary general meeting to be held at the Electric Lighting Station, Whitehall-road, Leeds, on Tuesday next, at 2.30:—

The profit (including £162. 1s. 9d. brought forward) amounts to £6,483. 3s. 11d., which the Directors propose shall be appropriated as follows:—To reserve, for general purposes, £2,000; for depreciation, £1,300; payment of interim dividend at the rate of 4 per cent. per annum on the Ordinary shares for the half-year to June, 1895, £1,000; payment of final dividend at 6 per cent. for the half-year to December 31st (making 5 per cent. for the year), £1,500; payment of dividend at the rate of 5 per cent. on 18,948 shares on the amount called and paid up thereon from the respective times of payment to December 31, 1895, £165. 7s. 7d.; balance to carry forward, £517. 16s. 4d.; total, £6,483. 3s. 11d.

The works and plant of the Company have been maintained in an efficient state, and the quality of the supply of electrical energy continues to gives satisfaction. The number of lamps connected to the mains increased during the year from the equivalent of 19,858 to the equivalent of 32,539 35-watt lamps. A reduced scale of charges for current, at a maximum price of 6d. per unit, was brought into operation on July 1st last. The Leeds Corporation, in the last session of Parliament, introduced a Bill authorising them to construct and work electric or other tramways, which affected the Company's interests, and the Directors obtained the insertion of a clause in the Bill, by which the rights of the Company are protected. The Company's mains have been extended to Chapeltown, which has resulted in an encouraging demand for current. It having become apparent that the plant in operation will not suffice to meet the requirements for the winter of 1896, the Directors have decided upon an important extension of the Company's works, and arrangements are being made to carry out that object. In order to obtain the necessary capital, the remainder of the authorised capital, consisting of 9,900 Ordinary shares, was offered to the existing Ordinary shareholders *pro rata* to their previous holdings, and 8,848 shares were taken up.

Mr. Grosvenor Talbot and Mr. Robert Hudson offer themselves for re-election as Directors, and Mr. J. Gordon, Jun., as auditor.

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Anglo-American Telegraph Company (Limited).

The report of the Directors of this Company, to be presented at the ordinary general half-yearly meeting, to be held at Winchester House, Old Broad-street, London, on Friday next, at 2 o'clock, states that the total receipts from July 1st to December 31st last, including balance of £831. 2s. 7d. brought forward, amounted to £165,589. 11s., an increase of £15,764 compared with the corresponding period of last year. The total expenses of the half-year, including the repair of cables, &c., amounted to £54,795. 10s. 1d., a decrease of £1,056. 8s. 4d.

The Directors have, before declaring the net profits, set apart the sum of £12,000 to the Renewal Fund, leaving a balance to be dealt with of £93,794. 0s. 11d.

Interim quarterly dividends of 10s. per cent. on the Ordinary stock, and £1 per cent. on the Preferred stock, were paid on November 1st last, absorbing £35,000, leaving a balance of £63,794. 0s. 11d, out of which the Directors recommend the proprietors to declare final dividends of 18s. per cent. on the Ordinary stock and £1. 16s. per cent. on the Preferred stock, amounting to £63,000, making a total distribution for the year ended December 31st of £2. 9s. per cent. on the Ordinary stock, and £4. 18s. per cent. on the Preferred stock, and leaving £794. 0s. 11d. to be carried forward to the next account.

The Company's repairing steamship "Minia" has been employed during the past half-year in the repair of the 1873 cable, broken off the coast of Ireland, and of three cables between Newfoundland, Cape Breton and the United States. She has also been employed by the Direct United States Cable Company for the repair of cables belonging to that Company, the payment for which appears in the Revenue Account.

Proceedings in the French law suit are still pending.

Messrs. Francis A. Bevan and William S. Cunard offer themselves for re-election as Directors, and Messrs. Joshua Dean and John Gane as auditors.

Cambridge Electric Supply Company (Limited).

The Report of the Directors of this Company to December 31st last will be presented to the meeting of shareholders to be held to-day (Friday) at the Company's offices. It states that the prospects of the Company continue to be satisfactory. During the past year there has been added to the Company's mains the equivalent of 3,016 8 c.p. lamps, making the total 14,660. In addition to certain alterations, a new 75-unit dynamo and engine has just been added to the plant, bringing up the total capacity of the station to 525 units. A length of 903 yards of main conduit pipe has been added, making a total of 13,051 yards, whilst another sub-station, fully equipped, has been constructed to supply Trinity College, Trinity-street, Bridge-street, and Sidney-street. At the end of the year, one-third of the total supply was delivered from the sub-stations, resulting in a marked economy in fuel. The number of units supplied during the year has been 150,510, against 112,084, an increase of 38,426, or 35 per cent.

The Company has made a profit on the year's working of £1,489. 8s. 10d., which, added to £19. 12s. 2d. brought forward, leaves £1,509. 7s., and after paying £48. 11s. 11d. interest on debenture capital there remains a balance of £1,460. 15s. 1d., and the Directors recommend the payment of a dividend of 3½ per cent., absorbing £1,126. 17s. 11d., leaving £333. 17s. 2d. for depreciation and carrying forward.

NEW COMPANIES, STATUTORY RETURNS, &c.

ARMSTRONG POZZUOLI COMPANY (LIMITED).—This Company was registered on January 23rd, with a capital of £185,000, in £10 shares, to acquire the Italian branch of Sir W. G. Armstrong, Mitchell and Co. (Limited), to enter into an agreement for this purpose, and to carry on the business of hydraulic, electrical and general engineers, ordnance and torpedo manufacturers, &c.

ELECTRICAL APPLIANCES SYNDICATE (LIMITED).—This Company was registered on January 23rd with a nominal capital of £2,000, in £1 shares, to acquire any patents, patent rights, secret processes, inventions, trade marks, or other privileges in connection with electrical appliances, to sell, use, develop, or otherwise turn to account the same, and to erect and construct all necessary machinery and apparatus, workshops and other factories, telegraph, telephone and electric light and transmission wires and lines. The first subscribers are J. T. Hamilton, R. R. Morris and W. F. Hamilton (200 shares each), and James G. W. Aldridge, engineer, K. G. Metcalfe, H. Knight and D. Davies (one share each).

"KUMA" (LIMITED).—This Company was registered on January 22nd, with a capital of £10,000, in 5,000 Fifteen per Cent. Cumulative Preference and 5,000 Ordinary shares of £1 each, to acquire any patents or patent rights relating to the manufacture of a plastic material known as "Kuma," to enter into an agreement with P. W. Wierdsma and J. Kuipers, and to carry on the business of manufacturers of and dealers in plastic materials, chemicals, &c., engineers, electricians, electric supply contractors, metallurgists, &c.

PACIFIC AND EUROPEAN TELEGRAPH COMPANY (LIMITED).—The annual return to December 25th has just been filed. The whole nominal capital of £100,000, in £10 shares, has been subscribed, and a call of £4 per share has been made and paid.

PHŒBUS ELECTRIC BATTERY SYNDICATE (LIMITED).—The statutory return to December 12th has been filed. The nominal capital is £3,000, in £1 shares; 492 of these have been taken up, and the full amount per share has been paid.

PIONEER ELECTRIC CARRIAGE COMPANY (LIMITED).—The annual return to January 2nd has been filed; 64 shares have been subscribed for out of a capital of £20,000 in £50 shares, and the full amount has been called.

PORTABLE ELECTRIC LAMP COMPANY (LIMITED).—The statutory return to January 10th has been filed. The nominal capital is £50,000, in £1 shares. Only seven shares have been subscribed for, and the full amount has been paid thereon.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30⅜d. per oz. (Jan. 30th). Consols (2¾ per cent.) 107¼—108 for money, 107⅞—108 for account; 2½ per cent. 104½—104⅝ (Jan. 30th). Stock Exchange Settling Days: Consols, Feb. 3rd; Stocks and Shares Continuation Day, Feb. 11th; Ticket Day, Feb. 12th; Pay Day, Feb. 13th; Mining Share Carry-over Day, Feb. 10th.

BRIGHTON AND ROTTINGDEAN SEASHORE ELECTRIC TRAMROAD COMPANY (LIMITED).—At a recent meeting of this Company the Bill for extending the time for completing the line, and a resolution in favour of raising additional capital, were approved. The chairman said he believed the line would be open for traffic at Whitsuntide.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended January 26th amounted to £994, against £998 in the corresponding week of 1895, a decrease of £4. The total receipts for the half year are £4,035, against £3,999 for the corresponding period of 1895, an increase of £35.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The Directors of this Company recommend a dividend on the Ordinary shares at the rate of 8 per cent. per annum, free of income tax, for the half-year ended December 31st.

ELECTRIC TRACTION ON RAILWAYS.—Mr. John Bell, presiding at the meeting, on the 24th inst., of the Metropolitan Railway Company, stated, in submitting to the shareholders the various objects sought by the Bill which the Company has deposited in Parliament for next Session, that certain properties had been scheduled with the view of improving the ventilation of the line. It was a curious fact that on the subject of ventilation every one seemed to have a theory, but if the Company had tried on their railway one tithe of the experiments or theories for improving the ventilation, the shareholders would have received no dividend that day, and probably the atmosphere of the tunnel would not have been improved to any appreciable degree. They had always regarded electric traction with a longing eye. He had been twice to America—once at his own expense—with a view to seeing whether there was not some development of it which would be worthy of their trial, at all events, but he had found that there was nothing which could by any possibility be made capable of hauling trains of the capacity and weight of those run on the Metropolitan Railway. Up to the present they had found no one able to demonstrate satisfactorily that electric traction could be provided to meet the Company's requirements at the same cost as steam haulage. Still, it was their hope in the future. Daily developments of this wonderful power was being made, and at the present moment they were in communication with an electric supply company, who thought they saw their way to overcoming the difficulty which had hitherto prevailed. He need hardly say that the directors would welcome any success in that direction. While, however, they had been waiting for electricity as hauling power, they had not been unmindful of their duties to the public. Much had been done to secure a purer atmosphere, but they would like to do more, and it was with that object that they proposed to ask Parliament to sanction the purchase of the properties in question.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 26th inst. amounted to £1,043. The amount for the corresponding week last year was £943; increase, £100.

SCHUCKERT AND CO., NUREMBURG.—This Company is calling in for February 7th an extraordinary meeting of shareholders for the purposes of resolving upon the proposed increase of the capital by £300,000. The Company explains that the continuous growth of the business necessitates the building of further workshops, for which the funds in hand are not sufficient. More facility is especially wanted in the departments for traction work, search-light apparatus, chemical testing, &c. It is proposed to issue 6,000 shares of £50 each.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee has appointed Wednesday, February 5th, as a special settling day in the Provisional Certificates of the further issue of £100,000 Five per Cent. Debenture stock of the City of London Electric Lighting Company (Limited). An application has also been made to the Committee to appoint a settling day in and to grant a quotation for £105,000 Four and a-Half per Cent. Second Debenture stock of the Brush Electrical Engineering Company (Limited).

ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The share transfer book of this Company will be closed from January 27th to February 10th inclusive, preparatory to payment of half-yearly dividends to December 31st last.

SUBMARINE CABLES TRUST.—Notice is given that on and after the 1st February the sum of £1 5s., balance of the coupon due October 15, 1895, will be paid by Messrs. Glynn, Mills and Co., 59, Lombard-street, E.C. Coupons should be left four clear days for examination.

VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).—Coupon No. 11 of the 5 per cent. First Mortgage Debenture, due 31st inst., will be paid at the Consolidated Bank, Threadneedle-street, London, E.C., or at Messrs. Westendop and Co.'s Bank, Amsterdam. Coupons should be left four clear days for examination.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended January 24th, 1896, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,804.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Jan. 22.	Price Wednesday, Jan. 29.	Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending Jan. 25. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	10/0	Anglo-American	45 47	47 49	4 11 10	Jan., Apr., July, Oct.	45	..
£2,993,560	Stock	20 0	Do. Preferred	85½ 87½	87½ 88½	5 4 0	" "	87½	85
£2,993,560	Stock	5/0	Do. Deferred	6½ 6¾	7½ 8	..	.. ..	7⅞	6½
£173,400	100	4%	African Direct Teleg. 4% Deb. (Reg. & Bearer)	100 104	100 104	3 17 1	January and July ..	..	..
£250,000	£10	..	Amazon Telegraph	9½ 10¼	9½ 10½	..	.. ..	..	..
130,000	£10	9/0	Brazilian Submarine	13 13½	3½ 13¾	5 11 10	Mar., June, Oct., Dec.	13½	13⅛
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110 114	110 114	5 8 1	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	160 170	160 170	3 2 4	Jan., Apr., July, Oct.	..	..
16,000	10	3/0	Cuba Submarine	12½ 13½	12½ 13½	5 14 4	February and August	12¼	..
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	2 ½ 2 ⅛	4 13 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	3½ 4½	4 5	4 0 0	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 5 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	102½ 105½	104½ 107½	4 4 4	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8 8½	8½ 9	4 8 11	Jan., Apr., July, Oct.	8¼	..
400,000	10	2/6	Eastern	16½ 16¾	16¾ 17½	3 16 4	" "	17⅛	16½
70,000	10	6%	Do. 6 per Cent. Preference	17½ 18½	18 18½	3 4 10	" "	18	17 5/16
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	120 123	126 129	3 2 6	May and November	128½	124½
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1892	107 110	107 110	4 13 0	February & August	..	..
250,000	10	2/6	Eastern Extension	17 17½	17½ 8	3 17 9	Jan., Apr., July, Oct.	17¾	17½
£820,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128 131	129 33	3 1 5	February & August	129½	129½
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	100 104	100 1 4	4 16 7	January and July .	103½	..
£80 600	100	5%	* Eastern and S. African 5 p. Cent. Mor. Deb., 1900	1 0 104	1 0 1 4	4 16 7	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	107 110	107 110	3 4 1	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115	114% 115	3 9 10	May and November	..	..
180,227	10	1/6	Globe Telegraph and Trust	9½ 10	9½ 10½	4 0 6	Jan., Apr., July, Oct.	10	9½
180,012	10	6%	Do. 6 per Cent. Preference	16½ 17	16½ 17	3 10 7	" "	16⅛	16½
150,000	10	5/0	Great Northern	21½ 22½	22 22½	3 15 7	Jan., April, and July	22 5/16	21½
£181,000	100	5%	* Do. 5 per Cent. Debentures, 1883 Issue	104 107	104 107	4 15 0	March & September	..	..
17,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	43½	43
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 110	106 110	5 11 7	March & September	..	..
£100,000	£100	4%	* Pacific European Tel. 4% Guar. Debs. "Red" 1942	108 111	108 111	3 12 3	.. ..	..	..
11,830	8	4/0	Reuter's	4½ 5½	4½ 5½	..	April and October ..	5½	..
8,331	£100 Cert.	3/0	Submarine Cables Trust 6 per Cent.	126 131	126 131	4 11 7	" "	129½	123
15,602	10	2/0	West African Telegraph	5½ 6½	5¾ 6½	..	January and July ..	..	..
£233,300	100	5%	Do. 5 per Cent. Debentures (red.)	101 104	101 1 4	4 18 0	March & September	..	..
30,000	10	2/0	West Coast of America	1 2	1 2	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	94 99	94 99	8 8 4	June and December	..	..
88,321	10	1/3	West India and Panama	¾ 1½	¾ 1½	..	.. ..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 10⅝	10½ 11½	5 6 8	May and November	10½	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	8½ 9½	9 11	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108 111	108 111	4 10 6	June and December	..	..
61,218	15	3/9	Western and Brazilian	9 9½	9 9½	5 4 0	May and November	..	..
33,129	7½	3/9	Do. 5 per Cent. Cumulative Preferred	6½ 6¾	6½ 6¾	..	.. ..	..	..
33,129	7½	1/6	Do. Deferred Ordinary	2¾ 3½	3 3½	..	..	3 5/16	3½
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	104 107	104 1 8	5 14 3	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	1 4 1 8	5 14 3	" "	..	..
$1,177,000	$1,000	7%	* Western Union 7% 1st Mort. (Building) Bonds	113 118	1 3 118	6 0 5	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	102 105	102 105	5 17 8	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3½ 3¾	3½ 3¾	..	..	—	—
221,850	10/0	1¼	Consolidated Telephone Const. & Maintenance	1/16 1/8	1/16 1/8	..	May and November	..	..
171,504	£1	8/-15	Oriental Telephone and Electric (fully paid)	1/16 1/8	1/16 1/8	..	Yearly	..	..
484,597	5	2/6	National	6 6½	6¼ 6⅝	3 18 5	June and December	6½	5½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	15½ 16½	16 17	3 10 7	" "	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅜ 6⅝	6¼ 6⅝	4 8 11	— —	6 1/16	—
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	104 107	104 107	3 19 8	January and July ..	106	105
58,000	5	3/0	United River Plate	2½ 3	2½ 3	..	" "	..	..
£145,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	90 95	90 95	5 5 10	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	12⅜ 13½	13½ 14½	1 14 6	—	13½	13½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15½ 16½	15⅝ 16½	3 18 10	—	16	15 5/16
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	133 137	134 138	3 13 9	June and December	135⅜	—
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	—	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½ 5¾	5½ 5¾	..	—	5½	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	—	..	..
2,475	£8	..	County of London & Brush Prov. Ord. (fully paid)	8 9	8 9	..	—	..	..
10,000	£10	9½d.	Do. Pref. (£8 paid)	10½ 11	10½ 11	..	—	..	..
8,822	£5	..	House-to-House Electric	.. ..	.. ..	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July ..	..	..
45,000	£5	8/0	Liverpool Electric Supply (fully paid)	7⅞ 8½	7⅞ 8½	3 13 10	—	..	..
111,000	5	..	London Electric Supply	.. ..	.. ..	..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	10½ 11½	11½ 12½	3 12 0	—	11	..
150,000	Stock	4½%	* Do. 4½% Debs.	114 117	115 118	3 16 6	June and December	..	..
6,462	£10	2/0	Notting Hill Electric	8½ 9	8½ 9	..	—	..	..
..	..	..	Rand Electric	¼ ½ prem	¼ ½ prem.	..	—	..	..
19,980	£5	2/0	St. James and Pall Mall	8½ 9	8½ 9	..	—	..	..
20,000	£5	7%	Do. 7 per Cent. Preference	9 9½	9 9½	3 13 8	—	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8½ 9½	8½ 9½	2 19 6	—	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/3	Brush Electrical Engineering	1 1½	1 1½	12 1 0	—	1	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝ 1¾	1⅝ 1¾	6 8 0	—	1¾	1⅝
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112 1 5	113 115	3 19 10	March & September	113½	..
28,180	5	..	Crompton and Co., 7 per Cent. Cumulative Pref.	2 2½	2 2½	..	January and July ..	..	..
80,261	5	1/6	Edison and Swan United	1½ 1⅝	1½ 1⅝	..	..	..	..
£103,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 4 5	..	105	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	.. ..	..	..	..	..
110,000	2	..	Electric Construction	⅜ ½	⅜ ½	..	..	..	..
12,845	2	2 9/8	Do. 7 per Cent. Cumulative Pref.	2 2½	2 2½	5 11 0	..	..	..
91,195	2	10,0	Elmore's Patent Copper Depositing	½ ⅝	⅜ ½	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½ ⅝	½ ⅝	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	20 21	20½ 21½	3 9 9	February & August	21	19½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	102 1 4	102 104	4 7 10	March & September	..	..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	⅜ ½	⅜ ½	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	43 45	44 46	5 4 5	March and July	45	44
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	103 105	4 15 8	January and July .	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	13½ 14½	13½ 14½	4 2 9	—	13½	..
£50,000	10	7/0	Do. 7 per Cent. Preference	15½ 16½	15½ 16½	4 4 10	—	..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108 111	108 111	4 2 7	—	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway	40 41	40 42	2 16 6	May and November	41⅜	40⅜
7,650	10	5%	Do. 5% Perpetual Preference	14½ 15½	14½ 15½	3 5 7	..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	180 182	180 182	3 0 7	May and November	..	..
37,500	£10	2½%	Liverpool Overhead Railway	11⅛ 12 5/16	12⅜ 12½	1 16 0	—	..	..
10,000	10	5%	Do. 5% Preference	15½ 16	15⅝ 16	3 3 6	—	..	..
145,000	Stock	4%	Do. 4% Debenture	112 114	113 114	3 10 2	January and July ..	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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NOTES.

We learn from copious advertisements appearing in various daily papers that the investing public has been called upon to subscribe some £77,000 on behalf of the Town and Village Electric Light and Power Company between 10 a.m. on Wednesday and 4 p.m. yesterday. If the required amount be not obtained, the failure will not be due to adverse criticism by technical journals; since these have had no opportunity of expressing an opinion on the Parfitt series-system of lighting since May last and the opinions then expressed do not figure amongst the many quoted, although room has been found for the valuable testimonial of *The South African Financial Record*. We may say at once that the Parfitt idea of bifurcating the outgoing lead and cross-connecting the bifurcations at intervals is a good one; the system has also been subjected to a lengthy trial under practical conditions, and the electromagnetic switch appears to have come out of it satisfactorily; finally, the granting of American and German patents may fairly be taken as a stronger evidence of novelty than the granting of an English patent, which is practically no evidence at all. On the other hand, now that the Board of Trade limit for low pressure has been raised to 500 volts a village supply on the three-wire system should prove quite as cheap as one on the Parfitt plan, and it would certainly be vastly more convenient. In other words, it is an open question whether, to put the matter in its lowest terms, the Parfitt system is the only one for the purpose in view. But what is the purpose in view? The lighting, apparently, of some of the "992 Urban District Councils, and more than 30,000 parishes, townships, hamlets and places" to be found in England and Wales. In no case where a house-to-house supply on any of the well-tried methods is feasible is it possible to imagine a supply on the Parfitt plan being rationally preferred; it only has advantages in the lighting of scattered districts by overhead wires. There is, it is true, an imposing number of villages to be electrically lighted. But a big field does not necessarily mean a big profit; the soil must be of a certain degree of fertility to be worth cultivating. A special company formed for the special purpose of running a special system in a special field—and as we hold in a specially poor field—does not commend itself to us as containing the elements of a commercial success in this year of grace. The device did not succeed particularly well in the early eighties, and there is no reason why it should succeed better in the late nineties.

In the prospectus of the Town and Village Electric Light and Power Company there is a mention of a gross profit of over 33 per cent. having been made on the operations of the Kingswood plant, this profit being exclusive of any charge for depreciation, repairs, renewals or establishment expenses. This is a peculiar though it may be technically correct way of foreshadowing probable future *nett* profits. But the serious *non sequitur* which follows, whilst it does credit to the ingenuity of the compilers of the advertisement, does not do equal credit to their ratiocinative powers:—"The foregoing practical test proves that the Company will be able to supply the Parfitt system for public and private lighting on advantageous terms to the consumers, and with very profitable results to the shareholders. The Syndicate having demonstrated the foregoing facts and established the commercial value of the invention this Company has now been formed. . . ." Facts, proofs, demonstrations—evidences of *commercial* value! The English dictionary had better be revised at once.

An article by Mr. H. P. Gaze, which will be found in another column, deals with a branch of research which may be of great importance. That paraffin and similar bodies insulate worse at high temperatures was, of course, well known, but the curious properties mentioned by Mr. Gaze have, we believe, been discovered by him. We do not exactly know what temperatures paraffin goes through during its manufacture or purification, but in making condensers the paraffin is generally kept continuously at a high temperature to drive the moisture out of the fibre when the paper is immersed, and in this connection Mr. Gaze's results are worthy of careful consideration. We do not think oil insulation is going to play a great part in the future. Dry paper is the best cheap insulator, and oil or wax merely reduces the insulation. It is only put there to keep out water.

As we recently remarked in a somewhat similar connection, it is a comparatively easy task to make objections and to foretell difficulties when any scheme of a more or less novel character is propounded. At the same time, when the air is full of military and naval novelties, it is as well that the public should not take all of them too seriously. A Mr. C. Scott Snell, for instance, has, in some recent issues of *Invention*, devoted his time and talents to working out a "Cable Defence Scheme." This scheme is as follows: Special 20-knot cruisers fitted with cable-laying apparatus, are to accompany each British squadron when on the warpath, and in this way

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the commanders of the aforesaid squadrons will be kept in touch with Whitehall; whether to the benefit of our naval operations may be doubted. But the general outline of a scheme of this character is as nothing compared with the carrying out of its details. To fully deal with Mr. SNELL's proposal, and to follow the author through the imaginary naval conflicts he so graphically depicts, would occupy too much of our space. Suffice it to say that while the author is evidently well ahead of the time in his ideas, he is a long way astern of current cable-engineering practice. We hope, however, on behalf of the "eminent manufacturers" that the following specification is not complete. It runs thus:—"The cable to consist of seven No. 22 tinned copper wires, and having No. 20 sheathed steel wires. Diameter 0·45in. Weight per knot 11·4cwt. in air, and 8·75cwt. in salt water. Price £60 per knot, and may be laid and lifted more than once." Mr. SNELL will, we feel sure, unnecessarily add to the difficulties of his scheme if he adheres too strictly to the above specification. In time of war, no doubt, something of the kind proposed by Mr. C. SCOTT SNELL will be done. In fact, it is an open secret that some years ago, when there was a probability of naval operations having to be undertaken by the British Government, it was arranged that the operating squadrons should be attended by cable steamers with a view to connecting them with their base. If the idea is still considered worthy of attention, it would certainly be well for the main details to be worked out by experienced cable and mechanical engineers, and at any rate pigeon-holed by the Admiralty. The job would probably furnish occupation to many able men for some time to come.

STUDENTS of the gas engine who are still puzzling over the many inexplicable points in gas-engine theory will be not a little astonished to hear from Mr. DUGALD CLERK that he propounded a theory so long ago as 1882 which is "now generally accepted." We are naturally inclined to wonder why, if this is the case, there has been so much pother about what goes on in a gas engine between the moment when the charge is fired and the moment when exhaust is completed. Indeed, most of the heavy fighting, if we may so express it, has taken place since 1882; and he would be a rash man who should say that even now the war of words is ended, and an ultimate theory peacefully agreed upon. Without doubt, Mr. DUGALD CLERK's 1882 Paper on "The Theory of the Gas Engine" (*Proc.* Inst. C. E., Vol. LXIX.) was a valuable contribution; and both it and the discussion which ensued did much to clear away many of the erroneous notions which were prevalent at the time, as well as to set the conditions of good gas-engine practice upon a better footing. But the main value of the Paper lay, not so much in its contribution to theory as in its practical bearing. So far as theory went, Mr. CLERK advocated the dissociation hypothesis of retarded combustion, a hypothesis which has always met with stout resistance from some of the ablest authorities. Not even to-day can we say to what extent dissociation plays a part in shaping the indicator diagram and the $\theta\phi$ diagram of a gas engine. The practical importance of compression in a gas-engine cycle is, however, well brought out in the 1882 Paper, and was at the time a valuable lesson to gas-engine makers. Nowadays no one would dream of questioning the value of this operation in a gas engine; but it may not be generally known to what extent modern improvements in gas-engine economy are due to an increase in the compression. The Paper on "Recent Developments in Gas Engines," which Mr. CLERK recently read before the Institution of Civil Engineers, an abstract of which we reprint this week, gives some useful information on this head.

SOME countries pride themselves upon the lightning-like rapidity with which they recognise and adopt improvements. England, on the other hand, has, until quite lately, taken a certain amount of pride in its surly suspicion of novelties. And the two facts taken together would seem to show that when it comes to being proud about anything, one thing will do as well as another. However, without wishing for one moment to cast any serious doubt upon the general principle of super-lengthy consideration, it is impossible not to think that it has been just a little overdone in the matter of the reform of the standard of light. So long ago as 1888, as Mr. DIBDIN tells us in his recent Paper at the Society of Arts, the Board of Trade, the London gas companies, and the London gas authorities "had all joined in one condemnation of the existing candle," and we quite agree with Mr. DIBDIN that in view of this unanimous condemnation by authorities usually conflicting, "an impartial observer would probably have drawn the conclusion that the time was then ripe for a change, and that legislation would follow without delay." Nevertheless, here we are at the beginning of 1896 in much the same position, scientifically speaking, that we were at the end of 1888; and it must be borne in mind that it is not a question of totally abolishing the Parliamentary candle, but merely of finding a more constant exponent of its many virtues than a spermaceti candle $\frac{7}{8}$in. in diameter burning 120 grains per hour (six candles to the pound). The pentane air-gas flame was in favour in 1888 and remains so to-day; the square-millimetre-of-positive-carbon standard being still in difficulties, experimental and natural. Small wonder, then, that the Expert Committee which was appointed in December, 1891, now recommends the adoption for use in gas testing of the Dibdin 10 c.p. pentane-Argand air-gas flame, and suggests that the gas referees should be given a little freedom in future in the matter of adopting and certifying improved standards. If it is to take something like a decade to obtain Parliamentary sanction for the adoption of an improved standard against which to test London gas, a century may very well be consumed in securing anything in the shape of a really radical reform, should such ever be required.

ONE speaker in the discussion on Mr. DIBDIN'S Paper seemed to think that the proposed standard was guaranteed to be constant everywhere, and under all conditions, and referred to its probable behaviour at 7,000ft. above and 3,000ft. below sea level. The 10-candle standard has been conclusively shown to be, as compared with the spermaceti candle, the mirror of constancy within

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the limits of London atmospheric pressure, temperature, &c. That fact, almost alone, should, one would think, suffice to secure the prompt adoption of this by no means startling innovation.

THE great convenience of a ready quantitative means of detecting the presence of Röntgen rays is apparent to every one. The photographic plate, in addition to being merely qualitative or at any rate directly quantitative, does not possess the merit of being readily and expeditiously applied. A more useful method is described by Prof. J. J. THOMSON in our correspondence column this week, and consists in allowing the rays to fall on an electrified plate. The presence of Röntgen rays dissipates the charge whether it be positive or negative, even when the plate is embedded in a solid dielectric. The inference which Prof. THOMSON draws from this latter fact is startling enough to justify his use of italics, and interesting enough to bear repetition—viz., that "all substances through which the Röntgen rays are passing become for the time conductors of electricity."

A Novel Telephone Subscriber.—When the "St. Paul" went ashore at Long Branch, N.J., a telephone was fitted up inside her and connected to the New York and New Jersey exchange. This is stated to be the first instance on record of a stranded ship becoming a subscriber to a telephone exchange.

Queen's Counsel.—Amongst the last batch of new Q.C.'s we note the name of Mr. R. W. Wallace, for many years standing counsel to the National Telephone Company, a Director of the Kensington and Knightsbridge Electric Lighting Company, and a well-known figure in most electrical patent cases.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Aden—Zanzibar	January 26, 1896 ...	Feb. 5, 1896.
Puerto Plata—Martinique ...	December 19, 1895 ...	—
Perim—Obock	January 2, 1896 ...	—
Odessa—Constantinople	January 17, 1896 ...	—

Absorption of Electrical Vibrations by Electrolytes.—No. 22 of the *Communications* from the physical laboratory of the University of Leyden, which recently reached us, contains two Papers by Dr. P. Zeeman. The first of these is on "Measurements Concerning the Absorption of Electrical Vibrations in Electrolytes," and the second treats of "Measurements of the Absorption of Electrical Vibrations in Different Electrolytes." Both of these Papers are reprinted from *Verslagen der Afdeeling Natuurkunde der Kon Akademie.*

The American Institute of Electrical Engineers.—According to the "catalogue of membership" of this Society it comprised on January 1, 1896, 2 honorary members, 305 members, and and 693 associate members, or a grand total of exactly 1,000. The two highly-honoured honorary members are Lord Kelvin and Mr. W. H. Preece. The alphabetical list is followed by one giving the geographical distribution of the members. New York City by itself contains one quarter of the total membership (257) and New York State contains in all 355 members and associates.

The Systems of the Molecules.—At the close of his address, delivered at the dedication of the physical and electrical engineering laboratory of the University of Kansas, Prof. A. A. Michelson drew a comparison between astronomy and the "infinitesimal systems of pigmy stars" of the molecular universe. He concluded with the following declamation:—

"When will the Kepler come to marshal the present ever-increasing array of facts and queries into one great and consistent whole? When will a second Newton appear to solve the riddle of that complex microcosm we call a molecule? This, their problem: to penetrate, as far as it is permitted to human r wonderful ymeason, that sterious whole we call matter, whose solar systules, whose cworems are molelds are atoms."

The Atom and its Charge.—The following letter has been sent by Prof. J. J. Thomson to the *Philosophical Magazine* and is published in the last issue of that journal:—

"I find that the view expressed by me in my Paper 'On the Relation between the Atom and its Charge' (*Philosophical Magazine*, December, 1895, p. 541), that a negatively electrified atom moved more rapidly than a positively electrified one in the same electric field, was arrived at from different reasons by Prof. Schuster, and given by him more than five years ago in the Bakerian Lecture for 1890. I am glad to find that this view is held by so eminent an authority, and regret that I had previously overlooked such strong evidence in its favour. There is another result given in the same Bakerian Lecture, which I ought to have quoted. I allude to Mr. Stanton's interesting experiments on the escape of electricity from a hot copper rod surrounded in one case by oxygen and in another by hydrogen."

The Magnetic Influence of the Planets.—In the meteorological records of the St. Petersburg Academy of Sciences, Vol. XVII., there is an exhaustive discussion of the magnetic observations made at St. Petersburg and Pawlowski from 1878 to 1889, and their bearing on the influence of the various planets on the magnetic declination. From this it would appear that all the planets exercise a marked influence not only on the absolute value of the declination, but also on its diurnal variation. All the planets except Mercury increase when they are near the earth both the absolute value of the declination and the periodic portion of the daily variation. The extreme values of the declination differ in a year by 0'·85. Taking this amplitude as unity, the following numbers express the amplitude of variation corresponding to an entire synodic revolution of the respective planet:—Mercury 0·58, Venus 0·61, Mars 0·59, Jupiter 0·40, Saturn 0·12, Uranus 0·15, Neptune 0·27. ——In the current number of *Nature* there is an interesting article by Prof. A. Schuster, criticising this alleged magnetic influence. Prof. Schuster thinks that "among the many improbabilities of magnetic influences which are hanging over us, that of a planetary effect may for the present be set aside."

The Elektrotechnischer Verein of Berlin.—At the last meeting of this Society, on January 28th, the annual election of officers took place. The elections were, as usual, very quickly got through. The Verein has at present a surplus of £1,350, and Dr. Strecker made the warmly-received proposal not to let the surplus accumulate, but to employ it in a more useful way. For instance, the provision of a free barrel of beer at every meeting of the Society would not be a bad plan. Other proposals were made as to the selection of a more comfortable place of meeting. The surroundings at present always created a feeling of being in a church or a picture gallery. A large number of members were hard at work during the day, and these required a little recreation before going on with more intellectual work. Again, one could not speak well on an empty stomach. The meetings should commence at 8 p.m., instead of 7 p.m. as hitherto. There was a visible tendency at present to shorten the meetings and get away to refresh the inner man.

Expiring Patents.—On Sunday next will expire Patent No. 626, of 1882, granted to A. A. Common for "Improvements in Electric Lamps." The specification describes a non-focussing arc lamp.——On Tuesday, the 11th inst., will expire Patent No. 661, granted to H. H. Eldred and T. B. Doolittle for "Improvements in Telephone Exchange Systems and Apparatus, part of which Improvements is also applicable to other similar purposes." The specification describes a system in which a central exchange is supplemented by a system of sub-exchanges connected by trunk wires.——On Tuesday next will also expire Patent No. 677, granted to W. E. Langdon for "Improvements in Interlocking Electric and other Signalling Apparatus for Railway and other traffic, particularly applicable to existing forms of Electric Railway Signalling Apparatus."——On Tuesday next will also expire Patents Nos. 686-689 granted to G. M. Hopkins for "Improvements in Telephone Call or Signalling Apparatus," &c. The batch of specifications describe a system and details of apparatus for telephonic intercommunication.

Coal Consumption on French Electric Tramways.—Comparative figures of the coal consumed per car-mile run on French tramways, employing different methods of propulsion, are contained in an article on electric lines by E. Cadiat in the *Portefeuille*

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Economique des Machines. As regards storage battery traction, on the lines from St. Denis to the Madeleine and from the Opera to Neuilly the car-mileage aggregated, in 1893, 502,060, or 1,376 car-miles per day. The steam engines at St. Denis furnished for this service a total of 6,500 H.P. hours, or 4·72 H.P. hours per car-mile. M. Badois, who reported these figures, gives 2·75lb. of coal as the consumption per horse-power hour, and arrives at 12·98lb. of coal per car-mile. At Marseilles, during the first two weeks of operation of the trolley system, 150,348lb. of coal were consumed to run 19,970 car-miles, and during the second two weeks 150,975lb. for 18,983 car-miles. The average is 7·75lb., which, however, includes the coal used in connection with the lighting of the cars and the power station.

Extensive Water-Power Scheme in Canada.—According to the *Electrical Engineer* of New York, "Among the water-power enterprises lately developed in America one of the most noteworthy in many respects is the work of the Keewatin Power Company at the outlet of the Lake of the Woods, Canada. The Company's constructions are expected to supply a minimum of 40,000 H.P. in the driest seasons. The Lake of the Woods covers an area of 3,000 square miles, is fed by the Rainy River and many small streams draining an area of about 30,000 square miles. The ambitious design of converting this great lake into a mill pond, and its outlet into power flumes by an enormous dam across the Winnipeg River, has already been carried to a successful issue. This dam, with its long row of massive granite piers built on the solid rock of the river-bed, is a structure as permanent as the rocky shores of the river. It has been constructed with all the requisites for retaining and regulating the flow of water, and the head maintained for the flumes is about 21ft. The commercial and industrial possibilities of this 40,000 H.P. supplied by Nature in a district surrounded by abundant wooded land, and in the excellent farming country between Winnipeg and Lake Superior, can scarcely be over-estimated. The many inventions which have multiplied the uses of wood fibre will be advantageously turned to practical use in a district where cheap power and an abundance of the pulp woods are found together. The ever-increasing harvests of the North-West will also, in the natural course of events, call for increasing milling capacity, and cheap power will be a material factor in transferring to the Western Continent the work of grinding wheat for the European consumers."

Obituary.—We regret to announce the death of Mr. Augustus Calder, the Metropolitan Manager of the National Telephone Company, which took place at his residence at Wandsworth on Sunday last. Mr. Calder, who was only 42 years of age, entered the service of the National Company almost at the commencement of its existence, and by merit alone speedily improved his position in the Company, until at the time of his death he was the Metropolitan Manager and responsible for the working of the metropolitan exchanges. Mr. Calder took an active part in the recent metallic circuiting of the London telephone system, and contributed much to the success of the work. Deservedly popular with the large staff of the National Company, Mr. Calder will be sadly missed by a large circle of acquaintances. Mr. Calder was married, but leaves no family. Early in December he appears to have contracted a bad cold, and subsequently this developed into rheumatic fever. He was away from business until the beginning of January, and then again caught a severe cold, which developed into pleurisy and pneumonia, from which he died.——We regret to announce the death of Mr. D. K. Clark, which took place at the age of 74, on the 22nd ult. Mr. Clark was well known as the author of several treatises on engineering subjects, and his works on "Tramways: their Construction and Maintenance," "The Steam Engine," and his "Manual of Engineering Rules and Data," are highly valued by engineers. His associations were principally with locomotive practice, on some branches of which he was a distinguished authority; but his literary work showed close acquaintance with a very much wider field of engineering practice.

Electric Railway Supply by the Niagara Falls Power Company.—Our Niagara Falls correspondent sends us the following particulars with regard to the electric supply of the Buffalo and Niagara Falls Electric Railway, the Niagara Falls and Suspension Bridge Railway, and the Whirlpool and Northern Electric Railway, which are all now enjoying a power service from the central station of the Niagara Falls Power Company. In reducing the voltage and changing the current from alternating to direct, a rotary and a pair of static transformers are used. It is a well-known fact that if the armature of any direct-current dynamo be tapped at points which are electrically 180deg. apart, an alternating current can be drawn from this armature. If now the dynamo be run as a motor from the direct-current end, and an alternating current can be drawn from collector rings tapped on at the points above mentioned, and *vice versâ*, if the dynamo be run as a synchronous alternating-current motor a direct current can be taken from the commutators. This last is the principle on which is constructed the 500 H.P. rotary transformer supplying the electric railways around Niagara Falls. The cables from the Power House are connected to the middle points of two double-pole, double-throw switches. Throwing the switches up throws the current into two auxiliary static transformers, the secondaries of which are connected to a quarter-phase starting motor. The armature of this starting motor is on the same shaft as the rotary transformer armature. Then the field circuit of the main armature is closed and voltage allowed to build up. The switches are put down, the current passing through the two static transformers being reduced in voltage by them from 2,250 to about 440. In its passage through the revolving armature the voltage is increased in the ratio of 7 to 10, which makes the final direct-current voltage about 600.

The Alternate-Current Transformer.—In his third Cantor Lecture Dr. Fleming dealt with the testing of transformers. A clear idea of what was meant by magnetic induction was, he said, essential to the proper understanding of the subject. He then gave the following rule, by which, knowing the throw a given quantity of electricity will cause when sent through a ballistic galvanometer of known resistance, and knowing also the number of turns of the coil through which the whole induction (N) is threaded, we can determine N from the galvanometer throw due to the sudden withdrawal of the induction from the coil. The rule is as follows:—Webers × Linkages = Coulombs × Ohms or Microwebers × Linkages = Microcoulombs × Ohms. (1 Weber = 10^8 C.G.S. lines.) The Ewing hysteresimeter was then shown and described, and a table of hysteretic constants (η) for various irons and steels was thrown on the screen. Coming next to the methods of testing transformers, Dr. Fleming expressed his astonishment that so few central station engineers ever took the trouble to test the transformers they purchased, and stated that he should that evening confine his attention to methods which were really practicable in supply stations, workshops and similar places. After alluding to the three-ammeter method, the accuracy of which was, he said, limited by the limited accuracy of the average commercial ammeter, and to the ingenious and useful differential method due to Dr. Sumpner, the lecturer explained in detail a method of testing a transformer with the aid of an auxiliary transformer for keeping the main pressure constant, a transformer for supplying the current to the shunt coil of the wattmeter, a wattmeter, ammeter, voltmeter and non-inductive resistance. An ingenious simplification of this method, in which the wattmeter transformer is dispensed with, was next described. Experiments were then made to exhibit the necessity of constructing alternate-current wattmeters without metal parts, and the lecturer stated that he had found that the fixed thick wire coil, unless properly made, had eddy currents set up in it, which vitiated the results. Dr. Fleming then showed some of his resistance "cages" for dissipating energy, a detailed description of which appears elsewhere in our present issue. Curves were next thrown on the screen, showing the marked effect of temperature on iron core losses, which fall off as the temperature rises, and *vice versâ*; the core loss in the case of a 50-kilowatt transformer was about 10 per cent. less after 18 hours' running than when cold. Core loss was also, he said, greatly influenced by the shape of the wave of primary E.M.F., a peaky wave giving less loss than a flatter wave. The lecture concluded with an experiment showing how bad magnetic leakage in a transformer could be detected by the rotation of a pivoted iron disc held within the region of the stray field.

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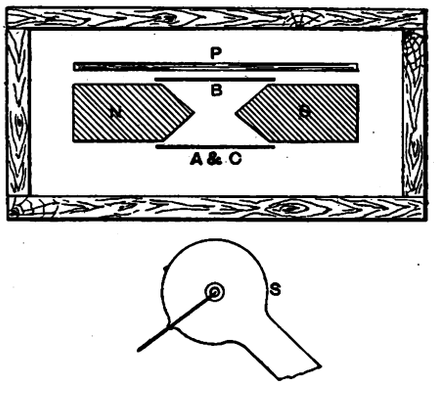
ON THE PRESENT HYPOTHESES CONCERNING THE NATURE OF RÖNTGEN'S RAYS.

BY DR. OLIVER LODGE, F.R.S.

When I wrote the article last week, which you printed on page 438, I was still uncertain whether Röntgen rays might not experience a trace of deflection in a strong magnetic field; and this, notwithstanding the assertion of the discoverer that he had found no deflection. No details of the experiment had been given, and although it might seem safe to trust the bare assertion of so known an experimenter as Prof. Röntgen, yet, on account of the portentous gravity of the issue, I felt bound to satisfy myself by a direct confirmatory experiment. If only there were a magnetic deflection of the rays, the very simplest of all possible hypotheses would be confirmed—the hypothesis, viz., of a kind of sound-pulse conveyed by electrified particles, streaming on the whole in one direction, with interchanges of energy, passing on the motion in a Grotthüs-chain kind of fashion, but passing it on by simple material impact; a kind of electrolytic radiation, as I then expressed it. The details of this hypothesis were given by Prof. Fitzgerald in your columns, Vol. XXXII., p. 573, and Vol. XXXIII., p. 151.

My first experiment on magnetic deflection, the shadow-graph of a magnet with a back-ground of wire-gauze, only showed that if there were any shift by reason of passage of rays between the poles it was very small; but I have now definitely to assert that a further experiment has been made which effectually removes the idea of deflectibility from my mind, and confirms the statement of Prof. Röntgen.



Experiment on Magnetic Deflectibility. S = Source of Radiation with Spherical Cathode. P = Sensitive Plate. N.S. Magnetic Poles; A, B, C, are wires of which A and C are one above the other, about half an inch apart so that the shadow of B lies between them. Wooden box ¼-inch thick.

A strong though small electromagnet, with concentrated field, had a photograph of its pole-pieces taken, with a couple of wires, A and C, stretched across them on the further side from the plate—nearer the source—and a third wire B also stretched across them, but on the side close to the plate (see Figure). These three wires left shadows on the plate, of which B was sharp and definite, while A and C were blurred.

A couple of radiographs were taken by Mr. Robinson, one with the magnet on, and one with the magnet reversed. On subsequently superposing the two plates, with the sharp shadows of B coincident, the very slightest displacement of shadows A and C could have been observed, although those shadows were not sharp. But there was absolutely no perceptible displacement, the fit was perfect. Consequently the hypothesis of a stream of electrified particles is definitely disproved; as no doubt had already been effectively done in reality by Prof. Röntgen himself.

But it must be noted that the hypothesis of a simple molecular stream—not an electrified one—remains a possibility. The only question is whether such an unelectrified bombardment would be able to produce the observed effects. In so far as it could affect photographic plates one would suppose it must be by means of phosphorescence, but it is doubtful whether it would even have the power of exciting phosphorescence.

It must be remembered that Dr. Lenard found among his rays two classes as regards deflectibility—some much deflected, others less deflected;—and it must be clearly understood that his deflections were observed, not in the originating vacuum tube, where the fact of deflection is a commonplace, but outside, after the rays had been as it were "filtered" through an aluminium window. He did not, indeed, observe the deflection in air of ordinary density, it was in moderately rarified air that he observed it, but he showed that the variation of air density did not affect the amount but only the clearness of the minimum magnetic deflection. The circumstance that affected the *amount* of the deflection was a variation in the contents of the originating or high-vacuum tube.

The hypothesis, therefore, that naturally suggests itself is that the highly-charged particles flying from the cathode deliver up the greater part of their charges when they reach the aluminium window, and that the outside particles which take up the running are less charged, some of them perhaps not charged at all. These last would not be so likely to excite phosphorescence, hence Lenard would not perceive them; he would only observe those that had managed to retain or acquire a modicum of charge, and these would be deflected.

The question has still to be asked, therefore, whether the rays discovered by Prof. Röntgen, which are not at all deflected, are those which possess no trace of charge.

Besides, it must be remembered that the absence of deflection has only been proved in ordinary air, while the presence of magnetic deflection has only been proved in somewhat rarefied air; the investigation into this matter is not finished until a further experiment is done—viz., to verify the non-deflectibility of the Röntgen rays even in a fairly good vacuum.

So much for what remains of the almost defunct radiant-matter hypothesis (defunct only, be it understood, for the particular kind of rays studied by Prof. Röntgen; and not really defunct for them, but in a state of suspended animation. The hypothesis of a bombardment of uncharged particles I have by no means yet abandoned).

The alternative hypothesis, as generally conceived, is some form of waves. True, no absolute necessity has been yet made out for a periodic disturbance travelling at a finite speed; but the circumstance that fluorescent materials are excited, and chemical action precipitated, suggests a periodic motion not altogether out of time with the vibration-frequency of molecules.

Let us grant, then, that this circumstance renders it likely that the cause of the Röntgen effects is to be sought in some kind of wave-disturbance in the ether. The next question that arises is, Is it of the nature of etherial *light* or of etherial *sound*? Is it such transverse or electrical vibrations as are obedient to the equations of Maxwell, or is it a mode of longitudinal disturbance requiring some generalisation or modification of those equations in order to express it?

On the principle that we are bound to apply the simplest hypothesis until it can be shown to be insufficient, it is necessary to consider how far the hypothesis of transverse or electrical vibrations can be made to serve. The chief difficulty here is the transparency of electrical *conductors*. To Maxwell's waves, *i.e.*, to *light* of every kind, they ought to be opaque. But already the translucency of gold leaf has been a slight known difficulty in the same direction, and it has been shown that by postulating interstices or lack of homogenity, *i.e.*, a structure not infinitely fine-grained with respect to the size of light waves, the difficulty can be more or less satisfactorily overcome. Why not, then, assume that these new waves are much smaller than any hitherto known? Why not assume that they compare closely in size with the atoms themselves? Indeed, if they compare in frequency, they *must* compare also in size if they are transverse waves, for the only pace at which such waves can travel through the ether is accurately known. That there is plenty to be said for this hypothesis is obvious from the fact that it appears to commend itself both to Prof. Schuster and to Prof. Fitzgerald. Among other things that can be said in favour of it are the following. Electrical oscillations in conductors are known to have the power of exciting light-waves, hence light-waves may be expected from electric oscillations or surgings in atoms; but visible waves are not so

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excited. Visible light appears to be due to something more like the sound-vibration of atoms, as if they were bells or plates struck and made to vibrate. Bells and plates of atomic size would vibrate at about the required pace, viz., 400 to 800 million vibrations per second.

But electrical or Hertz-like oscillations of a charge on conductors of atomic size would vibrate immensely faster, being controlled not by the rate at which *sound* travels across an atom, but by the rate at which *light* travels, and this is just about 100,000 times as quick. Hence, as has often been pointed out, electrical oscillations in atoms are too quick for light; but yet they must occur, one would think, when atoms are being violently disturbed and charged and discharged; and if ever such oscillations occur, transverse waves must be emitted. Why should not these constitute the Röntgen rays?

This matter of the extra-rapid ultra-ultra-violet light may be safely left in the hands of its supporters. Its great advantage is that it utilises no new or unknown property of the ether—nay, more, it utilises a disturbance which, although not yet otherwise discovered, must naturally be assumed to exist, unless definite reason is shown against it. It is needless to emphasise further the high probabilities in favour of this hypothesis. Such statements as there are against it will follow incidentally.

Now we come to the last hypothesis, the one suggested by Prof. Röntgen—the one which, judging from page 447 of your last issue, commands the high support of Prof. Boltzmann,—the one which it is not too rash to assume is regarded not unfavourably by Lord Kelvin,*—viz., the hypothesis of etherial sound or longitudinal waves in the ether. The only facts hitherto assumed to utilise longitudinal or pull-and-push properties in the ether are the facts of gravitation and of cohesion. Newton himself showed that an etherial tension or pressure would account for gravitation. Nothing is known about these properties, and there are difficulties in supposing that the ultimate space-filling medium can be really compressible. It is not, indeed, necessarily compressible to account for cohesion and gravitation, but it must either be compressible, or else simulate the effects of compressibility, if it is to transmit a periodic or atom-shaking disturbance at any finite pace.

Assume for the moment a slight compressibility of some sort, and consider what occurrences there are in a well-exhausted vacuum tube which could start longitudinal waves in such a medium. We have in the vacuum tube a violent torrent of atoms striking on the glass. Suppose that the vacuum is about 10^{-6} of an atmosphere—which appears to be something like that needed to give good effects—then the distance apart of the residual atoms in the exhausted space is a hundred times as great as in ordinary air, and a thousand times as great as in liquids; hence the distance will be about 10^{-5}cm.; or each spot of glass will receive a hundred-thousand blows from every centimetre length of the stream to which it is subjected. But the speed of the cathode rays has been directly measured by J. J. Thomson as something comparable to 10^{7}cm. per second. Hence the glass will be struck on the average, at every point, 10^{12} or a billion times a second, by the mere procession of negatively-charged atoms. It is easy for this estimate to err by a factor 10, and it is also easy for places to be sometimes struck ten times more frequently, by reason of the above estimate being only an average. Hence it may be surmised that the frequency of luminous vibrations are occasionally reached, and the glass not only grows hot but also shines.

It is probably quite unnecessary to appeal to this rapidity of bombardment in order to account for visible fluorescence, but the rapidity of bombardment is of interest because in any compressible medium such rudely periodic disturbances could hardly help starting some kind of sound waves.

But, besides that, the atoms themselves are known to be elastic, and to have definite periods of vibration like plates or bells, as evidenced by their spectroscopic lines; hence the blows to which they are subjected must be thought of as likely to excite vibrations or crispations in them. The frequency of these are such as to emit luminous waves in an ether possessing electromagnetic properties, the atoms being charged; but if they occur in an ether which is anything like a compressible fluid, how can they avoid exciting mechanical or sound waves too?

Nothing can be known for certain about the wave-length or velocity of such waves in ether until an interference or diffraction experiment has been performed, but the order of magnitude of the frequency can be taken as that of light, say 10^{15} per second, or quicker. The only way at present to gather some idea of the wave length is to attend, (*a*) to the sharpness of the shadows, (*b*) to the thickness of medium which is effectively opaque.

The longer the wave the more transparent are things likely to be, because waves are always damped out logarithmically, and this needs a certain number of swings, or at least a certain fraction of a swing, for notable damping to occur. A wave a yard long is not likely to be effectively stopped by an obstacle an inch thick. Without a knowledge of the damping-ratio, however, no numerical estimate can so be made, but a better estimate can be got from the sharpness of shadows. Take a point source, and investigate the outline of the shadow of an object held at a moderate distance from the screen or sensitive plate. No clear shadow will be thrown when the size of the obstacle is comparable to a wave length, if its size is small, or when it is removed several wave lengths from the plate, if the size of the obstacle is large. For, in wave theory, shadows are thrown by interference; and diffraction effects become prominent even when a want of precision about the source hinders the recognition of any clear diffraction pattern. The latter would not only indicate the wave length, but measure it. Short of that an estimate can be hoped for. Mr. A. W. Porter, in Prof. Carey Foster's laboratory, has obtained the sharpest radiographs I have yet seen, and he has the best chance of getting the data for an estimate. Suppose for the moment we guess that a wave length of about 1cm. is not unlikely, then the speed of the hypothetical longitudinal waves would be of the order 10^{15}cm. per second, or more, *i.e.*, about as much quicker than light as light is quicker than sound.

Such waves if they existed might be reasonably styled gravitational waves; for although gravitation does not need any wave propagation, only a state of statical stress or tension, yet it would be the rate at which the tension travelled outwards if a fresh piece of matter started existence, or probably if an old piece of matter moved about with sufficient rapidity. Such motion would appear likely to entail aberrational effects, but aberrational questions are notoriously difficult, and the subject is only here mentioned because it is doubtful whether the Laplacian difficulty would be felt in astronomy if gravitation travelled a million times as quick as light. The pull of the sun would be felt in the time that light needs to travel 92 miles, and this is nearly instantaneous; or, otherwise, the terrestrial aberration-angle for gravity would be only the hundred-thousandth part of a second of arc.

But what about the Cavendish-Faraday-Maxwell experiment? that experiment which is held to establish the incompressibility of the ether, or the electrostatic law of inverse square, or the impossibility of a free or isolated electric charge (*see* "Modern Views of Electricity," Second Edition, pp. 9, 11, 29, 31-34, 257). We cannot tell what the volume-elasticity of the ether has to be, in order to transmit condensational waves of the above speed, unless we know its density. Dr. Larmor has shown some reason for supposing that ether may be as dense as platinum. If it be anything like that, and if the longitudinal wave velocity is 10^{15}, then the incompressibility is more than 10^{30} C.G.S. units; too great for any such experiment to show.

The object of mentioning these matters here is to help to realise that there is nothing in present knowledge obviously fatal to the idea of longitudinal waves in the ether; but the arguments in their favour, in connection with Röntgen rays, remain to be given. Assuming wave propagation of some kind, every argument against tranverse is in favour of longitudinal, and *vice versâ*.

* In this connection it is interesting to refer to Lord Kelvin's Presidential Address to the Royal Society, November 30, 1893 (Harrison & Son, London), on the subjects of Hertz-waves and Radiant Matter, in which he confidently anticipates further progress and gives an interesting *résumé* of the history of highly exhausted vacuum-tube effects in connection with that subject. He emphasizes the important part played by Cromwell Varley in 1871, before either Hittorf or Crookes, in the discovery of cathode rays, and strongly supports the material view, in opposition to many Continental workers.

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Now the thing that suggested longitudinal waves to Röntgen was the fact that crystalline properties were of no importance: *e.g.* that Iceland spar and quartz were equally transparent or opaque whichever way you turn them. But it must be admitted that such a test as that is next door to none. If *tourmaline* is transparent to Röntgen rays going along its axis it would be a much better test; and this I have myself ascertained to be the fact. J. J. Thomson also has found that a pair of ordinary cut tourmalines are equally transparent whether their axes are "crossed" or parallel; which is an excellent test. Nothing suggestive of polarisation in any form has yet been observed; a fact which tends against transverse and in favour of longitudinal waves. But the strongest argument in favour of longitudinal waves is derivable from the fact that the rays discharge electrified bodies. Lenard found this, and J. J. Thomson and I have both obtained it easily under Röntgen-like conditions; but their peculiarity is that (unlike light) they discharge positive and negative about equally.

Now, Elster and Geitel showed that when polarised light discharges a really smooth surface it is most effective when the electric oscillation is partly normal, not tangential, to the surface; in other words, that it is what may be called the longitudinal or end-on component of ordinary light that is by far the most effective in discharging electricity.

Mr. Robinson thinks he has observed that the same thing is true as regards the power of exciting fluorescence: an important observation if true, but the examination is not complete yet. If it turns out so, then the two things that Röntgen rays are known to do are characteristic of end-on or normal vibrations.

As to the photographic or *radiographic* action, it is so slow and inadequate at present that it hardly looks like a direct primary effect but even there it seems as if thick films did better than thin.

Another fact that gives a gravitational look to Röntgen's rays is the fact that they appear to pay more attention to specific gravity or ordinary density than to any other property of matter. This can be said without stating that opacity and density are strictly proportional. Any way, electrical properties of matter seem to be quite unimportant; polish or roughness, a coherent block or a powdered mass, are all the same to these waves, as they are to gravity.

Direction of crystallisation matters nothing, nor does shape; an aluminium prism cannot bend them; they cannot be bent or even reflected to any considerable extent. If it be found that physical state is also unimportant, so that the same molecules obstruct equally however they be aggregated, whether into solid, liquid or gas, that will be a further contribution to the evidence in the same direction.

Thus there is plenty of scope for experiment. A few weeks may be sufficient to intensify our conviction in one or other of the already-mentioned directions, or we may find ourselves urged by new facts in some other direction not yet thought of.

In conclusion, let it be remembered that Lenard, Hertz, Goldstein and the Germans generally (except Helmholtz—a notable exception!) have consistently urged that cathode rays were something more than a stream of particles; in case it should so turn out, Lenard urged this for his rays outside, in air, Hertz, I believe, urged it for the rays inside the vacuum. It may be that the streaming particles are there, but an ethereal process may be also there. Outside in the Lenard rays both processes possibly coexist, one deflectible by a magnet, the other not. That both processes exist also inside the vacuum is not likely. J. J. Thomson has exposed a protected plate in the very rays themselves inside the vacuum and got no result. It looks as if the streaming particles alone could not achieve it.

If the sun emits any rays that can reach photographic plates through boxes or hand bags, even through black paper, every touring photographer should know; but if cathode rays alone have no direct action, without the intervention of a phosphorescent substance, then even the absence of direct solar action would constitute no valid and conclusive proof that the coronal rays are not electrical, though it would very much militate against a method of easily obtaining a photographic record of the corona which has been suggested.

Liverpool, February 2, 1896.

THE EFFECT OF TEMPERATURE ON THE RESISTANCE OF PARAFFIN AND RESIN OIL.

BY H. P. GAZE.

Although it is many years since the use of mineral and vegetable oils for insulating purposes was suggested by Prof. Hughes, it is remarkable how little research on this subject has been carried out, or at any rate published. With the exception of a few indefinite tests mentioned in the *Proceedings* of the Institution of Electrical Engineers for March, 1892, in the discussion on Prof. Hughes' Paper on "Oil as an Insulator," and a series of tests on vacuum and on pure oils

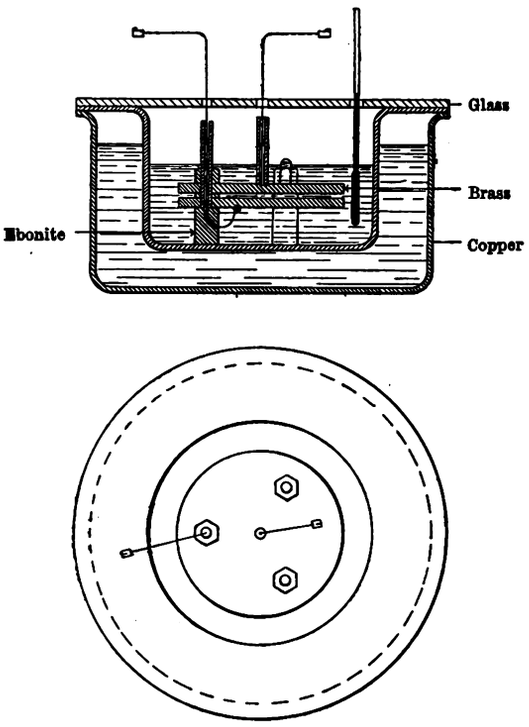

Fig. 1.

in Messrs. Bedell and Kinsleys' Paper on the "Residual Charges of Condensers," there appear to be no accessible results of experimental work on this subject; yet the growing use of oil insulation in electrical apparatus, such as transformers and condensers, renders a close knowledge of the behaviour of oils under varying temperatures of great interest and commercial importance.

The present investigation was confined to the behaviour of paraffin and resin oil, at various temperatures within the ranges met with in commercial apparatus. The apparatus

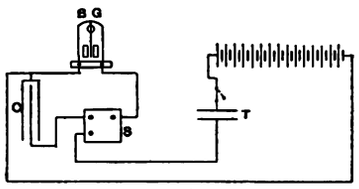

Fig. 2.—Diagram of Connections.
C=Muirhead Standard Condenser. S=Two-way Paraffin Block-key.
T=Sample under test. B G=Ballistic Galvanometer.

used consisted of a copper bath, containing the substance under test, the temperature of which could be varied and controlled by its immersion in a second bath filled with the same substance and heated externally, a steady and gradual rise of temperature of the internal bath being thus obtainable. In the inner bath were supported two circular brass plates of equal area, kept at a distance of 1mm. from each other by three small ebonite distance pieces, the whole being insulated from the bath by substantial ebonite feet (Fig. 1). To avoid any risk of impurities passing over from the outer to the inner bath, the same substance was used in each.

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The method of test (Fig. 2) was to charge the condenser through the substance tested for 60sec. and discharge through the ballistic galvanometer. The E.M.F. used was from 110 to 120 volts.

The insulation of the apparatus was thoroughly tested over the whole range of temperature employed and found practically perfect. The paraffin used was the ordinary white commercial paraffin wax.

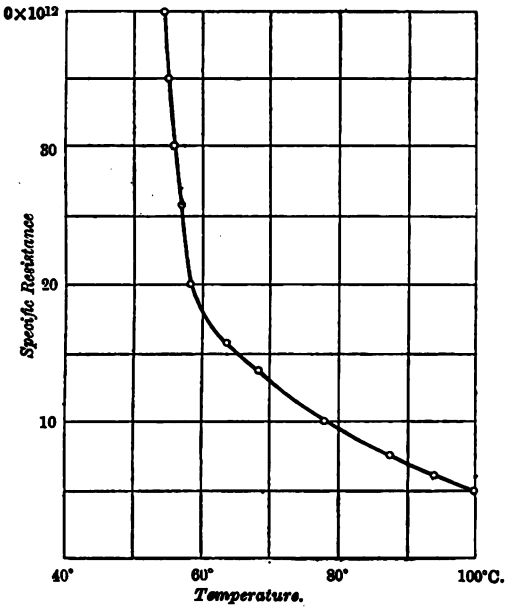

FIG. 3.

Though the apparatus used was not sufficiently sensitive to find the value of the specific resistance at normal temperature, it was found to be not less than 10^{18} ohms.

A series of tests was taken with rising temperature up to 55°C., the temperature of solidification of paraffin, and no

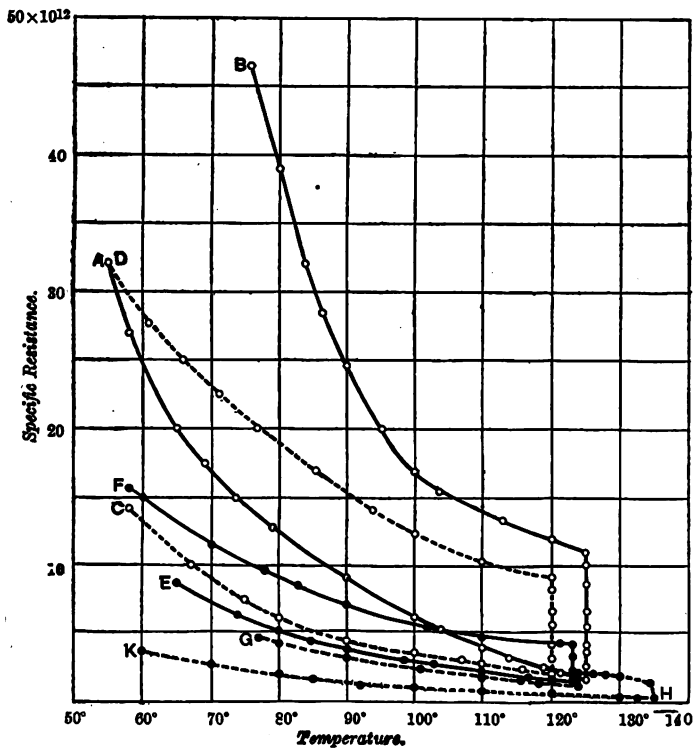

FIG. 4.—Test I., from A along —— line to B.
Test II., „ C „ ..... „ D.
Test III., „ E „ —— „ F.
Test IV., „ G „ .. ... „ H and back to K.
Paraffin cooled solid after each test.

appreciable change in the resistance was observed, but at this point the resistance fell suddenly to 4×10^{13} ohms; after this the fall of resistance up to 120deg. was steady and the resistance was constant at any one temperature, the curve Fig. 3 showing the fall of resistance from 55°C. to 100°C.

At 120deg. to 123deg. a curious *rise* of resistance with time took place, the insulation improving steadily for about an hour and then apparently attaining a steady value. On cooling the values of the resistance on the cooling curve were all much higher than on the curve of rising temperature. When cold the resistance of the paraffin was too high for measurement.

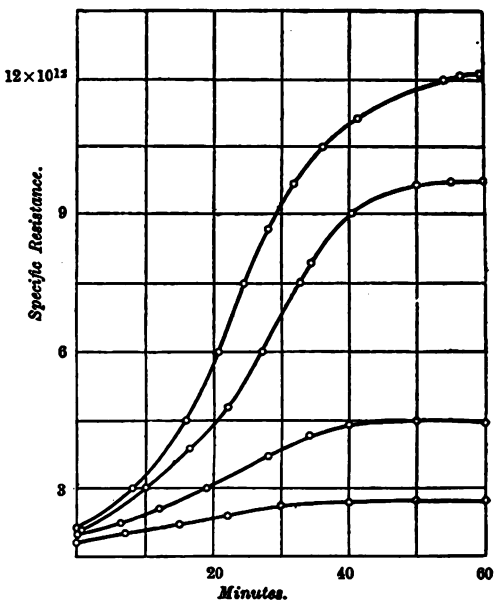

FIG. 5.

The test was repeated on four successive days, with the same sample, and, as will be seen, the phenomenon was repeated on each occasion, although the values were lower on each successive cycle, Fig. 4 showing the four series obtained.

The resistance at the commencement of the improvement on each cycle was fairly constant at about 2×10^{12} ohms. The curves in Fig. 5 give the extent of the improvement on each test, and show very clearly the gradual diminution in the improvement after repeated heatings, until on the fourth day the improvement is very small at the critical point and the values low all along the curve.

After the small improvement of the fourth test, the temperature was again raised, and the resistance was found to be fairly

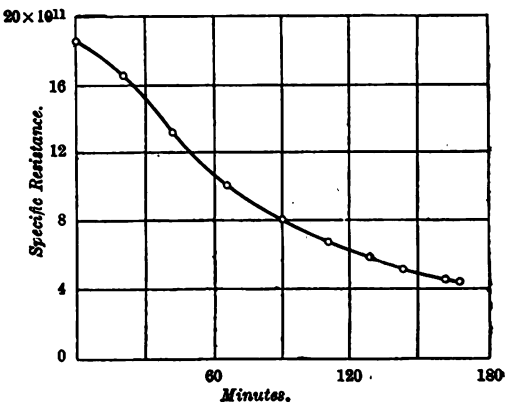

FIG. 6.

constant at each temperature up to about 135deg. Here the insulation deteriorated steadily with time and showed no signs of attaining a minimum value, the curve Fig. 6 showing the rate of deterioration with time. On cooling solid, the paraffin was now evidently permanently damaged, having a specific resistance of $6{\cdot}5 \times 10^{14}$, enormously less than that of the original substance; the wax was also slightly discoloured, being tinged with yellow.

A further test on a fresh sample of paraffin was also taken, the temperature being quickly raised to a high value, about 170°C. The deterioration with time was much more rapid, the

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resistance being reduced in 25min. from 5×10^{12} to $1{\cdot}6 \times 10^{12}$ ohms. On cooling solid the paraffin was permanently damaged, being of a pale yellow colour, and having a specific resistance of $1{\cdot}6 \times 10^{15}$ ohms.

Finally, a test of six hours' duration was taken on a fresh sample, the temperature being kept constant at 123deg., the critical point to be investigated. The curve obtained (Fig. 7) shows that the improvement is only of a temporary character, being complete after about an hour's time; the resistance then gradually fell again, having only fallen to its initial value at the temperature even after six hours, showing the extremely slow rate at which the substance decomposes at this temperature.

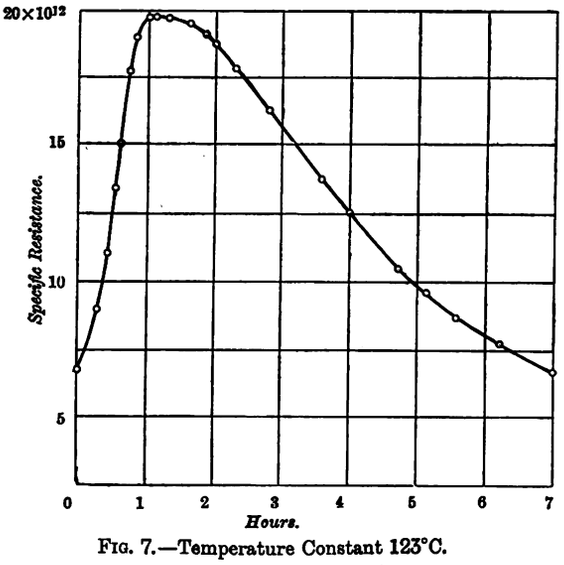

FIG. 7.—Temperature Constant 123°C.

It was at first thought that the improvement observed might be due to the distillation of volatile impurities. To test this theory a fresh sample was heated in a retort at a temperature of 123deg. for more than three hours, but there was no appearance of any distillate in the condenser.

The explanation of these phenomena seems to be that at about 125°C. a molecular change takes place in the paraffin, which is complete at the end of about 60min., the resulting substance then having a very considerably increased resistance;

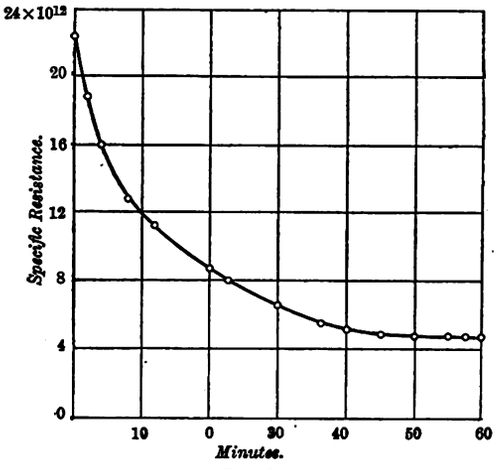

FIG. 8.

but, simultaneously with this action, there is also a slow decomposition or resinization, which shows no signs of ceasing after six hours' continuous heating, the resistance in this space of time having fallen to about 40 per cent. of the maximum value.

This explanation fully accords with repeated curves in Fig. 4. From these it seems that the molecular change is reversed on cooling after a lapse of several hours, but that the deterioration is permanent. Consequently the second curve begins at a lower value, and lies altogether below the first one. Apparently the deterioration caused by the repeated heating diminishes the amount of molecular change, there being finally practically no improvement.

Commercial paraffin is not a simple body, but a mixture of several members of the paraffin series. It is, however, probable that both the molecular change and the decomposition occur in the same one of the series, and that finally the continued heating decomposes this member, and the molecular change disappears altogether.

Although *each* of the curves in Fig. 4 might be explained by the removal of a volatile substance, yet this explanation cannot be valid, for the drop of resistance due to standing for a day happened in each case, and the removal of an impurity would have effected a *permanent* improvement. Therefore a change of molecular state which cannot exist at lower temperatures, and is only slowly reversed on cooling, is the only apparent explanation. The slowness of all these changes is clearly indicated by the fact that a long-continued heating at 135°C produces a greater permanent deterioration than a short period of heating at 170°C., though, in the latter case, the deterioration per unit of time is much more rapid.

The practical result of these tests is to show that up to 100°C. no permanent injury to paraffin results, although its insulation resistance is enormously diminished and possesses only a very moderate value; but long-continued heating, up to temperatures of 130deg. or more, causes a very marked and permanent deterioration, such paraffin being rendered quite useless for resistanee coils and hardly satisfactory for condenser dielectrics, though the apparent resinisation as indicated by change of colour may be so slight as to be hardly perceptible except in a large mass.

Resin Oil.

Tests with the same apparatus were also taken on samples of resin oil supplied by Callender's Bitumen Company, being the

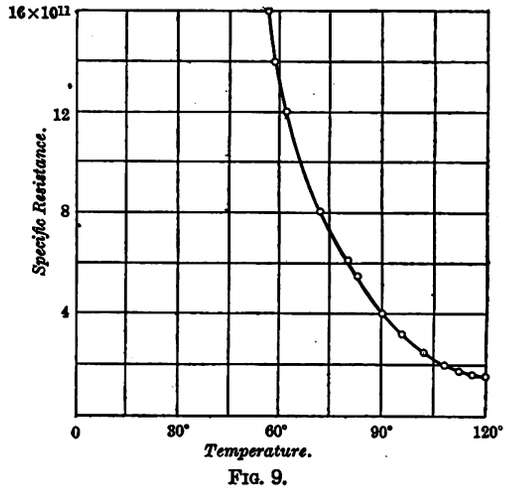

FIG. 9.

insulating oil used in the street junction boxes of the Liverpool Electric Supply Company's system. Tests were taken over the range of temperature likely to be attained in transformer coils or other oil-insulated apparatus.

The specific resistance at a temperature of 18°C. was found to be $3{\cdot}2 \times 10^{14}$ ohms.

From 18°C. the temperature was slowly raised, and a large fall of resistance was quickly apparent, as the oil became less viscid. At each temperature the resistance fell at first rapidly, then slowly, attaining a steady value after from 30 to 40 minutes. Fig. 8 shows the rate of deterioration at 45°C., this curve being typical of the variation at temperatures from about 20deg. to 50deg. As the temperature rose the resistance attained its constant value at each temperature more quickly, until at temperatures of about 80deg. and upwards the oil reached its minimum resistance almost simultaneously with the rise of temperature.

The fall of resistance was most rapid at quite moderate temperatures; at 25deg. the specific resistance had fallen to about one-fourth of its value at 18deg., and at 45deg. the value was about $\frac{1}{70}$th of the normal; at higher temperatures the deterioration was much less rapid, the resistance at

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122deg. being only about $\frac{1}{40}$th of its value at 45deg. At from 110deg. to 120deg. the fall of resistance became very slow. Fig. 9 gives the curve of variation with temperature from 58deg. to 122deg., the latter being the final temperature attained.

The various values of the specific resistance at the different temperatures are given in the following table, the resistance difference between the limits of temperature being too great to plot a convenient curve :—

Temperature. Deg. Centigrade.	Specific resistance.	Temperature. Deg. Centigrade.	Specific resistance.
18	3275×10^{11}	62	12·0
23	2456·0	72	8·0
25	819·0	75	7·3
37	614·0	79	6·0
30	412·0	82	5·5
57	178·0	90	4·0
41	82·5	102	2·7
45	48·0	112	1·75
47	36·5	115	1·6
50	27·0	120	1·5
55	17·7	122	1·45
60	13·2		

The sample, on cooling to normal temperature, was found to be perfectly uninjured, and repeated heating within the range of temperature employed had no effect on the insulating properties of the oil at normal temperature, the resistance always returning to approximately the same value as that found for the first sample.

It is thus clearly shown that resin oil is quite free from permanent deterioration when exposed to high temperatures of the order ever likely to be met with in commercial apparatus. The reduction, however, in its insulating properties at not unusual temperatures, is sufficiently great to make it worthy of note in the use of resin oil as an insulating medium for high-tension transformer coils and other similar apparatus.

My thanks are due to Prof. Baily for his kind advice and assistance, and also to Mr. E. E. Johnston for help in carrying out the tests.

NON-INDUCTIVE RESISTANCES FOR TESTING PURPOSES.

In his last Cantor Lecture, Dr. J. A. Fleming described a form of inductionless resistance which he has devised and employed for a long time past in transformer testing and for other laboratory purposes. This form of resistance will probably be found to be very useful as soon as it is generally known. In every laboratory, testing room, or workshop where current is supplied at a constant pressure of 100 volts or so it becomes continually necessary to be able to take off small currents of various magnitudes for experimental purposes for working induction coils, motors, calibrating ammeters, and other numerous purposes for which the experimentalist requires current. Now that current is laid on to most private houses, and many experimentalists are engaged in private laboratories in work requiring induction coils, whether for the prosecution of the new photography or anything else, it becomes exceedingly useful to be able to tap off any required current taken from the 100-volt mains. Of course this can be done by incandescent lamps, but these have the great disadvantage that they give out a great deal of light, and therefore cannot be used where darkness is required.

Dr. Fleming's patent form of resistance consists essentially of two glass or porcelain head pieces having on them four or eight pins or studs. These head pieces are fixed on a brass rod, one of them being firmly attached to the rod, and the other loose. They are kept pressed apart by a strong spiral spring (see Fig. 1). Over these head pieces is wound longitudinally one or more bare fine wires, either of platinoid, manganese steel, nickel steel or any other suitable material. This wire is wound backwards and forwards longitudinally over these head pieces in such a way that the resistance has a small self-induction, and yet offers a very large surface for radiation and ventilation. The ends of the resistance wire are brought back to the fixed head piece, and there terminate in copper conducting wires. The spring forcing the loose head piece outwards always operates to keep the resistance wire tight, no matter how much it may have expanded by heating. This form of resistance coil, which Dr. Fleming calls a *cage*, constitutes the unit by which any required resistance is built up. Two such cages are generally fixed in a wooden frame

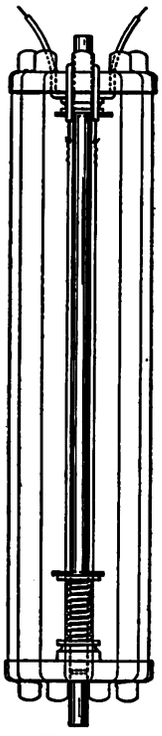

Fig. 1.

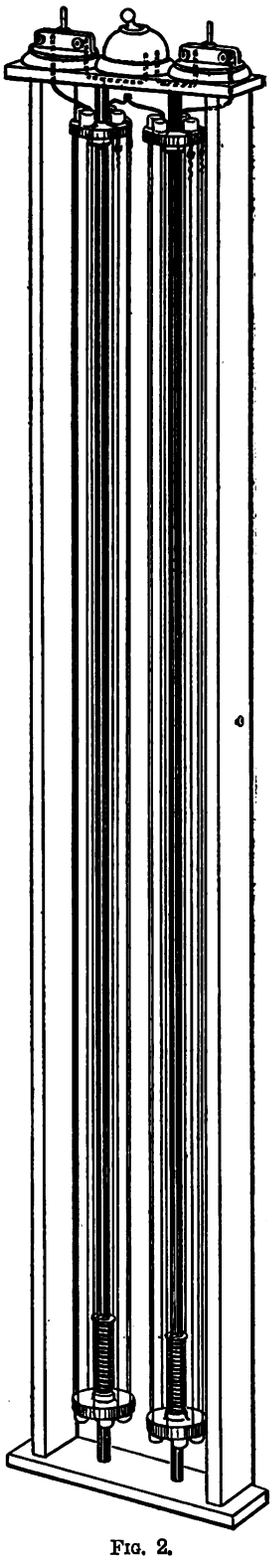

Fig. 2.

(see Fig. 2), the back of the frame being filled in with a sheet of perforated zinc. On the top of the frame is placed a switch and two porcelain cut-outs, the switch and cut-outs being in series with the resistances. These resistances can be made up to take any required current. A very useful size is a cage having a resistance of 100 ohms and capable of passing one ampere safely. Hence, when put across a 100-volt circuit, it can never

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pass more than one ampere. A number of these frames carrying the cages can be fixed together by pins protruding from the wooden frame, and the resistances can be joined up so that the resistance wire with the switch in series is in parallel across a pair of main conductors, or they can so be joined up that the resistances are all in series, each resistance being capable of being short-circuited by the switch. Thus, for instance, 10 one-ampere cages can be joined up so as to give a united resistance of either 1,000 ohms capable of passing one ampere or 10 ohms capable of passing 10 amperes, the resistances being put in series or in parallel as required. It will thus be seen that a set of 10 such 1-ampere cages enables the experimentalist to draw off from the 100-volt circuit any required current from one-tenth ampere to 10 amperes. Twenty such 100-ohm cages can be joined in series to give a resistance of 2,000 ohms, or, if need be, can be formed to have a resistance of 4,000 or more ohms. Each cage is well insulated from its neighbour, and the whole resistance can be then placed across a 2,000-volt circuit taking up one-half or 1 ampere as required. In this way a safe resistance can be constructed, capable of being put across a high-pressure circuit and absorbing any required amount of power.

In a long investigation which Dr. Fleming made some time ago of the transformers of the City of London Electric Lighting Company, he employed such a series of cages placed across a high-pressure circuit, capable of carrying 3 amperes safely, and absorbing, therefore, at 2,000 volts, nearly 8 H.P. This resistance was employed for standardising the wattmeter used in testing large transformers of 50 and 30-kilowatt capacity. The remarkable thing about these resistances is that they radiate their heat at a low temperature and get rid of much of it by convection, so that when such an 8 H.P. resistance is placed across high-pressure circuit it is hardly possible to tell, when standing near it, whether the resistance is on or off; whereas, if 8 H.P. were being dissipated in incandescent lamps, it would be highly disagreeable to stand near them for any length of time, owing to the great radiation of light and heat.

These resistances are largely used in the Electrical Laboratory at University College for supplying currents for the experimental work, drawn off from the 100-volt mains fed by a secondary battery. One point in favour of this form of resistance is that it is very easily repaired. If a wire happens to become broken it is simply rewound again with a proper length of bare platinoid wire, and can be repaired at the expense of a few pence. Moreover, the insulation of this form of resistance is so high that the cages can with perfect safety be used across high-pressure circuits; resistances which take the shape of covered wire wound up in turns closely touching one another are not, on the other hand, over safe or satisfactory to use when dealing with very high pressures. Dr. Fleming's resistances can be obtained of most manufacturers of electrical apparatus.

MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(*Continued from page 308*).

Oil Engines.

Oil fuel is principally derived from petroleum. It is used (1) as a fuel for raising steam, (2) by explosion in an internal combustion engine, similar in action to a gas engine. It is with the latter use that we are here concerned. There are two distinct classes of internal combustion oil engines: (1) those consuming light and easily vaporised petroleum spirit; (2) those consuming heavy oils requiring the application of considerable heat to vaporise them.

Petroleum Spirit Engines.—Soon after the commercial use of the gas engine was commenced, engines working on a similar principle, but consuming benzoline and other light hydrocarbon liquids, were introduced, though with little success. The fuels requisite for these engines were of so volatile a nature that their flashing point was below ordinary temperatures; their vapours, when exposed to the air, were highly explosive, and therefore dangerous. It was this fact which impeded the introduction of these engines and enormously restricted their application. The explosive charge was generally obtained by passing air through some porous fabric soaked in the liquid fuel, when the air became heavily charged with the vapour of the spirit. Drawn thus into the cylinder, the air became converted into an explosive charge, which was fired by means of an electric spark or by a flame in the rear of the cylinder. Recently there has been a revival of this class of motor, for use in mechanically-propelled road carriages; and it would seem that the revival promises considerable extension in the near future. In the modern types the Otto cycle is adhered to, and generally the electric spark or hot tube ignition; and special precautions are taken to ensure against the accidental ignition or explosion of the oil.

Petroleum Oil Engines.—The earlier petroleum engines were incapable of using ordinary burning oils, owing to the difficulty which was experienced in properly vaporising these heavier distillates of petroleum. Yet, the safety of the oil engine depended upon the invention of a successful method of using these heavy oils. Brayton, in 1872, was the first to attempt the use of burning oils in an internal combustion engine; and he succeeded in running an engine with petroleum of 0·850 specific gravity. An inefficient cycle, together with faulty mechanical construction, combined to make the Brayton engine somewhat uneconomical. The consumption of oil was about 2·16lb. per I.H.P. per hour. The thermodynamic efficiency was only 6 per cent. The engine was constructed to give an impulse every outward stroke, during which stroke the compressed air and petroleum vapour were drawn into the cylinder, and gradual combustion ensued, the pressure of the combustion being sufficient to propel the piston. Ignition took place within a small recess in the back of the cylinder, this recess being partitioned off from the vaporiser by means of several grids of perforated metal. Flame continually burned within this small recess.

To Messrs. Priestman Bros., however, must the credit be given for having first succeeded in constructing an engine to work on the Otto cycle with ordinary burning oils. Thus they have the honour of being the pioneers of the modern oil engine. The essential feature in their invention is the preparation of the oil in a vaporiser, placed externally to the engine, in such a manner that it might be drawn with air into the engine cylinder and treated like the explosive charge of an ordinary gas engine. The object to be attained was to convert the liquid oil into a state so nearly resembling gas that it would neither condense within the cylinder nor deposit tarry residues either in the vaporiser or in the engine. Though differing in the manner in which this is attained, all modern oil engines depend for their action upon this principle.

Priestman Oil Engine.—In the Priestman oil engine the liquid fuel is prepared for combustion by being sprayed into a heated chamber adjoining the cylinder. This chamber is called the vaporiser; and, though heated by a small lamp when the engine is about to be started, it is normally kept hot by the circulation of the exhaust gases around it. A longitudinal section (Fig. 82) shows the details of the vaporiser and spray maker, a separate section of the latter being shown in Fig. 83. Referring first of all to the latter diagram, it will be seen that the nozzle consists of two passages, both opening into a conical discharge passage. The innermost passage is for the oil, while the annular passage surrounding it conducts a blast of air towards the oil jet, and thereby causes the oil to be broken into spray. The position of this nozzle is indicated at E, in Fig. 82, and it will be seen that it is situated at the entrance to the vaporising chamber. Surrounding the nozzle are a number of air passages, D, through which air passes from the chamber B, in the end cover of the vaporiser. The direction of the jets of air issuing from these orifices D is such as further to spray the oil before it passes into the heated chamber, as well as to admix the spray with a plentiful supply of air. The air, entering by the passages D, is drawn in by the valve L through the passage F; but the air which passes through the annular orifice in the nozzle E, by the passage J, is

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forced by a special pump in the frame of the engine. The oil is forced from the oil tank under the same pressure, through the passage K. It will be seen that the oil passes through a hole in the governor spindle H, at M. The governor, actuating the lever I, regulates the amount of throttling of the oil at this point, and thus adjusts to the load the amount of oil supplied for each explosive charge. The engine is not permitted to miss explosions, but regulation is entirely obtained by variation of the richness of each charge. The indicator diagrams taken from one of these engines, and referred to more particularly later, show how the variation of the composition of the charge affects the indicated

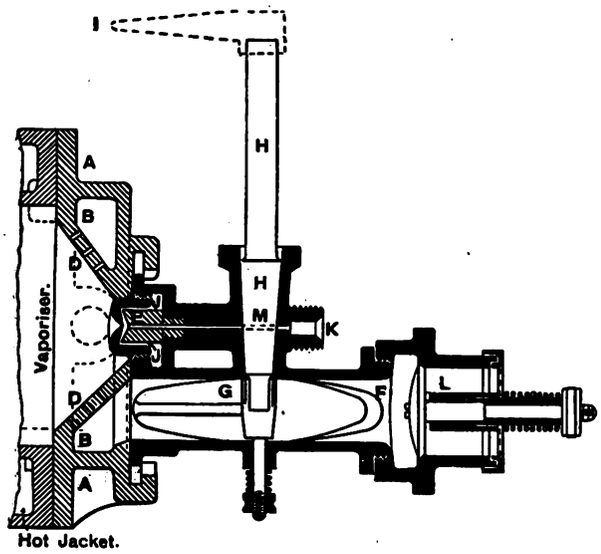

FIG. 82.—Priestman Oil Engine. Longitudinal Section of Vaporiser and Spraying Apparatus.

work done per cycle. It should be mentioned, in regard to the vaporiser, that one of the chief merits in preparing the oil fuel in this way is that the oil is only gently heated and is not altered in chemical composition by its passage through the vaporiser. It is sufficient to raise the temperature of the oil spray enough to ensure that it will be held in suspension in the air until ignition; a higher temperature might, and if it were much higher certainly would, decompose the oil, giving rise to tarry matter which would choke the passages and injure the cylinder liner.

Having been drawn through the vaporiser, by the indraught of the forward "charging" stroke of the piston, the oil and air enter the cylinder through one of two mushroom valves in

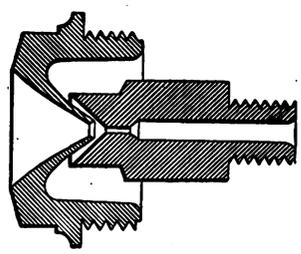

FIG. 83.—Priestman Oil Engine. Section of Spray-making Nozzle.

the cylinder end, as shown in Figs. 84 and 85. During the next stroke of the piston this charge is compressed into a large clearance space in the rear of the cylinder, the extent of this space being indicated in Fig. 85, the piston in this figure being on the inner centre. Immediately this inner centre is passed an electric spark is caused to pass between two electrodes, I, on the insulated igniter K (Fig. 84). A working stroke ensues, followed by the exhaust of the greater part of the gases shrough the other mushroom valve in the cylinder end.

The type of Priestman engine most commonly used for driving a dynamo is the horizontal type, the latest form of which is shown in longitudinal section in Fig. 85. The footnote to this illustration will make the position and action of the principal parts clear; but reference may be made to one or two of the details of the engine which are not shown. Upon one end of the crank shaft there is a single reduction spur gear, which turns a short eccentric shaft at half the speed of the crank shaft. The eccentric upon this has three actions: (1) It propels the pumps which supply the enclosed chamber C with oil and compressed air; (2) it actuates the exhaust valve at the cylinder end; and (3) it closes at the proper moment the circuit of the current which generates the igniting spark. The closing of this circuit is effected by means of a metal knob on the eccentric rod at about the middle of its length. This rod, as it oscillates, carries the knob between two insulated metal springs, which are included in the circuit of the spark-generating apparatus. When the knob passes between these two springs it metallically connects them, and allows of the development of a spark between the electrodes within the cylinder of the engine.

An automatic starting apparatus is usually used on engines of more than 4 H.P. to 6 H.P. This is a simple and effective apparatus, and consists of a hand pump, H, together with a number of special hand valves, for supplying the passages for the explosive gases before the engine gets into regular action. To begin with, the vaporiser is warmed by means of the

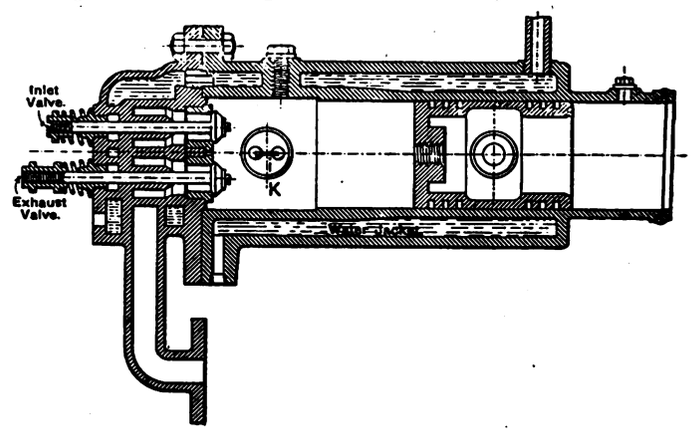

FIG. 84.—Priestman Oil Engine. Longitudinal Section of Cylinder, Valves and Piston.

lamp L. While this is going on, the hand pump will be used to force air at about 25lb. pressure (the pressure being indicated on a small gauge) into the chamber C. The flywheel will now be turned round so as to bring the igniting knob into contact with the two springs, the piston being ready to make a forward stroke. With the electric battery temporarily disconnected, the compressed air from the enclosed chamber, C, is permitted to pass through the vaporiser into the cylinder, filling the clearance space with an explosive charge. The closing of the battery circuit will now cause a spark to pass, which will fire the charge and start the engine.

Performance of the Priestman Engine.—Notwithstanding the extra duty of pumping oil and air for its own consumption, the Priestman oil engine appears to give very excellent results in regard to its mechanical efficiency. Prof. Unwin found that an engine running at 207 revolutions per minute, and developing 7·40 I.H.P., absorbed 0·64 H.P. in engine friction, developing 6·76 B.H.P. This represented the extraordinarily high mechanical efficiency of 91 per cent. The same engine, running at 204 revolutions per minute, and developing 9·86 I.H.P., was found to have a mechanical efficiency of 82 per cent. The former results were obtained with "Russoline," and the latter with American oil. About 16·12 per cent. of the total heat was utilised as *indicated* work, leaving 47·54 per cent. to be carried off by the jacket water, 26·72 per cent. by the exhaust gases, and 9·61 per cent. by other losses. The consumption of oil per brake horse-power per hour was 0·941b. of "Russoline," in the first-named test, and 0·841b. of American oil in the second-named test. In general practice the author has found that this type of engine consumes approximately one pint of petroleum per brake horse-power per hour; and in setting off the cost of this against that of steam or of gas, it must be

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remembered that this supplies not only fuel for one horse-power hour, but cylinder lubrication as well. The excellence of the graded charge system of governing in the Priestman engine is illustrated by the accompanying set of indicator diagrams (Fig. 86), which were taken from an oil engine used for electric lighting at Alnwick Castle.

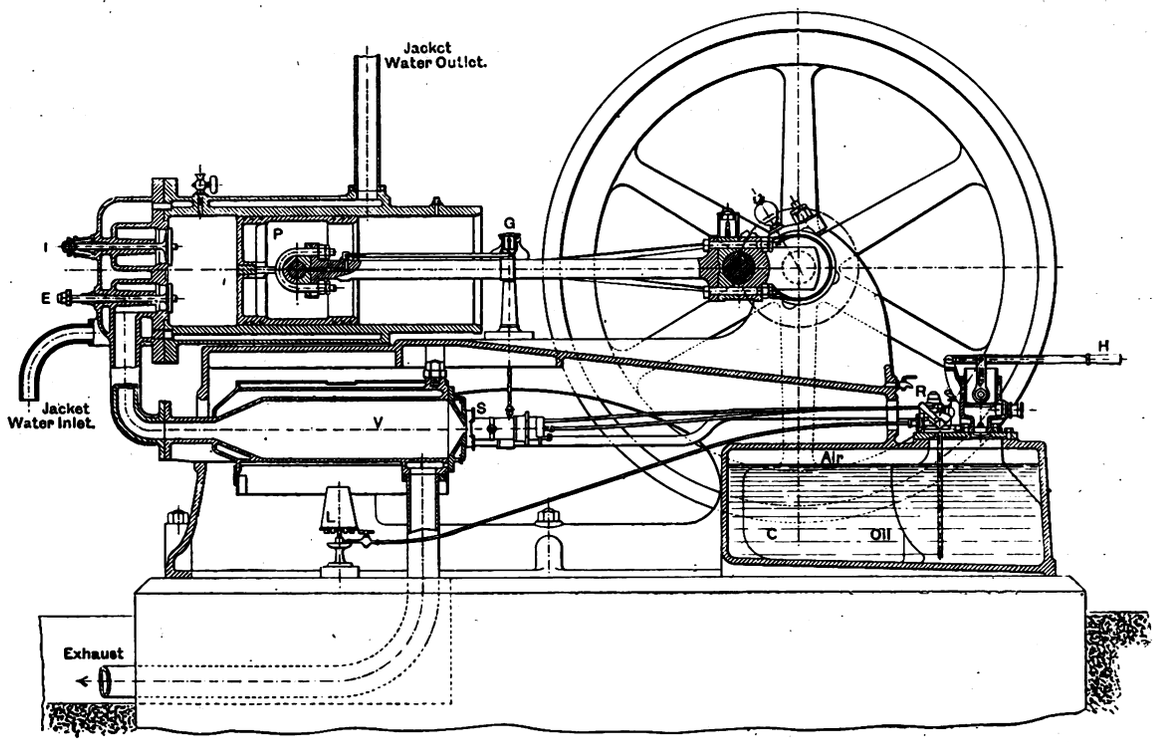

FIG. 85.—Priestman Oil Engine. Longitudinal Section.

C = Compressed Air and Oil Reservoir. H = Hand Pump for Starting Operations. R = Regulator for Starting, Stopping, &c. G = Governor actuating Supply of Oil to Vaporiser. V = Vaporiser. S = Spray Producer. L = Lamp for Heating Vaporiser at Starting. P = Piston. E = Exhaust Valve. I = Admission Valve.

Hornsby-Akroyd Oil Engine.—The Hornsby-Akroyd oil engine represents an attempt to simplify and reduce the number of the working parts of an engine designed to work with the heaviest and cheapest mineral oils in the market. The most noticeable feature is the absence of a separate

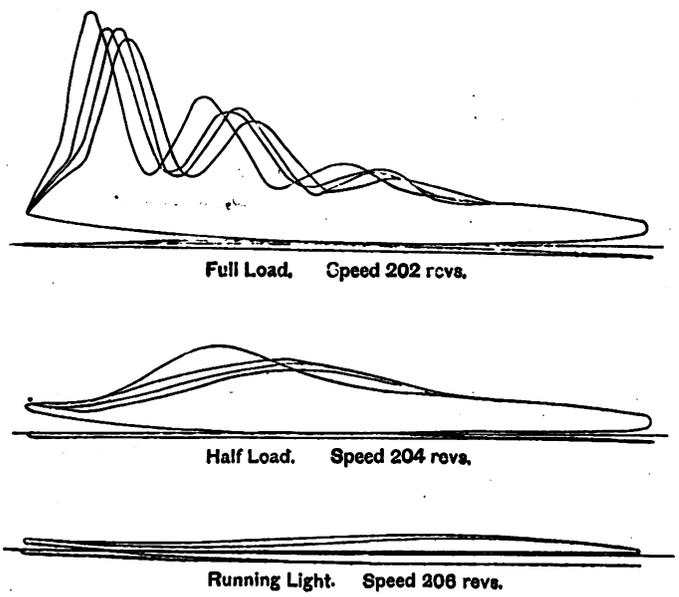

FIG. 86.—Indicator Diagrams of Priestman Oil Engine, showing Action of Graded Charge System of Governing.

chamber for vaporising the fuel, the oil being pumped directly, drop by drop, into a gasefying combustion chamber immediately behind the cylinder and forming an extension of the cylinder space. This chamber is normally at a low red heat, its heat initially being obtained from a lamp temporarily used, and being afterwards maintained by the ignition of the oil within this chamber. There is no water jacket around this combustion chamber, but air is permitted to circulate around it, to keep the temperature even. A water jacket surrounds that part of the cylinder which is immediately outside the path traversed by the piston. The heat of the exhaust gases is partially recovered, by being imparted to the air as it is drawn into the combustion chamber previously to compression. No external means of ignition is found necessary, the compression of the heated air into the space containing the gasefied oil being enough to set up an explosion, and certain enough in its action to render premature firing unlikely to happen. Messrs. Hornsby and Sons, of Grantham, are the makers of this engine; and it is claimed by them that oils of so great a density as 0·854 (flashing point, 220°F.) may be consumed in it, in continuous work. The consumption of petroleum oils of the density used for lighting purposes—0·800 to 0·850—is about one pint per brake horse-power per hour. The reduction of the fuel to a gaseous state, instead of a state of vapour, results in the charge being very much drier than in the Priestman type of engine, and necessitates the use of cylinder lubrication.

"Trusty" Oil Engine.—The ingenious idea to place the oil vaporiser around the hottest end of the cylinder, in the form of a jacket, occurred to Mr. Knight, of Farnham, whose name has been prominent in connection with the use of oil engines for road carriages. The patent in connection with this invention was acquired by Messrs. Weyman and Hitchcock, of Guildford; and their engine embodying it is called the "Trusty" oil engine. The "Otto" cycle is followed; and ignition is now by means of a heated tube. The vaporisation in this engine takes place at a sufficiently high temperature to gasefy the oil; but as a rule only slight residue, or none at all, will occur in the vaporising jacket. The engine has been exhaustively tested by Mr. W. Worby Beaumont, who has kindly favoured the author with a copy of his Report on the trials. This Report states that the "Trusty" oil engine will work with heavy oils, including the Broxbourne (paraffin) and lighthouse oils, having a flashing point as high as 240°F. No trouble was found to arise from deposits; and perfect combustion of the oil gas took place in the cylinder.

During the trials, the particulars of which are tabulated below, an American petroleum known as "Royal Daylight" was

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used, having a specific gravity of 0·802 (one pint = 1·0025lb.). The calorific value was assumed to be 19,500 B.T.U. per pound. The engine was rated at 6 B.H.P., and was tested at full, half and no load. Separate measurement was made of the amount of oil required to heat the ignition tube. This item was found to vary from 6oz. to 7oz. per hour, and was practically independent of the load on the engine. The following particulars give the exact results of the trials :—

Trials of a 6 B.H.P. *"Trusty" Oil Engine.*

—	Full power.	Half power.	Running light.
Duration of trial, hours.....	4·00	2·00	1·00
Diameter of cylinder	7·375	7·375	7·375
Length of stroke, inches	14·00	14·00	14·00
Area of cylinder, square inches.....	42·71	42·71	42·71
Circumference of brake rope, ins. ...	15·75	15·75	15·75
Brake load, mean effective lbs.	50·57	28·00	...
Revolutions per minute, mean	247·79	248·97	253·8
Misses per minute, mean	15·25	32·00	57·2
Pressure in cylinder, mean effective...	44·15	39·55	25·7
Brake horse-power	5·98	3·32	...
Indicated horse-power	7 043	5·48	2·72
Oil used per hour, lbs.	4·906	3·749	2·25
Oil used per brake horse-power, lbs...	0·820	1·129	...
Oil used per indicated horse-power, lbs.	0·696	0·685	0·827
Mechanical efficiency	0·850	0·606	...
Water used in jacket per minute, lbs.	13·85	11·0	8·03
Water used, initial temperature, mean	61·80	62·4	60·0
Water used, final temperature, mean	92·6	91·1	82·2
Water used, rise in temperature, mean	30·6	28·7	22·2

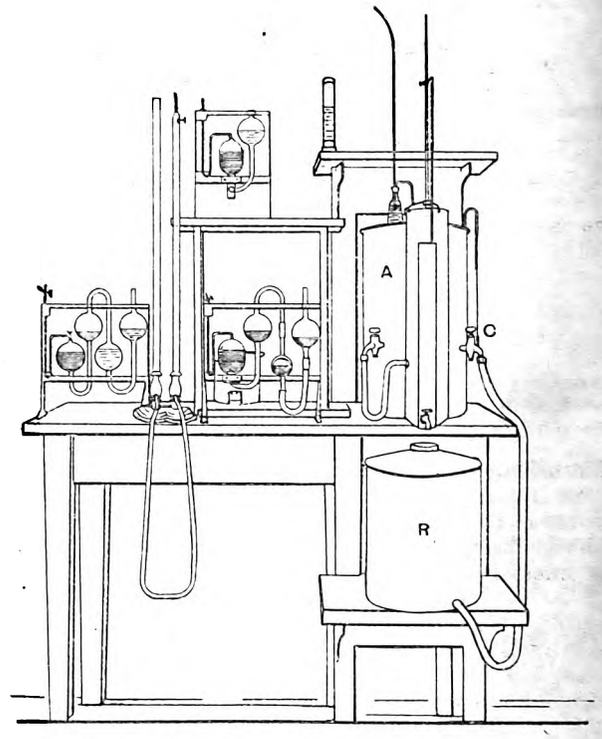
(To be concluded).

FURNACE GAS ANALYSING APPARATUS.

The best authorities on boiler practice are agreed that it is most important to make regular and frequent analyses of the furnace gases, in order to find out whether, and to what extent, the combustion is economical. The chief points to be determined are the percentages of CO and CO_2, as well as that of the free oxygen. Engineers have been hindered from systematically adopting this practice, partly from ignorance of its importance, but more particularly from lack of reliable apparatus, which would enable a representative analysis to be made with expedition and without great technical skill. At Messrs. Bryan Donkin and Co.'s engineering works in Bermondsey, we have recently seen in operation a set of apparatus, which, we judge, will meet the requirements of the case very thoroughly. This firm is not only adopting it for its own boiler furnaces, but is also, we believe, making and supplying the complete equipment. The apparatus is constructed for use on the "Waller" system, a method of gas analysis which was first introduced into Messrs. Waller's works in Belgium. In the accompanying illustration the chief details of the apparatus are shown, just as they would be arranged for regular work, the illustration having been prepared from a photograph of the Bermondsey plant.

To sample the gases the brass vessel or aspirator A is first completely filled with water. The upper part of this vessel is in communication, through a small metal tube, with the part of the furnace whence the sample is to be drawn. The lower part is connected to a drip cock, from which the water trickles into a receiving vessel R, thereby gradually drawing a sample of furnace gas into the aspirator A. By adjusting the drip cock the period over which the sampling is done can be regulated; and this period may conveniently extend from 8 or 10 hours up to 24 hours. When the complete sample has been collected it will be analysed for CO_2, CO, and oxygen. To refill the aspirator with water it suffices to open the cock C, communicating with the bottom of the receiving vessel R, and to lift this latter vessel above the level of the aspirator for a few moments.

Having collected the sample, to commence an analysis a measured volume (usually 100cc.) will be transferred from the aspirator to a burette; and this known volume will then be subjected to volumetric analysis by passing it through a succession of U-tubes and bulbs containing the various reagents. Into the details of the process it is not necessary to enter, but it may be stated that in a very short space of time the percentages of the chief ingredients, previously named, may be estimated to a degree sufficiently close for practical purposes. The percentage of CO_2 which will indicate good practice will vary with the class of coal burned, and may lie between 11 per cent. for bituminous coals and 15 per cent. for anthracite coals. The percentage of CO should, of course, be as near to zero as possible. There will always be a certain necessary percentage of free oxygen, and the amount of this will depend not only on the class of coal, but also on the type and construction of the furnace, and on the draught, &c. If there is not sufficient free oxygen there will certainly be some CO, and there may also be smoke. The right percentage of free oxygen will therefore be readily determined after a little experience. A comparison between the best percentages and those actually found by analysis, will often reveal defects in the boiler plant or in the stoking. For example, it may show that air is leaking into the flues through cracks in the brickwork, or that the stoker is not handling his fire properly. A firm of engineers which uses this analysing apparatus has devised a system of bonuses for the



stokers, the amount of the bonus rising with the percentage of CO_2 obtained. There was one stoker who, whatever boiler he was put in charge of, always managed to head the list, a fact which shows two things—firstly, that gas analysis will reveal what the stokers are doing; and secondly, that the duty of any given boiler largely depends on the stoker.

RECENT DEVELOPMENTS IN GAS ENGINES.

At a meeting of the Institution of Civil Engineers on January 28th a Paper was read on "Recent Developments in Gas Engines," by Mr. Dugald Clerk, Assoc.M.Inst.C.E. The author stated that the theory of the gas engine outlined in a Paper read by him before the Institution in 1882 was now generally accepted, while the stratification theory had vanished. Great advances had since been made in gas engine construction, and the heat efficiency of such engines had been much improved, while their dimensions and power had increased. Engines working on the Otto cycle had been proved to be the best adapted of all yet invented for present needs, and their popularity had gradually led to the extinction of other types. The mechanical development of the Otto type was illustrated by the comparison of drawings of an engine built thirteen years ago with those of one recently constructed. The advance in heat efficiency was almost, if not completely, due to increase in the pressure of compression before explosion. It was shown that each

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step of diminished gas consumption of the Crossley Otto engine was attended by an increase in compression. The results were summarised in the following table, showing the absolute indicated efficiency of Crossley Otto engines of similar size since 1882 :—

—	Efficiency.	Pressure of compression above atmosphere.
		Lb. per sq. in.
1882-88	0 16	33·0
1888-94	0·19	66·6
1894.....	0·25	87·5

These results showed that economy increased with the compression, but it was open to question whether the increased compression completely accounted for the improved performance. Theoretical efficiencies, as well as the actual efficiencies obtained in the gas engine, were shown in a table, from which it appeared that the economy had improved, chiefly on account of the increased compression. It was noted that in every case the actual indicated efficiency obtained from the various gas engines was about one-half that which would have been given by an ideal air engine following the same cycle in a perfect manner without loss to the sides of the cylinder. Also, that the actual efficiency improved more rapidly with the increase of compression than did the thermodynamic advantage due to the compression. Thus, when the theoretical efficiency was 0·33, the actual experimental efficiency was $0·33 \times 0·45 = 0·15$; and with the theoretical efficiency 0·39, the actual efficiency was $0·39 \times 0·48 = 0·19$; while with 0·428 theoretical efficiency, the actual efficiency was $0·428 \times 0·58 = 0·25$. The ratio of actual to ideal efficiency thus rose with increase of compression from 0·45 to 0 58, and this, it was stated, meant that with higher compressions, two advantages were obtained, the thermodynamic advantage, due to improvement in cycle, and a further advantage due to diminution of the proportional loss of heat to the cylinder walls.

In comparing the earlier with the recent Crossley Otto gas engine, it was pointed out that the great differences between the two engines which resulted in the superior economy of the later, were found in (*a*) the abandonment of the flame slide-valve ignition, and the substitution for it of ignition by an incandescent tube of metal or other material ; (*b*) the diminution in the relative volume of the compression space ; (*c*) the improved proportioning of the values and ports in order to minimise the throttling of the charges during the inlet period and the back pressure of the exhaust gases during discharge. This statement was illustrated by reference to numerous indicator diagrams. The author described his tests of the new Crossley Otto scavenging engine, stating that although it was highly desirable to discharge all the exhaust gases and replace them by pure air, as so long contended by him, yet that such displacement was not accountable for more than 5 per cent. of the improvement produced in the Otto scavenging engine. It was stated that scavenging possessed practical advantages quite apart from improvement in gas consumption. Otto gas engines, constructed by Messrs. Andrew and Co., of Reddish, and by Messrs. T. B. Barker and Co., of Birmingham, were also described and illustrated, and the various peculiarities of the different Otto-cycle engines were pointed out. It was stated in discussing these engines that engineers had not sufficiently recognised the importance of limiting the port surface to the utmost, in order to minimise the cooling surface in contact with the intensely hot gases. The Barker engine was referred to as one in which this point had been well kept in mind by the designer.

From a mechanical point of view the Otto cycle was a very imperfect one, allowing at most an impulse for every two revolutions of the crankshaft for each single-acting power cylinder ; but the mechanical imperfections of the engine had until now been more than compensated by the simplicity of the single cylinder and piston, and the readiness with which the practical conditions of charging, exploding, expanding and exhausting could be made to comply with the requirements of economical working. The great difficulty of the problems involved in impulse-every-revolution gas engines was then referred to, and the author described several engines which had been designed with a view to overcome those difficulties. In the first engine built by the author, early in 1878, there were two cylinders, each having a diameter of 6in , with a length of stroke of 8in., one a pump cylinder, and the other a motor cylinder. The pump crank followed the motor crank at right angles, and it pumped the mixture of gas and air into an intermediate reservoir through a check valve. From this reservoir the explosive mixture was supplied to the motor cylinder by means of a slide valve, and was compressed in the reservoir to a pressure of 70lb. per square inch above the atmosphere. The motor piston moved back to the end of the cylinder, leaving only a mechanical clearance, and the exhaust valve was shut a little early in order to cushion the piston, as was done with steam engines. The motor piston moved forward from the end of its stroke about 2in., taking in the compressed mixture from the reservoir ; the slide valve then cut off the supply, and ignition was effected by an incandescent platinum cage carried in the slide. The engine was, the author believed, the first compression gas engine working by explosion ever built which gave an impulse for each revolution of the crankshaft. The difficulties which prevented the success of this type of engine were described.

The author then considered the modifications still to be made in the indicator diagram of a gas engine to further increase its heat efficiency, and in this he particularly referred to the Otto cycle, although he stated that it was to be remembered that impulse-every-revolution engines could now be arranged to produce any of the results brought about by the Otto engine. It was pointed out that the actual indicated efficiency of a gas engine increased with the theoretical efficiency, and that the actual efficiency varied between 0·45 and 0·58 of the theoretical efficiency. It was also stated that the indicated efficiency increased with the dimensions of the engine, other things being similar, when the ratio of compression space—and therefore the theoretical efficiency—remained constant. Thus an engine having a cylinder 9½in. in diameter with a length of stroke of 18in. had a theoretical efficiency of 0·40, and gave an indicated efficiency of 0·19, or 0·47 of that theoretically attainable. An engine having a cylinder 14in. in diameter, with a length of stroke of 25in., of which the theoretical efficiency was 0·41, gave an actual efficiency of 0·277, that was 0·675 of the theoretical efficiency. The actual efficiency, instead of being only 0·47 of the theoretical, increased to 0·675 without practical change in the compression. This comparison proved that efficiency increased with the dimensions. It was pointed out that a limit was reached to the increase of efficiency due to increase of dimensions, and the conditions were calculated. It was shown that further economy might be obtained by increasing the compression and expansion, but it was considered that for high compressions and large gas engines it would be advisable to adopt the compound principle, although the conditions of success, for compound gas engines, were not yet fully understood.

In conclusion, the author considered that the gas engine would yet assuredly be applied upon railways and to ships, just as it was now used in factories ; its principles were better understood, and engineers were daily improving their knowledge of the properties of flame, and the means of utilising flame in place of steam.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-Day) FRIDAY, February 7th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting. Paper to be read: "On the Construction of a Form of Wheatstone's Bridge Box," by Gustave J. Lemmens.

MONDAY, February 10th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture IV.: "Alternate-Current Transformers," by Dr. J. A. Fleming, F.R.S.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting at the Palatine Hotel, Hunt's Bank, Manchester. Paper to be read: "The Paralleling of Alternators," by Robert Hammond.

TUESDAY, February 11th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "The Manufacture of Aluminium by Electrolysis, and the Plant at Niagara for its Extraction," by Alfred E. Hunt.

WEDNESDAY, February 12th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Water Purification by Means of Iron," by F. A. Anderson.

THURSDAY, February 13th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Continuation of discussion on the following Papers: (1) "The Electric Wiring Question," by F. Bathurst; (2) "Concentric Wiring," by Sam Mavor.

FRIDAY, February 14th.

PHYSICAL SOCIETY.

5 p.m. Annual General Meeting at Burlington House. Paper to be read: "On the Determination of High Temperatures with the Meldometer," by Prof. W. Ramsay and N. Eumorfopoulos.

INSTITUTION OF JUNIOR ENGINEERS.

8 p.m. Meeting at the Westminster Palace Hotel, Victoria-street. Paper to be read: "The Stability of Tall Chimneys," by F. J. Bancroft.

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CHEMICAL FACT AND THEORY.

It is noteworthy that, while the interpretation of electromagnetic and electrostatic phenomena has progressed from a purely electrical standpoint to one which is becoming increasingly mechanical or dynamic, the interpretation of chemical phenomena has taken a converse development, and is gradually progressing from a dynamical character to one which is becoming more and more completely electrical. In the early days of "current electricity" electrical phenomena were expressed in terms of two quantities—electricity and magnetism—each of which was non-dynamical and *sui generis* as regards the conception scientists held of it; and it has been from this crude and incoördinated stage that electrical science has developed into its modern expression in terms of mechanical quantities. Indeed, the avowed purpose of the pioneers of electrical theory is its ultimate expression rationally in terms of the three fundamental quantities—of length, mass and time. On the other hand, chemistry has but recently emerged from an era in which chemical phenomena were vaguely and somewhat inconclusively expressed in terms of "chemical affinities," forces between the atoms of a dynamical or statical nature, and "bonds," by which the molecules were held intact, and the "affinities" of the component atoms "satisfied." Such phraseology savoured more of the language of the alchemists than that of rational science; yet, in its underlying conception, it was mechanical in its nature, and it had as its main basis the conception of attractions between the atoms of chemically-reacting bodies. There was a half-truth in all this complication of bonds and affinities; and when the light of electrical science was shed upon chemical phenomena it began to be seen how closely allied these phenomena were to those of the electric charge and the electric circuit. First, it dawned upon scientific thinkers that the chemical forces between atoms were due to electrical charges upon those same atoms; and later, it has come to be seen that many, and probably all, chemical reactions between atoms are of a nature which has its simplest expression in a voltaic element circuited through a conductor.

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The reprint which we recently made of a Paper by Prof. J. J. THOMSON, on "The Relation between the Atom and the Charge of Electricity Carried by It," has already been commented upon. It is not too much to say that the researches which formed the basis of that Paper, and the deductions which Prof. THOMSON has drawn therefrom, mark one of the most important stages in the history of chemical theory. A careful perusal of that Paper can hardly fail to carry conviction in regard to the main propositions, as to the dependence of chemical reaction upon the actual electrification and the normal electro-chemical properties of the atoms concerned. Closely associated with this subject is another reprint, which we commence this week—namely, the Address delivered by Prof. H. E. ARMSTRONG before the Chemical Society, on "The Nature of Chemical Change and the Conditions which Determine It." While, in these two articles, there is a great diversity of scope, that by Prof. ARMSTRONG covering, by way of illustration, a much wider range of actual chemical phenomena, it will be seen that in their inferences and conclusions they are practically identical. "Chemical action," writes Prof. THOMSON, "does not, in general, take place between a single pair of molecules alone in the field, but requires the formation of aggregates either of the inter-acting molecules or of some third substance which is either a conductor of electricity or has a large specific inductive capacity." On this head, Prof. ARMSTRONG, who has aptly described chemical action as "reversed electrolysis," states that "in any case in which chemical action is to take place it is essential that the system operated on shall contain a material of the nature of an electrolyte," a statement which becomes unified with that quoted from Prof. THOMSON'S article by the following further quotation from Prof. ARMSTRONG'S address: "The essential moment conditioning the occurrence of chemical change, according to the view of which I am an advocate, is the formation of a conducting system in which electrolysis can occur, and within which, as already said, change will necessarily take place so soon as the system is established, if exothermic change be possible under the conditions—as in any voltaic cell."

Quite startling support of this theory is given by the behaviour, when in the pure state, of certain pairs of substances which, when mixed in a state of slight impurity—as when slightly moistened—are violently active. Reference need only be made to one instance, but several others, equally convincing, might be cited. At the Oxford meeting of the British Association, Mr. H. B. BAKER showed that perfectly dry and pure ammonia could be admixed with hydrochloric acid in a similar condition, without chemical change; whereas, almost every schoolboy knows that admixture of the ordinary gases is accompanied by energetic combination.

Prof. ARMSTRONG expresses the hope that the behaviour of the non-metallic elements will eventually justify a classification of the elements according to whether they electrically conduct or insulate, defining "a metal as an element which conducts, and a non-metal as an element which insulates." The first difficulty, that non-metals do not perfectly insulate, may possibly be disposed of in the majority of cases by assuming that the imperfection arises from impurity, the impure components setting up electrolytic conduction. A great deal of importance has been attached to the influence of impurities; and throughout his address Prof. ARMSTRONG insists upon "the great importance of the part played by 'impurity' in Nature in conditioning chemical change." The next difficulty is met with when we attempt to classify the metalloids: arsenic, tellurium, &c. These cannot be regarded as being conductors purely by virtue of their impurities; and the only apparent way to get them into line with the definition of a metal is to transfer them to the class of metals, which step many chemists would resist. But the most insuperable obstacle, to our mind, is the element carbon. To regard this as a metal would stretch the imagination to the breaking point; while to be told that it is not a conductor is just as liable to stagger the practical electrician. Yet Prof. ARMSTRONG does not hesitates to tell us that it is not. "The conductivity of what is so wrongly called carbon," he tells us, "in the form used for electric light purposes, is well known to be electrolytic in character, and is, therefore, most probably conditioned by the presence of salts, and not a specific property of the modification of the element present is such materials." Now, what is so wrongly called carbon is used by electrical engineers in two forms, in the incandescence lamp filament and in the arc-lamp "carbon" rod. The process of making each of these, but more especially the latter, is conducive to the existence of salts in the finished article. Yet in neither case can the percentage of these salts be much in excess of a mere trace; and in the glow-lamp filament, with careful manufacture, the trace might easily be made untraceable. Are we, then, to credit that the conductivity of these articles of carbon, falsely so-called, is entirely due to the electrolytic influence of their impurities? A comparison between the conductivity of salts and that of the maligned but useful articles, shows that the conductivity of the "carbon" is very considerably the greater and makes it difficult to accept this explanation. We are, therefore, still face to face with the question as to the class into which elementary carbon should be placed. Carbon is, in many of its chemical relationships, somewhat an anomaly. It would be better to assume that in this particular respect its behaviour is anomalous, rather than on the one hand to force it into a class to which it does not apparently belong, or, on the other hand, to deny it properties which it gives such striking evidence of possessing.

In regarding the theory propounded in his address as a "theory of *association*," as opposed to the older theory of *dissociation*, we think Prof. ARMSTRONG may have assumed an antagonism which does not really exist. We are at one with him in thinking that "the main article of faith in the dissociationist's creed, that a certain very limited class of compounds —electrolytes—fall to pieces, as it were, more or less completely on entering into solution," necessitates "a profound distinction being made between electrolytes and other compound molecules generally." Profound indeed, but not necessarily a radical distinction, for it seems to us that the dissociation theory, in support of a limited application of which there is so much direct evidence, may be but a restricted portion of a more widely-extending theory—an all-embracing theory such as that of *association*. It is conceivable that in certain cases a preliminary process of dissociation may precede the chemical or electro-chemical processes of association, which are represented by the obvious and ultimate reaction between the bodies concerned. This as we understand it is the point of Prof. J. J. THOMSON'S illustration of the combination between hydrogen and chlorine, in the Paper to which we have already referred (*The Electrician*, January 3rd, pp. 324 and 344). He first assumes the existence of an external dissociating agency, and proceeds to show that half of the H or Cl atoms would be positively and half negatively electrified. Unless conducting circuits can be formed between the dissociated atoms, as by the presence of a third substance, this state of affairs will not alter. If, however, such circuits can be formed, a re-adjustment of the atomic charges will take place, all the H becoming positive and all the Cl negative,

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with the result that chemical combination might ensue. Taken conjointly, it seems to us that the two articles by Profs. ARMSTRONG and THOMSON not only emphasise the importance of viewing all chemical phenomena from the electrical standpoint, but they give good ground for hope that the details of the true theory will be found to reconcile the "association" with the "dissociation" hypotheses.

THE NATURE OF CHEMICAL CHANGE AND THE CONDITIONS WHICH DETERMINE IT.*

"All the facts show us that that power commonly called chemical affinity can be communicated to a distance through the metals and certain forms of carbon; that the electric current is only another form of the forces of chemical affinity; that its power is in proportion to the chemical affinities producing it; that when it is deficient in force it may be helped by calling in chemical aid, the want in the former being made up by an equivalent of the latter; that, in other words, *the forces termed chemical affinity and electricity are one and the same.*" †—Faraday's "Experimental Researches in Electricity," 1834, Series VIII., § 918.

Foremost among the problems to which during recent years attention has been devoted is that of the nature of chemical change. Whilst English workers especially have made most important contributions to our knowledge of the conditions under which change will occur, foreign workers have been most active and successful in developing mathematical methods of treating the subject. Indeed, the statement recently made in a prominent chemical journal that "it has certainly become impossible to read chemical theory without a working knowledge of the calculus" is a striking comment on the alterations in the conditions under which the chemist will work in the future, which must serve to remind us how very different a preparation students must now undergo if they desire to thoroughly master the theories of our science.

The subject first came under consideration in this Society just 10 years ago. In the discussion on Mr. Brereton Baker's Paper on combustion in dried gases I ventured to insist that the evidence that action did not take place between two substances was so strong that chemists would ere long be forced to form a definite conception of the nature of chemical action and of the conditions under which chemical action could take place; and I then pointed out that physicists were in advance of chemists, drawing attention to Ayrton and Perry's Paper on the contact theory of voltaic action, in which it is directly stated that Ohm's well-known law is equally applicable to electrical and chemical changes.‡

On the occasion in question I defined chemical action as *reversed electrolysis*, and explicity stated that in any case in which chemical action is to take place it is essential that the system operated on shall contain a material of the nature of an electrolyte. The expression "chemical action" was used as including all cases of exothermic change, cases of endothermic change being obviously comparable with direct electrolyses, as in all such cases energy from without must be impressed on the system.

Later in the year, at the British Association meeting at Aberdeen, in my address to the Chemical Section, I discussed the matter more fully, and then stated in so many words that the conditions which obtain in any voltaic element are those which must be fulfilled in every case of chemical action. I carefully pointed out, however, that there was nothing new in this, and to justify my assertion drew attention to various passages in Faraday's "Experimental Researches in Electricity," in which such a doctrine is laid down in the clearest possible terms.§ Let me here again say that nothing is to me more surprising than the continued disregard of Faraday's teaching on this subject. We know that in regard to purely electrical questions, even in this country, it was not until Clerk Maxwell came forward as his interpreter that attention became riveted upon his conceptions; and abroad, even, Clerk Maxwell was disregarded until Hertz's experimental demonstration ensured that respect being paid to his pleadings which they were so long denied. Faraday's views regarding chemical action have never yet received proper notice, although the language in which they are expressed is so simple and direct that they cannot be misunderstood, and their completeness is surprising.

But one conception has been added to Faraday's teaching—that of "electrolytic or ionic dissociation or ionisation." Although introduced by Clausius in 1857, it lay dormant until it was reintroduced and applied by Arrhenius in 1884, who gave to the hypothesis a quantitative form; but it did not become popular until 1887, when Van't Hoff introduced the conception of osmotic pressure. The successful application of the hypothesis in explanation of the abnormally high results obtained in the case of conducting solutions at once secured for it a very large measure of support. Whatever view may ultimately be taken of the hypothesis—whether it be retained as a permanent addition to our theories or not—its introduction has been eminently fruitful of results, and an already too voluminous literature of the subject has grown up with surprising rapidity. Yet it appears to me that it has been accepted by a particular school—at the head of which stands Ostwald, and who regard and treat all unbelievers as heretics worthy of the stake—not as a mere working hypothesis, but as an absolute creed, without any sufficient attempt having been made to discuss its *general* probability. And the application of Avogadro's axiom to solutions, however successful as affording a mathematical method of discussing results, in principle involves the complete disregard of the essential difference between the liquid and gaseous states, and of the fact that in liquids the molecules are subject to a control which they mutually exercise and which distinguishes the liquid from the gaseous state. Also it must not be forgotten that the arguments made use of apply almost entirely only to weak solutions—to solutions to which a law of simple proportionality may be expected to apply; that, in fact, the region explored is one in which the rate of change is represented practically by a straight line. Lastly, it is applicable only to electrolytes. Personally, I am still entirely unconvinced of the validity of the hypothesis, although no one can be more willing to admit that, in so far as *weak* solutions are concerned, a "law" has been discovered which is broadly true *in mathematical form*, however open to question the fundamental premises may be on which it is based. I am satisfied also that the phenomena of chemical change are, as a rule, far more complex in character than is assumed by the advocates of the hypothesis.

If electrolysis, and therefore electrolytic conduction, be—as I contend and have long contended—conditioned *by a conjoint influence* exercised by the solvent A and the dissolved substance B; there is, I imagine, no reason why other phenomena in which the conjoint influence of A and B comes into account should not be expressible in mathematically similar ways. In extenuation of such heresy, I can only quote Clerk Maxwell's argument that if in a battery a septum be used which diminishes the diffusion, it is probable it will increase in exactly the same ratio the resistance of the element, because electrolytic conduction is a process the mathematical laws of which have the same form as those of diffusion, and whatever interferes with one must interfere equally with the other, the only difference being that diffusion is always going on whilst the current flows only when the battery is in action.

It has always appeared to me that the chief objection to be urged against the ionic dissociation hypothesis is the fact that, of the very large number of compounds known to us, extraordinarily few are electrolytes—not even metallic chlorides generally are conductors, but only a very limited number; and it is particularly remarkable that whilst such inactive substances as lead and silver chlorides, when fused, are among the best conductors known, aluminium chloride—one of the most active compounds with which we are acquainted—is apparently not an electrolyte. Electrolytes are clearly a very limited class, and if we consider the general properties of compounds which conduct more or less readily, whether alone or in solution, and contrast them with compounds which are practically dielectrics, it is impossible to discover any good reason why "ionic disruption" should take place in the case of the one set and not in that of the other. And if, confining our attention to acids, we contrast those which in solution are apparently good conductors with those that are bad conductors, there is again no satisfactory "motive" for so considerable a difference discoverable; for example, taking sulphuric and acetic acids, why should the former suffer ionic dissociation so readily and to so considerable an extent, and the latter to so slight an extent? I imagine that it is fair, for this purpose, to regard the acids as modified water, and to assume that the slight tendency of water to undergo ionic dissociation—of which more later on—is enhanced by the association of the water with the oxygenated group, and that whereas sulphuric anhydride has a marked effect, acetic anhydride has a very slight one. Yet this is hardly satisfactory, and would probably involve the conclusion that sulphuric acid should diminish in conductivity as the temperature is raised, as it then dissociates into anhydride and water; the very different behaviour of sulphuric and acetic acids when vaporised, the former but not the latter undergoing dissociation, may be regarded as an indication that a similar change does not take place in the case of

* Abstract of an address delivered by Dr. H. E. Armstrong before the Chemical Society.

† The italics are Faraday's own.

‡ "Hitherto chemists have only employed the two ideas of chemical affinity and the amount of chemical action, but we have shown that these ideas are simplified when regarded as electromotive force of contact and currents of electricity. To connect the two ideas we have a third—viz., *resistance*, and the electrical law of Ohm becomes the chemical law—*the quantity of chemical action in unit time equals the sum of a great number of terms, each of which is an electromotive force divided by a resistance.*" (Ayrton and Perry, *Proc.* Roy. Soc., 1867, 27, 227.)

§ Series VII., §§ 850, 858, 859; VIII., §§ 869, 918.

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acetic acid, and, therefore, it might be supposed that acetic acid would undergo ionic dissociation to a far greater extent than is assumed to be the case as a consequence of the anhydride retaining its influence.

It may possibly be contended, as it has been in the case of water, that compounds generally are conductors to a very slight extent; but as all bad conductors seem to become worse conductors as they are more carefully purified, the burden of proof rests upon those who make such an assertion; and it is not in accord with the fact that very many such compounds are as active as compounds which conduct well, and which are therefore, by hypothesis, more or less fully dissociated. For example, acid chlorides generally act on alcohols generally with very considerable readiness under conditions under which the halhydrides produce but a slight effect.

With regard to water itself, to argue, as Arrhenius, Ostwald and others have done, from the hydrolytic action of water on the salts of weak acids and bases, that water to a certain but very small extent contains ions—that is, H and OH, is but to beg the question entirely, and a clear case of reasoning in a circle.

The recent redetermination of the electrical conductivity of water by F. Kohlrausch and Heidweiller gives the value $0{\cdot}04 \cdot 10^{-10}$ at 18deg., instead of $0{\cdot}25 \cdot 10^{-10}$ previously arrived at by F. Kohlrausch. These authors have deduced from their results a value for the conductivity of *pure* water—viz., $10^{10} \cdot \kappa = -0{\cdot}0361$. They calculate that if this conductivity be due to the presence of water ions a cubic metre of water at 18deg. would contain 0·08 milligram of dissociated hydrogen ions, and point out that if present only in this excessively minute proportion there would still be milliards of atoms of hydrogen per cubic millimetre, and neighbouring atoms would be separated by distances of the order of light waves in dimension. These conclusions, however, are based on the acceptance of the view put forward by Arrhenius, that the dissociated ions alone conduct the current—from my point of view, therefore, it is a case of deducing one unknown with the aid of another unknown—of proving one assumption by another assumption, which is admittedly an unsatisfactory proceeding. I venture to think that it is still open to question whether pure water, indeed whether any *pure* substance outside a very limited number perhaps, such as the silver haloïds, &c., be an electrolyte. Minute in the highest degree as the amount of impurity in the water examined by Kohlrausch and Heidweiller must have been, yet even this may have exercised a very considerable effect, and in fact there is clear evidence in the Paper that an extremely minute amount of impurity does so act. Moreover, the difference between the lowest observed value and the corrected value appears disproportionately small when the reduction of the value previously obtained by Kohlrausch, effected by the removal of what after all must have been a very minute amount of impurity, is considered. The point is one of the utmost importance, and cannot be lightly brushed aside.

The methods made use of in calculating the amount of ionic dissociation of water are apparently all open to the criticism that they are based on eminently hypothetical premises, and it is particularly open to question whether the phenomena from which fundamental values have been deduced have received the proper interpretation. For example, the origin of the E.M.F. developed in liquid couples such as have been studied by Worm Müller, and much later by Nernst, and of the concentration currents of von Helmholtz, is by no means clear. Nernst assumes that in such cases forces acting at the electrode surfaces are entirely eliminated, but, if so, it is not clear why any more than when an acid neutralises an alkali an E.M.F. should be developed, for I imagine that in all such cases the changes take place within closed circuits. In fine, I am inclined to doubt whether polarisation effects can be regarded as eliminated; the inquiry must be included with that into the existence of a true contact difference of potential independent of chemical change. The values deduced by Ostwald are based on the study of couples of the form :—platinum-hydrogen | acid | alkali | hydrogen-platinum, and it is assumed that the E.M.F. developed is due to the formation at the one electrode of water from the hydrogen and the OH ions in the liquid, and at the other of hydrogen from hydrogen ions in the liquid and the hydrogen of the electrode. Unfortunately the description promised of the experiments has not yet been given, and it is therefore difficult to criticise them; it is not impossible, however, that the real cause of the E.M.F. was dissolved oxygen.

Pure liquids do not conduct, according to Kohlrausch, because (as Ostwald has put it, *Brit. Assoc. Report*, 1890, 335) their molecules have no space within which to resolve themselves into ions, and it is therefore not improbable that water would conduct electrolytically—and I presume that Ostwald meant even to imply that it would be a good conductor, as he immediately afterwards spoke of water too containing ions to a certain but very small extent—if we could find a suitable solvent for it. But we never have found a suitable solvent—unless it be hydrogen chloride. The fact that single substances such as the silver haloïds, when liquefied, readily conduct, would appear in itself to be a sufficient argument in controversion of Kohlrausch's explanation of the influence of the solvent. Moreover, it is to be supposed that any liquid capable of acting as a solvent should condition electrolysis if the function of the solvent be but to act as a screen.

As a matter of fact, there is good reason to think that among liquids, *water is the only effective solvent that we can use!*

Alcoholic and some other solutions, it is true, conduct more or less well, but it is by no means improbable that when every precaution is taken to deal with highly purified materials, and especially to dehydrate the alcohol as fully as possible, such solutions will be found to be practically destitute of conducting power. This is the more likely now that Perkin has established the incorrectness of the supposition that until recently has always been made that hydrogen chloride, when dissolved in alcohol, acts fairly readily on it (*Trans.*, 1894, 23). The observations made by Coldridge showing that solutions of hydrogen chloride in stannic chloride are but slightly conductive are also significant (*Phil. Mag.*, 1890, 29, 383).*

If it be assumed that even pure water is to some slight extent dissociated, it is, at least, probable that liquid hydrogen chloride would contain some small proportion of ions prior to admixture with water; and, in point of fact, it is impossible to urge any reason why the one compound should be regarded as more dissociated than the other in the pure state. Yet the "ionists" not only assert that when hydrogen chloride dissolves in water it becomes almost completely separated into its ions, but make the arbitrary assumption that practically it alone is dissociated, the extent to which the water is dissociated being, indeed, diminished by its admixture with hydrogen chloride, according to their view. This question is of fundamental importance as bearing on the validity of the argument on which Ostwald and others have sought to base a method of determining the heat of formation of water from its ions and on the interpretation they have given of the changes attending the neutralisation of acids by alkalis.

I long ago insisted that we have no right to draw any marked distinction between hydrogen chloride on the one hand and water on the other, inasmuch as, in so far as the chemist can test them, they do not differ markedly in stability. I venture to think that no sufficient answer has been made to my objection. To say that analogous compounds such as NCl_3 and PCl_3, or N_2O_5, and P_2O_5, exhibit differences equal to those manifested between HCl and H_2O is incorrect and beside the point—they are vastly different in stability; water and hydrogen chloride are not (compare Ostwald *Zeit. Physikal. Chem.*, 7, 418). So long as it was asserted that water, *per se*, underwent no change, the position was, perhaps, in a measure defensible; but when it is argued that pure water does dissociate into its ions, this advantage is sacrificed; the possibility of a change taking place in pure water being granted, it is no longer justifiable to draw a hard and fast distinction between water and hydrogen chloride. This argument is most materially strengthened by the fact that the majority of compounds are not electrolytes.

Although those who uphold the ionic hypothesis regard the solvent as mainly inactive, yet they do not deny that it may exert some influence comparable with that exercised by raising the temperature (compare Ostwald, *Zeit. Physikal. Chem.*, 1891, 7, 421; *Lehrbuch*, 2nd Ed, 1, 776). But it is impossible to gainsay that it has an altogether extraordinary effect in many cases. For example, in the case of hydrogen chloride, it is only necessary to mix this with nine molecular proportions of water to obtain a solution of maximum conductivity, in which, if we are to believe the ionists, nearly the whole of the dissolved hydrogen chloride is resolved into its ions. It is scarcely conceivable, however, that so small a proportion of water molecules should suffice to practically entirely prevent the reunion of ions which cannot by hypothesis be kept apart in the absence of the solvent; and the conclusion is the more striking if it be remembered that, according to Ostwald, hydrogen silicon fluoride only begins to undergo hydrolysis when present in a solution to the extent of 1 per cent., a very large proportion of water being required to prevent the reversal of the interchange $H_2SiF_6 + 2H_2O = SiO_2 + 6HF$—in other words, a compound which is almost generally regarded as a molecular compound is far less readily broken up† than one of the most stable of "atomic compounds!"

Or, taking the case of sulphuric acid, how are we to satisfactorily explain by the ionic dissociation hypothesis the fact established by F. Kohlrausch that the amount of acid required to form a solution of maximum conductivity increases as the temperature rises, from 30·2 at 0deg. to 35·4 per cent. at 70deg? If, however, electrolysis occur within a system of acid and water molecules, as a rise of temperature would promote the occurrence of dissociation in such a system, a larger proportion of acid would be required at higher temperatures to maintain the system of the same average composition.

In fact I believe it is impossible to deny that the solvent is intensely active, and that it is no mere screen preventing re-com-

* These observations require to be repeated, taking every possible precaution to exclude moisture.

† Incidentally it may be asked, how is the formation of hydrogen silicon fluoride from solid silica and hydrogen fluoride to be explained; and how are we to reconcile the fact that action takes place with such extreme readiness when hydrogen fluoride is by hypothesis so slightly dissociated?

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bination of the ions—it is rather to be supposed that the occurrence of electrolysis in a solution of hydrogen chloride, for example, is in some way directly conditioned by the conjoint influence of the solvent and the dissolved substance; that electrolysis is not merely an affair of atoms of ions, but of complex molecular systems; and most important of all—*that water, perhaps, is altogether peculiar among solvents as furnishing solutions which can be electrolysed.*

Having thus considered some of the apparent anomalies of the ionic dissociation hypothesis, I may now briefly refer to evidence of its insufficiency in the case of interactions, in which substances are concerned which are not electrolytes—a condition which is not fulfilled in the case of a very large number, indeed an overwhelming majority of carbon compounds. No doubt it may be asserted that, at all events, the agent used is dissociated, and that consequently the compound which is attacked is subject to the action of ions just as the zinc is in a voltaic cell. But is this a sufficient explanation? Consider the case of the hydrolysis of sugar—admitting, for the sake of argument, that when this is effected by dilute acid, the ions of the acid and of water either simultaneously or successively attack the sugar molecule; how are we to explain the action of the enzyme invertase? This cannot well be regarded as an electrolyte; and it is not sufficient even to assert that it does, to some slight extent, undergo dissociation into ions—it acts so readily, more readily even than an acid which, by hypothesis, is to a very great extent dissociated, that if at all dissociated it is presumably highly dissociated. The selective action of enzymes on glucosides, &c., is also very remarkable, as acids do not act selectively.

Difficulties such as appear to beset the ionic dissociation hypothesis are not met with in considering the alternative *association* hypothesis, and if this can be shown to be compatible with electrical requirements, it should command more general consideration—in fact, there have been many indications of late that this view is once more coming into prominence. Briefly stated, the hypothesis involves the assumption that complication, not simplification, precedes most, if not all, chemical changes; that complex molecular systems are first formed from the interacting substances, and that these, on breaking down, suffer rearrangement of the parts—such rearrangement taking place in consequence of elements which were previously separate being brought into one common "sphere of activity" within which it is possible for them to interact. The function of condensing and other agents—of catalysts generally—on this hypothesis is that of collecting into one system the various elements necessary for the occurrence of a particular change. Such systems may be regarded as, and, in fact, would be, closed voltaic circuits or potential circuits requiring only the removal of a resistance to convert them into closed circuits. The action of aluminium chloride, for example, in conditioning the formation of homologues of benzene from the two substances benzene and methyl chloride—both undoubtedly dielectrics, I imagine, which when together alone are entirely without action on each other, may be ascribed to the formation of an unstable compound of both with the metallic chloride. In like manner it may be supposed that ferric chloride conditions the interaction of bromine and benzene by combining with both, and so bringing them both within each other's range in an unstable system. The function of enzymes in promoting hydrolysis, referred to above, on this hypothesis, consists in bringing water into conjunction with the carbohydrate by combining with both. Lastly, if it be assumed that a solution consists of dissociable molecular compounds of solvent and dissolved substance, the occurrence of change on dissolving two substances in a common solvent, as in the case of methyl iodide and silver nitrate in alcohol, may often be conditioned by the solvent acting as "condensing agent" or catalyst.

Prof. Fitzgerald, who has carefully considered this hypothesis, if I rightly understand his argument, seems to see no difficulty in applying it to the explanation of electrical phenomena. The modification of Grotthus's hypothesis, which he has suggested, is certainly one which appears to be in entire harmony with chemical experience, and it is so important that the question should be fully discussed, that I will venture to quote his statements almost in their entirety from the *Brit. Assoc. Report*, 1890, 142, where they are too likely to escape general attention:—

"Electrolysis has been explained on two different theories by Grotthus and Clausius. As generally received they differ. Grotthus's theory, as generally given, assumes that the molecules in an electrolyte are both polarised and moved by the electric forces within the liquid. This seems so far untenable that it would appear that double the electric force would double both the polarisation and the motion of the molecules, and so should produce four times the electrolysis. The objection, however, assumes that we know the causes resisting the motion, and with proper and not very improbable assumptions as to the resistance to motion depending on it and on the polarisation, a linear relation between current and electromotive force, *i.e.*, obedience to Ohm's law seems possible. A modification of Grotthus's hypothesis in the direction of Clausius's is, however, possible. Suppose that when polarised, the molecules *drew one another apart* at a rate proportional to the polarisation. This at once makes the relation between electric force and the decomposition a linear one, and so satisfies Ohm's law in the case of small currents It also so far agrees with Clausius's hypothesis that it explains electrolysis and double decomposition as properties of the same kind. The molecules in a liquid will occasionally be arranged by accident in a proper polarised condition in a closed circuit for drawing one another apart, and if the circuit includes molecules of different kinds there will result double decomposition. There seem to be very serious difficulties in supposing that uncombined atoms are for any finite time free in the liquid; and the supposition that it is a particular arrangement that is required before exchanges take place, and that with this arrangement exchanges take place of their own accord, seems to explain electrolysis and double decomposition without supposing free atoms to exist within the liquid. . . .

"There are some other phenomena that have been explained upon the supposition that free atoms are gadding about in a liquid. Such are the lowering of the boiling and freezing points by solutions of salts and their effect on osmotic pressure. If dissociated atoms are going about in a liquid as in a gas, it seems impossible but that they must diffuse at different rates; and that this is not observed seems conclusive against the hypothesis, no matter what else the hypothesis may explain. Consider solution simply. Why does chloride of sodium dissolve in water? There must be some strong affinity between the two of a chemical or semi-chemical nature to break up the cohesion of the crystal; and it seems reasonable to assume that this same affinity keeps the molecules of NaCl moving about among the water molecules so that they diffuse about. Now if the forces drawing them about be independent of the nature of the molecule, most of the phenomena explained by gaseous laws are explained. Pressure of a gas depends, at any temperature, on the number of molecules and not on their kind. This is Avogadro's law, by which molecular weights are calculated; and if the forces drawing a molecule about in a liquid are independent of the kind of molecule, the very same law of pressure would hold, the pressure forwards of molecules of different kinds would depend on their number only, and in the same way as Avogadro's law would enable molecular weights to be calculated. In this connection it is well to state that some bodies may be much better able to produce pressure than others, because of their being more easily polarised, *i.e.*, turned into an effective direction. A molecule which could be easily turned into an effective direction would be about twice as effective as a molecule which went about in a higgledy-piggledy way; and one would consequently expect electrolytes to produce more, nearly double, the osmotic pressure that others did. As to the changes of boiling and freezing points, they seem explicable by exactly the same hypothesis. The reduction of vapour pressure by molecular affinity of dissolved salt would depend only on the number of molecules of salt if all salts have the same molecular affinity for water; and the same would apply to the change in freezing point. Hence all these phenomena are explained without assuming free atoms, and they are all explained by what can hardly avoid being a *vera causa*, namely, whatever affinities they are that cause solution, which latter is an unexplained phenomenon on the dissociation hypothesis. That it is reasonable to think that the forces keeping the molecules of salt moving about in the water are independent of the nature of the salt, appears from various considerations. In the first place these forces are in all probability due to the residual affinities of the non-metallic elements. These same forces are probably the cause of crystallisation. These are old suggestions. That these residual affinities should be nearly the same for different combinations does not seem at all unlikely. . . ."

I have said above that the complex systems within which chemical change is assumed to take place would be closed voltaic circuits. It is to be expected that evidence of the occurrence of electrolysis and chemical change as interdependent phenomena within such ssytems will frequently evade detection, as more often than not we have to do with circuits which cannot be explored; and on this account also our power of availing ourselves of the energy of chemical change is strictly limited. Probably no discovery could be made which would be of greater technical importance than the discovery of a method of burning fuel electrically, *i.e.*, so as to produce electricity instead of heat. Hydrogen may be burnt electrically in the manner discovered by Grove, apparently because it is possible by means of platinum to connect both hydrogen and oxygen in circuit with an electrolyte such as diluted sulphuric acid; but we have not yet succeeded in discovering a method of "plating" a conductor with carbonic oxide which would enable us to arrange it in a circuit with oxygen. If this could be done, probably the problem would be soon solved. In the case of solid fuel the problem presents other difficulties, especially that arising from the want of suitable electrolytes; thus, although heated lead oxide is readily reduced by carbon, it does not behave as an electrolyte when the attempt is made to burn carbon electrically by means of it, the action being purely local. In like manner we have to discover a means of converting nitrogen into either ammonia or a nitrate comparable with that which apparently enables the papilionaceous plant or associated bacteroid to assimilate nitrogen from the atmosphere.

Having broadly laid down the principle that chemical changes consist in the exchange of ions, and therefore take place exclusively between ions, the "ionists" may be presumed to accept the view that chemical and electrolytic changes generally are synonymous operations. This being the case, it is remarkable how little has been done by way of applying the hypothesis except as a means of correcting values obtained in working with solutions which behave as electrolytes. The expansion and application of Faraday's conceptions to the explanation of chemical change generally appears, indeed, to have been retarded rather than advanced by the

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assertions formulated by the advocates of ionisation as a precedent cause of chemical change; indeed, Faraday's writings appear to have received no notice from the school. No attempt has been made to differentiate electrolytes from dielectrics by explaining either the essential peculiarities of either class or the co-ordination of composition, *i.e.*, structure and function; or to explain the extreme readiness with which dielectrics are in many cases acted on; or to define the conditions under which chemical change will occur; or to explain the readiness with which a minute amount of "impurity" will often condition change.

(To be continued.)

CATHODE RAYS.*

BY G. JAUMANN.

M. H. Poincaré gave in the *Comptes Rendus* of December 3, 1895, an equation showing that cathode rays follow a general law which I only found separately for all the special cases. But he assumes that his equation gives the direction of propagation of cathode rays, which I cannot agree to. This equation gives the speed of propagation of the wave front, which has no general relation to the speed or direction of the ray.

For rarefied homogeneous gases in the static state M. Poincaré's equation takes the form of

$$k\frac{d\theta}{dt}+X_0\frac{d\theta}{dx}+Y_0\frac{d\theta}{dy}+Z_0\frac{d\theta}{dz}=0.$$

It is an equation of the first order which not only the variable θ but all the variables of the ray will satisfy. Let n be the direction of the normal to the wave front; we get for c the speed of the wave front

$$c=\frac{1}{k}\left[X_0\cos(n,x)+Y_0\cos(n,y)+Z_0\cos(n,z)\right].$$

It is impossible to make any deduction as to the direction of the rays. Perhaps the rays coincide with the normals to the wave front, as I think they do, then the speed of the rays is equal to c. Perhaps the rays follow the lines of force (X_0 Y_0 Z_0), as M. Poincaré thinks; then the speed of the rays would be independent of the inclination of the plane of the wave to the direction of the ray.

M. Poincaré concedes that wave fronts are deflected by the magnet. That being so, I find it difficult to understand how the direction and speed of the rays can be independent of the magnetic force. I only know three ways of finding the direction of the rays.

1. Huygens' method, which, as I have shown in my Paper, is only true for rays following a differential equation of the second order (light rays, acoustic rays, &c.), and not for the rays of the first order of my theory. This method would give the result that M. Poincaré has enunciated, but it gives results that are demonstrably wrong as to the propagation of the wave surface and as to reflection. Moreover, the elementary surface of Huygens degenerates in this case into a single point, which means that the undulation is propagated from the centre of disturbance in a single line, and not in all directions, which no one can believe.

2. Kirchoff's method, which is based on the ill-defined direction of the flux of energy.

3. The method employed by me in one case, and which is based on the distribution of intensity. If in the integral we can find lines where the intensity of the oscillations is constant, these are the directions of the rays. This method told me that the direction of the rays is everywhere normal to the wave fronts deflected by a magnetic force. In the same way, I do not think cathode rays follow the lines of electric force if the rays have magnetic components.

Hence I need not as yet modify my hypotheses. But it would not be difficult to do so in order to get over M. Poincaré's objection, which is very interesting, since it opens a discussion on the direction of the rays of the first order, a question which presented so many difficulties in the case of luminous rays of the second order.

Institution of Mechanical Engineers.—At the annual general meeting of the members of this Institution, held last week in the theatre of the Institution of Civil Engineers, it was stated that at the end of last year the number of names in all classes on the roll of the Institution was 2,270, as compared with 2,222 at the end of the previous year. The Council have bought a site at Storey's-gate, with the view of providing a permanent home for the Institution. Contracts are being prepared for a building, and it was hoped that next year the house would be completed.

* *Comptes Rendus*, Vol. CXXII, No. 2. Reply to a Note by M. H. Poincaré, for which see *The Electrician*, January 31st, p. 453.

BOARD OF TRADE REVISED ELECTRIC LIGHTING RULES.

In our issue of May 31, 1895, we published the draft revised electric lighting rules proposed by the Board of Trade for securing the safety of the public. In our issue of November 22, 1895, we published a full report of the Conference held at the Westminster Town Hall on the previous Tuesday and Wednesday. In our issue of December 13, 1895, we published the Report of the Special Committee appointed by the Board of Trade to consider the definition of "low pressure." To-day the cycle of events is completed by the publication of the new Rules in their final form.

DEFINITIONS.

In the following regulations—

The expression "the Order" means the ——— Order.

The expression "the Undertakers" means the Undertakers for the purposes of the Order,

The expression "consumer's wires" means any electric lines on a consumer's premises which are connected with the service lines of the Undertakers at the consumer's terminals.

The expression "aerial line" means any electric line which is placed above ground and in the open air.

The expression "pressure" means the difference of electrical potential between any two conductors through which a supply of energy is given, or between any part of either conductor and the earth; and—

(*a*) Where the conditions of the supply are such that the pressure may at any time exceed 500 volts if continuous, or 250 volts if alternating, but cannot exceed 3,000 volts, whether continuous or alternating, the supply shall be deemed a high-pressure supply;

(*b*) Where the conditions of the supply are such that the pressure may on either system exceed 3,000 volts, the supply shall be deemed an extra high-pressure supply.

The expressions "high pressure" and "extra high pressure" [respectively are used in relation to electric lines, conductors, circuits, and apparatus] according to the conditions of the supply delivered through the same or particular portions thereof.

Where these regulations require any metallic body to be "efficiently connected with earth," it shall be connected with the general mass of earth in such manner as will ensure at all times an immediate and safe discharge of electrical energy.

Other expressions to which meanings are assigned in the Order or in the above-mentioned Acts have the same respective meanings in these Regulations.

A.—REGULATIONS FOR SECURING THE SAFETY OF THE PUBLIC.

GENERAL.

Pressure of supply to consumers. 1. The pressure of a supply delivered to any consumer shall not exceed 250 volts at any pair of terminals, except with the express approval of the Board of Trade. Such approval will only be given for special purposes and on the joint application of the consumer and the Undertakers, and the supply will be subject to such further regulations as the Board of Trade may from time to time prescribe.

Pressure of supply to transforming apparatus. 2. The pressure of a supply delivered to a transforming station or to transforming apparatus on a consumer's premises may exceed 250 volts, but shall not exceed the limits of high pressure.

Limitations of extra high-pressure supply. 3. An extra high-pressure supply shall not be given except to distributing stations or other premises in the sole occupation of the Undertakers, and with the written consent of the Board of Trade, and subject to such regulations and conditions as the Board may prescribe.

Maximum current in conductors. 4. The maximum working current in any conductor shall not be sufficient to raise the temperature of the conductor or any part thereof to such an extent as to materially alter the physical condition or specific resistance of the insulating covering, if any, or in any case to raise such temperature to a greater extent than 30°F.; the cross-sectional area and conductivity at joints must be sufficient to avoid local heating, and the joints must be protected against corrosion.

Minimum size of conductors. 5. The sectional area of the conductor in any electric line laid or erected in any street after the date of these regulations shall not be less than the area of a circle of one-tenth of an inch diameter, and where the conductor is formed of a strand of wires, each separate wire shall be at least as large as No. 20 standard wire gauge.

Specification of insulating material. 6. All material used for insulating electric lines or apparatus shall be of the best quality, and thoroughly durable and efficient, having regard to the conditions of its use. Suitable provision shall be made for the protection of the insulating material against injury or removal.

If the protection so provided be wholly or partly metallic it shall be efficiently connected with earth.

Insulation test of electric lines. 7. Every main shall be tested for insulation after having been placed in position and before it is used for the purposes of supply, the testing pressure being at least 200 volts, and the Undertakers shall duly record the results of the tests of each main, or section of a main.

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Maintenance of insulation. 8. The insulation of every complete circuit used for the supply of energy, including all machinery, apparatus, and devices forming part of, or in connection with, such circuit, shall be so maintained that the leakage current shall not under any conditions exceed one-thousandth part of the maximum supply current; and suitable means shall be provided for the immediate indication and localisation of leakage. Every leakage shall be remedied without delay.

Every such circuit shall be tested for insulation at least once in every week, and the Undertakers shall duly record the results of the testings.

Provided that where the Board of Trade have approved of any part of any electric circuit being connected with earth, the provisions of this regulation shall not apply to that circuit so long as the connection with earth exists.

High-pressure conductors to be covered. 9. Every high-pressure conductor laid after the date of these regulations shall be continuously covered with insulating material to a thickness of not less than one-tenth part of an inch, and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulating material shall not be less in inches or parts of an inch than the number obtained by dividing the number expressing the volts by 20,000.

Testing of insulation of all parts of any high-pressure circuit. 10. A high-pressure circuit shall not be brought into use unless the insulation of every part thereof has withstood the continuous application, during one hour, of pressure exceeding the maximum pressure to which it is intended to be subjected in use—that is to say, in the case of every electric line a pressure twice the said maximum pressure, and in the case of every machine, device, or apparatus, a pressure 50 per cent. greater than the said maximum pressure.

The Undertakers shall duly record the results of each test.

Quick-acting cut-off for high-pressure lines, &c. 11. Every high-pressure electric line, conductor, or other apparatus shall be protected by a suitable automatic quick-acting cut-off.

Provided that it shall not be incumbent upon the Undertakers to provide such a cut-off for the outer conductor of a concentric main which is, with the approval of the Board of Trade, efficiently connected with earth.

Transformers. 12. In every case where a high-pressure supply is transformed for the purpose of supply to one or more consumers, some suitable automatic and quick-acting means shall be provided to protect the consumer's wires from any accidental contact with or leakage from the high-pressure system, either within or without the transforming apparatus.

Limit of power in high-pressure electric line. 13. A high-pressure electric line shall not be used for the transmission of more than 300,000 watts, or in the case of an aerial line 50,000 watts, except with the consent in writing of the Board of Trade, and efficient means shall be provided to prevent this limit being at any time exceeded.

Protection from lightning. 14. Where any portion of any electric line or any support for an electric line is exposed in such a position as to be liable to injury from lightning, it shall be efficiently protected against such injury.

Accidents to be reported. 15. Where any accident by explosion or fire, or any other accident of such kind as to have caused or to be likely to have caused loss of life or personal injury has occurred at any part of any electric line or work, the Undertakers shall give immediate notice thereof to the Board of Trade.

Aerial Lines where Erected with the Necessary Consents.

Maximum intervals between supports. 16. Every aerial line shall be attached to supports at intervals not exceeding 200ft. where the direction of the line is straight, or 150ft. where the direction is curved, or where the line makes a horizontal angle at the point of support.

Supports, construction and erection of. 17. Every support of an aerial line shall be of a durable material, and properly stayed against forces due to wind pressure, change of direction of the line, or unequal lengths of span. The factor of safety shall be for aerial lines and suspending wires at least six, and for all other parts of the structure at least 12, taking the maximum possible wind pressure at 50lbs. per square foot. No addition need be made for a possible accumulation of snow.

Attachment of aerial lines. 18. Aerial lines shall be attached to insulators, and shall be so guarded that they cannot fall away from the support. Conductors covered with insulating material shall not be attached to the insulators by un-insulated metal binders.

Height from ground and distance from buildings, &c. 19. An aerial line shall not in any part thereof be at a less height from the ground than 18ft.,* or where it crosses a street, 30ft.,* or within 5ft. measured horizontally or 7ft. measured vertically from any building or erection other than a support for the line, except where brought into a building for the purpose of supply.

Service lines from aerial lines. 20. Service lines from aerial lines shall be led as directly as possible to insulators firmly attached to some portion of the consumer's premises which is not accessible to any person without the use of a ladder or other special appliance, and from this point of attachment they shall be enclosed and protected in accordance with the subsequent regulations as to electric lines on the consumer's premises. Every portion of any service line which is outside a building but is within 7ft. from the building shall be completely enclosed in stout india-rubber tubing.

Angle of crossing thoroughfares. 21. Where an aerial line crosses a street, the angle between the line and the direction of the street at the place of crossing shall not be less than 60deg., and the spans shall be as short as possible.

* Note.—In the County of London 20ft. and 35ft.

Crossing wires, &c. 22. Where an aerial line crosses, or is in proximity to, any metallic substance, precautions shall be taken by the Undertakers against the possibility of the line coming into contact with the metallic substance or of the metallic substance coming into contact with the line by breakage or otherwise.

Suspending wires. 23. Every high-pressure aerial line shall be efficiently suspended by means of insulating ligaments to suspending wires, so that the weight of the line does not produce any sensible stress in the direction of its length. All suspending wires, if of iron or steel, shall be galvanised.

Discharge of pressure in case of fire. 24. In the case of any high-pressure aerial line exceeding one half mile in total length, means shall be provided whereby the pressure may be discharged from any portion of the line erected over or alongside of any building or buildings without loss of time in case of fire or other emergency.

Maintenance. 25. Every aerial line, including its supports and all the structural parts and electrical appliances and devices belonging to or connected with the line, shall be duly and efficiently supervised and maintained as regards both electrical and mechanical conditions.

Unused aerial lines to be removed. 26. An aerial line shall not be permitted to remain erected after it has ceased to be used for the supply of energy, unless the Undertakers intend within a reasonable time again to take it into use.

Electric Lines other than Aerial Lines.

Construction of receptacles for electrical lines. 27. All conduits, pipes, casings and street boxes used as receptacles for electric lines shall be constructed of durable material, and where laid under carriage ways shall be of ample strength to prevent damage from heavy traffic; and reasonable means shall be taken by the Undertakers to prevent accumulation of gas in such receptacles.

Crossing pipes, &c. 28. Where any electric line crosses, or is in proximity to, any metallic substance, special precautions shall be taken by the Undertakers against the possibility of any electrical discharge to the metallic substance from the line or from any metal conduit pipe or casing enclosing the line.

Electric continuity of metal conduits, pipes or casing. 29. All metal conduits, pipes or casings containing any electric line shall be efficiently connected with earth, and shall be so jointed and connected across all street boxes and other openings as to make good electrical connection throughout their whole length.

Precautions against charging of short lengths of pipe, &c. 30. Where isolated lengths of metal conduit, pipe or casing are used for the protection of any electric line at road crossings or similar positions, special precautions shall be taken to prevent the possibility of any electrical charging thereof.

Precautions to be taken when bare conductors are used. 31. Where the conductors of electric lines placed in any conduit are not continuously covered with insulating material, they shall be secured in position, and no unfixed uninsulated material of a conducting nature shall be contained in the conduit. No such conductor shall be at a higher potential than 300 volts.

Adequate precautions shall also be taken to ensure that no accumulation of water shall take place in any part of the conduit, and to prevent any dangerous access of moisture to the conductors or the insulators.

In the case of any such electric lines laid in conduits after the date of these regulations, the insulators shall be so disposed that they can be readily inspected.

High-pressure lines laid above ground. 32. Every portion of any high-pressure electric line placed above the surface of the ground, or in any subway not in the sole occupation of the Undertakers, shall be completely enclosed either in a tube of highly insulating material embedded in brickwork, masonry, or cement concrete, or in strong metal casing efficiently connected with earth.

High-pressure lines laid in proximity to other electric lines or to the surface of the ground. 33. Where any high-pressure electric line is laid beneath the surface of the ground efficient means shall be taken to render it impossible that the surface of the ground or any neighbouring electric line or conductor shall become charged by leakage from the high-pressure electric line.

Street Boxes.

Street boxes. 34. In addition to the provisions contained in Regulation 27 as to the construction of receptacles for electric lines, the following regulations shall be observed with respect to the construction of street boxes:—

(*a*) The covers of all street boxes shall be so secured that they cannot be opened, except by means of a special appliance.

(*b*) The covers of all street boxes containing high-pressure apparatus other than cables shall be connected to strips of metal laid immediately underneath the adjacent roadway, and efficient means shall be taken to render it impossible that the covers or other exposed parts of these boxes, or any adjacent material forming the surface of the street, shall become electrically charged, whether by reason of leakage, defect, or otherwise.

(*c*) Where street boxes are used as transformer chambers, reasonable means shall be taken to prevent as far as possible any influx of water, either from the adjacent soil, or by means of pipes; and in the case of any such street box exceeding one cubic yard in capacity, ample provision shall be made, by ventilation or otherwise, for the immediate escape of any gas which may by accident have obtained access to the box, and for the prevention of danger from sparking.

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(*d*) All street boxes shall be regularly inspected for the presence of gas, and if any influx or accumulation is discovered the Undertakers shall give immediate notice to the authority or company whose gas mains are laid in the neighbourhood of the street box.

TRANSFORMING STATIONS

Transforming stations. 35. Transforming stations, or points in a system of distribution in which a high-pressure supply is transformed for the purpose of supply to consumers, and which are not on the consumer's premises, shall be established in suitable places which are in sole the occupation and charge of the Undertakers.

CONSUMER'S PREMISES.

Responsibility of Undertakers for their lines, &c., on consumer's premises. 36. The Undertakers shall be responsible for all electric lines, fittings and apparatus belonging to them or under their control, which may be upon a consumer's premises, being maintained in a safe condition and in all respects fit for supplying energy.

Fire risks. 37. In delivering the energy to a consumer's terminals the Undertakers shall exercise all due precautions so as to avoid risk of causing fire on the premises.

Main fuses or disconnectors to be provided in a locked receptacle. 38. A suitable safety fuse or other automatic disconnector shall be inserted in each service line within a consumer's premises as close as possible to the point of entry, and contained within a suitable locked or sealed receptacle of fireproof construction, except in cases where the service line is protected by fuses in a street box.

Treatment of electric lines and apparatus on consumer's premises. 39. All electric lines and apparatus placed on a consumer's premises shall be highly insulated and thoroughly protected against injury to the insulation or access of moisture, and any metal forming part of the electric circuit shall not, unless efficiently connected with earth, be exposed so that it can be touched. All electric lines shall be so fixed and protected as to prevent the possibility of electrical discharge to any adjacent metallic substance.

Transformers and high-pressure apparatus to be enclosed in metal. 40. Where the general supply of energy is a high-pressure supply, and transforming apparatus is installed on a consumer's premises, the whole of the high-pressure service lines, conductors, and apparatus, including the transforming apparatus itself so far as they are on the consumer's premises, shall be completely enclosed in solid walls, or in strong metal casing efficiently connected with earth, and securely fastened throughout.

Connection to consumer not to be made where leakage would result. 41. The Undertakers shall not connect the wires and fittings on a consumer's premises with their mains unless they are reasonably satisfied that the connection would not cause a leakage from those wires and fittings exceeding one ten thousandth part of the maximum supply current to the premises; and where the Undertakers decline to make such connection they shall serve upon the consumer a notice stating their reasons for so declining.

Discontinuance of supply on discovery of leakage on consumer's premises. 42. If the Undertakers are reasonably satisfied, after making all proper examination by testing or otherwise, that a leakage exists at some part of a circuit of such extent as to be a source of danger, and that such leakage does not exist at any part of a circuit belonging to the Undertakers, then and in such case any officer of the Undertakers, duly authorised by them in writing, or, if the Undertakers so require, an electric inspector may, for the purpose of discovering whether the leakage exists at any part of a circuit within or upon any consumer's premises, by notice require the consumer at some reasonable time after the service of the notice to permit him to inspect and test the wires and fittings belonging to the consumer and forming part of the circuit.

In any case where the Undertakers require the services of an electric inspector under this regulation they shall pay him the prescribed fee.

If, on such testing, the officer or the electric inspector discovers a leakage from the consumer's wires exceeding one ten thousandth part of the maximum supply current to the premises, or if the consumer does not give all due facilities for inspection and testing, the Undertakers shall forthwith discontinue the supply of energy to the premises in question, giving immediate notice of the discontinuance to the consumer, and shall not recommence the supply until they are reasonably satisfied that the connection with earth has been removed. This regulation shall not affect any power contained in the Order or otherwise enabling the Undertakers to discontinue the supply.

Appeal to electric inspector. 43. If any consumer is dissatisfied with the action of the Undertakers in refusing to give or in discontinuing or in not recommencing the supply of energy to his premises, the wires and fittings of that consumer may, on his application and on payment of the prescribed fee, be tested for the existence of leakage by an electrical inspector.

This regulation shall be endorsed on every notice given under the provisions of either of the two last preceding regulations.

ARC LIGHTING.

Arc lamps to be guarded. 44. All arc lamps shall be so guarded as to prevent pieces of ignited carbon or broken glass falling from them, and shall not be used in situations where there is any danger of the presence of explosive dust or gas.

Height from ground. 45. Arc lamps used in any street for public lighting shall be so fixed as not to be in any part at a less height than 10ft. from the ground.

Cut-off switch. 46. Arc lamps used in any street for private lighting shall be fixed so as not to be in any part at a less height than 8ft. from the ground, and shall be so screened as to prevent risk of contact with persons. A cut-off switch, fixed in a suitable locked receptacle, shall be provided for every high-pressure arc lamp, and such switch shall be of such pattern and construction as will provide:—

(*a*) That the lamp can by its means be entirely disconnected from the supply circuit;

(*b*) That the switch itself can be safely operated in the dark without special precautions; and

(*c*) That there shall be no danger of any injurious electrical arcing, sparking, or heating being caused by the operation of the switch.

Penalties for default. 47. If the Undertakers make default in complying with any of the preceding regulations, they shall on conviction be liable to a penalty not exceeding £10 for every such default, and to a daily penalty not exceeding £10.

The recovery of a penalty under these regulations shall not affect the liability of the Undertakers to make compensation in respect of any damage or injury which may be caused by reason of the default.

B.—REGULATIONS FOR SECURING A PROPER AND SUFFICIENT SUPPLY OF ELECTRICAL ENERGY.

Notice of intention to supply through mains. 1. Forty-eight hours at least before the Undertakers are ready to commence to supply energy through any feeding, charging, or distributing main, they shall serve a notice upon the local authority of their intention to commence such supply.

Undertakers to provide constant supply. 2. From and after the time when the Undertakers commence to supply energy through any distributing main, they shall maintain a supply of sufficient power for the use of all the consumers for the time being entitled to be supplied from such main; and such supply shall, except so far as may be otherwise agreed upon from time to time between the local authority and the Undertakers, be constantly maintained. Provided that, for the purposes of testing, or for any other purposes connected with the efficient working of the undertaking, the authority by whom the electric inspector is appointed may give permission to the Undertakers to discontinue the supply at such intervals of time and for such periods as that authority may think expedient. When the supply is so discontinued, notice of such discontinuance, and of the probable duration thereof, shall be forthwith served upon the local authority.

Provisions as regards stoppage. 3. The system of distributing mains shall be so arranged that in case it becomes necessary to stop the supply through any portion of a main for more than one hour, for the purposes of repairs, or for any other reason, the stoppage of supply will in no case exceed in amount a maximum power of 200,000 watts, or extend to the premises of more than 80 consumers, and in the case of every stoppage for more than one hour reasonable notice shall be previously given by the Undertakers to every consumer affected thereby except in cases of emergency.

Pressure in mains during supply. 4. During the whole of the period when a supply of energy is required to be maintained by the Undertakers in the distributing mains under the Order and these regulations it shall be maintained at a constant pressure in these regulations termed the "standard pressure," but the standard pressure may be different for different portions of the distributing mains. Provided that the Undertakers shall be deemed to have complied with the requirements of this regulation so long as the pressure does not at any point vary more than 2 per cent. from the corresponding standard pressure in the case of a general supply at high pressure, or 3 per cent. in other cases, unless changes in pressure recur so frequently as to cause unsteadiness in the supply.

Fixing of standard pressure. 5. The standard pressure shall be fixed by the Undertakers, and notice of the amount of such standard pressure shall be given to the local authority before the Undertakers commence to supply energy to consumers, and such standard pressure shall not be altered except by permission of the local authority, and upon such terms and conditions as the local authority may impose, and after public notice has been given during a period of one month, in such manner as the local authority may require, of the intention of the Undertakers to apply for permission to alter the same. The Undertakers may appeal against any decision of the local authority under this regulation to the Board of Trade, whose decision shall be final.

Declared pressure at consumer's terminals. 6. Before commencing to give a supply of energy to any consumer, the Undertakers shall declare to such consumer the constant pressure at which they propose to supply energy at his terminals. The pressure so declared at any pair of consumer's terminals shall not at any time be altered or departed from except in consequence of any authorised alteration of the corresponding standard pressure. In the case of a transformation of energy on the consumer's premises, the Undertakers shall give the consumer the choice of a supply at either of two different pressures, one of which shall be approximately half the other, and in such case the pressure so chosen by the consumer shall be the declared constant pressure.

Provided that no change shall be made in the pressure of the supply to any premises which at the date of these regulations are supplied with energy by the Undertakers except with the consent of the consumer.

Variation of pressure at consumer's terminals. 7. The variation of pressure at any consumer's terminals shall not under any conditions of the supply which the consumer is entitled to receive, exceed 4 per cent. from the declared constant pressure.

Penalty for default. 8. If the Undertakers make default in complying with any of these regulations as to supply, they shall, subject to the provisions of the Order, be liable on conviction to a penalty not exceeding £5 for every such default, and to a daily penalty not exceeding £5.

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ELECTRICAL PLANT IN THE UNITED STATES PRINTING OFFICE AT WASHINGTON.*

BY W. H. TAPLEY.

The plant consists of one 187½-kilowatt direct-connected generator and three 80-kilowatt belted generators, all of the most improved compound multipolar Westinghouse type. The 187½-kilowatt generator is directly connected with a Westinghouse compound condensing engine of 250 H.P. The two machines occupy a floor space of 21ft. by 7½ft. The 80-kilowatt generators are driven from a line shaft which is belted to a 250 H.P. compound condensing engine of the marine type. Friction clutch pulleys are used for driving these generators, thus giving the greatest flexibility to the plant by allowing the stopping of any one of the three generators while the others are in use. These, independent of the direct-connected generator, are capable of furnishing all the necessary power as well as light needed in the office in case a total breakdown of the direct-connected unit occurs. The total capacity of the four generators is 8,500 50-watt 16 c.p. incandescent lamps—more than sufficient for all lighting and power demands.

The peculiarities of the work of the office make necessary a sectional rather than a general system of electric lighting. With this end in view, the wiring has been done entirely on the "crib" system. This affords a uniform distribution of light throughout every division of the office, the rooms farthest away from the generator station being equally as well lighted as those near by. So perfect is this result that nowhere in the building does the variation from the switchboard to lamp exceed 2½ volts, nor is the variation in any one room ever more than one-fourth to one-half volt, no matter how many or how few lamps may be burning on the circuit. The capacity of all main trunk lines and feeders is so large that circuit regulators on the switchboard are not required.

To make up any loss from generator to lamp, the generators are overcompounded 1½ per cent., and their makers guarantee that no greater loss than 3 per cent. will occur from full to no load. Thus there will be a constant voltage at the lamps, whatever may be the existing conditions, insuring full candle-power and the long life of the lamps. We are thus able to get full benefit of the current generated, and not have a considerable portion of it consumed in rheostats that the system may be kept in balance.

The crib system has been extended to vertical mains as well, thus allowing the disconnecting of one side of the circuit without interrupting the service throughout that circuit while in use. The crib system of wiring not only increases the flexibility of the plant, but minimises the possibilities of interruption of work, and also equalises the distribution of current to the lighting mains.

In carrying out the instructions as to the application of electrical power, the office will use at present 70 Crocker-Wheeler electric motors of ⅛ H.P. to 30 H.P., aggregating 225 H.P.

To secure full protection against any possible interruption of work, except through a total failure of steam-power by accident, a suitable electrical switchboard of special design became necessary. This board is one of the largest and most complete in the country. It presents many peculiar features and fully meets the exactions of the service here, which will not permit interruptions during the sessions of Congress. The switchboard is divided into five panels—three for lighting and two for power. It is so constructed that an additional panel may be made without changing any of the connections. There are two sets of 'bus bars extending the entire length of the board—one for the use of the lighting circuits and the other for power circuits. By the use of a switch the two 'bus bars can be connected so as to make one continuous 'bus bar, and power and lighting circuits may be run together and from one generator should occasion therefor occur. Each generator is connected to the switchboard by a double-pole double-throw switch, thus allowing any generator to be used for power or lighting as occasion may require. Each feeder circuit is also controlled by a double-pole double-throw switch, giving every circuit throughout the building two sources of current and providing for an uninterrupted system either of light or power. Under normal conditions all lights will be run from one set of 'bus bars and the power circuits from the other, but when both power and lighting load become sufficiently small so that the combined demands of both are not in excess of the power of one 80-kilowatt generator, all work will be so divided by the switchboard as to make it possible to run everything from one generator. This board allows the changing from one generator to the other without any interruption to the service in the building or the running of the generators in multiple.

Each panel is provided with a standard Weston volt and ammeter. Each power circuit is supplied with a round pattern Weston ammeter. There is also connected to the lighting service a recording voltmeter. For testing insulation of each circuit there is a special reading in ohms marked on one of the voltmeters, thus enabling a daily log to be kept of the condition of each circuit of the plant. The measuring will be done by drop-of-potential method, and not only will each individual circuit be tested, but each leg of each circuit, a suitable switch being provided for the purpose.

More than 20 miles of wire of the best kind was used in the circuits, and during its erection full use was made of every precaution known that would render property and life more safe.

The insulation test of this entire system with all cut-outs in circuit will reach, under ordinary conditions, 8 megohms.

One of the special features of this electrical plant is the transmission of power by electricity. In all cases where it was possible so to do without interrupting work, we have connected motors direct to the machines themselves, doing away entirely with the use of belting and its attendant losses, disadvantages, and dangers. We find that the printing presses and some of the other large machines were never driven to their full capacity by belts, and that since they have been geared direct to the electric motors nearly double the amount of work has been done on some of them.

In gearing motors direct to printing presses we have not only secured the advantage of displacing belting, but enabled the pressman, by the use of a reversing regulator, to have absolute control of his press when making ready, and move the bed-plate forward or backward as desired, and without the help of a labourer. The speed of the press can also be regulated at will.

The two principal advantages of electric motive power over shafts and belts are the reduction of the friction load to a minimum and the independent working of each machine. Under the shaft-and-belt system the breaking of a belt often necessitated the shutting down of all the mechanical divisions.

To each motor is attached an automatic cut-off, so that accidents are not liable to occur through carelessness of employés. A still further safeguard is the automatic circuit-breaker, which prevents the overloading of motors.

In the erection of the plant every approved electrical device has been used. The short period during which the new plant has been in operation prevents full statements as to the amount of current and power consumed by each division of the office and the actual amount of power saved, as compared with the old system.

* Report by the Chief Electrician to the United States Public Printer.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January 24, 1896.*

The Boynton Bicycle Railway.—For several years a company has been attempting to secure permission from the New York State Railroad Commissioners for the construction of a road on what is styled the "Boynton bicycle system." The peculiarity of the system consists in there being but a single rail underneath the car and a guiding rail overhead. Absurd claims have been made for the extraordinary efficiency of the system, supposed to follow from the peculiar construction described. The State Railroad Commissioners have refused to grant permission to build the road, for the reason, among others, that the system is such a special one that a special law will be necessary to authorise the Commissioners to take action on it.

A New Type of Steam Engine.—Mr. Elmer A. Sperry, one of the American pioneers in electric lighting, and more recently connected with the electric railway industry, had designed a peculiar engine, which permits double the number of revolutions to be made per stroke than with the usual type. The connecting rod of the engine, instead of connecting with the crank pin, reciprocates one member of a link motion, the second member of which connects with the usual engine connecting rod or the arm of a parallel motion similar to that used in old types of land engines. The link motion is of the usual form described in works on mechanism, which gives a reciprocating motion twice as rapid as that of the source. In the present instance, the shaft makes one revolution on the outstroke of the piston and another on the instroke; at the beginning of the first revolution the two arms of the link form an angle above the horizontal and at the end of the revolution a corresponding angle below the horizontal.

The Sprague Elevator.—At the meeting of the American Institute of Electrical Engineers on Wednesday of the present week, Mr. Frank J. Sprague read a Paper on Electric Elevators, describing more particularly the Sprague-Pratt

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elevator and the large plant built for its manufacture in the neighbourhood of New York. The Sprague-Pratt elevator is of the horizonal multiple-sheave type, with a travelling cross-head on a nut driven by a screw revolved by an electric motor directly connected and controlled by a small auxiliary motor and rheostat. The feature of most interest is the nut, the only points of contact between which and the threads of the screw being by a chain of balls which occupy a number of threads and enter and leave the end of the nut through tubes which are connected together so as to make a continuous conduit. The longitudinal thrust at the motor end of the screw is also taken on balls, and the sheaves are carried on ball or roller bearings. The controlling apparatus is actuated by a small motor of about one-sixth of a horse-power, which is manipulated from the car. The controller rheostat is made up of cast-iron resistances, which Mr. Sprague was the first to use commercially in this country. The resistance is about 60 times that of copper, and in working a very high temperature may be permitted.

CORRESPONDENCE.

RÖNTGEN RAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Those of your readers who are making experiments on Röntgen's rays may perhaps be interested in a method of testing their presence which is more delicate and expeditious than a photographic plate, and also more easily adapted to quantitative measurements. It is simply a charged insulated metal plate. I have found that when this is exposed to Röntgen's rays it rapidly loses its charge, and the test is so delicate that I have by this means been able to detect the rays after their passage through a zinc plate ¼in. thick. The leakage caused by these rays differs materially from that investigated by Elster and Geitel and due to ultra-violet light. In the first place the Röntgen rays discharge positive as well as negative electricity, and secondly, the leakage goes on even when the electrified plate is embedded in paraffin, ebonite, mica, sulphur, &c. This shows that *all substances through which the Röntgen rays are passing become for the time conductors of electricity*. This result seems to me very suggestive both as to the nature of the rays and also of the conduction through the insulator.—Yours, &c.,

J. J. THOMSON.

Cavendish Laboratory, Cambridge, February 4, 1896.

DR. HOPKINSON'S PRESIDENTIAL ADDRESS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Whatever may be said of the subject-matter of the above, some of the terms employed are decidedly old-fashioned and unsatisfactory. For instance, positive and negative electricity, frictional electricity, voltaic cell, galvanism, and loadstone (*sic*). The term galvanic is repeated *ad nauseam*, as in galvanic cell, galvanic battery, galvanic element, galvanic circuit, galvanic current, galvanic agency and galvanic effects.

Bearing in mind that the memory of Galvani and of Volta has been perpetuated in "galvanometer" and "volt," there is not the slightest need for the use of voltaic or galvanic, which terms are, in my mind, quite meaningless. To take a common example, apart from the above, why should voltaic arc so often be used? Why voltaic and not davaic or davic? Davy was the discoverer, not Volta. Electric arc, I take it, is the best term.—Yours, &c.,

W. PERREN MAYCOCK.

Croydon, February 1, 1896.

COLONIAL ELECTRICAL ENGINEERING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 31st ult. you make some rather sarcastic remarks on the design of the Melbourne Municipal Lighting Station, and, whilst not wholly agreeing with your remarks, they might serve as the text for an interesting article on "Colonial Engineering."

As to countershafting, that is almost invariable, and the colonial mind in 1892, when I left Sydney, had hardly got to the point of considering direct driving, there being only one such plant in Sydney to my knowledge—viz., at the Hotel Métropole—a duplicated combined Willans-Elwell-Parker set, 24 kilowatts.

At the time the Melbourne station was projected and designed, it must be remembered that there was only one practicable system of street lighting—high tension series, and the largest practicable arc-lighting machine was 60 lights, and it is not quite easy to see how such a number of machines could be run off the engines there laid down with the same convenience direct as off the countershaft. As regards the economy of the large engine units adopted, the load is necessarily uniform, and it is easier to build an economical (fuel) engine of large than small size. For the same reason the loss in running the countershaft is of less consequence than with a widely-varying load in proportion to the output.

There are further reasons for the choice of a large engine unit.

1st. Owing to the high price of labour in Victoria maintained by the Engineers' Society by the aid of a prohibitive protective Customs duty, the cost of building a large engine is substantially less per horse-power than a small engine.

2nd. By Victorian laws every engine-driver must have a certificate of competency (?) issued by an examining Board. By reducing the number of engines a reduction is made in the number of such certificated men, who might at any time combine and cause trouble to their employers. I may say that by the regulations issued a boy of 17 could *legally* be competent to drive a second-class engine after twelve months' experience, or one-fifteenth of my own, and before I could obtain such a certificate I should have to serve a year *under* that boy. It is needless to say that such a certificate is of no value whatever as a proof of competency, and is merely worked as a trades-union dodge, as was evidently the object of Mr. W. Allan's Bill, which failed to pass in the last Parliament, and it is my practical experience of the working of such a law that causes me to object to it on principle.

I think you will agree that the foregoing reasons are sufficient to show that Mr. Arnot was well advised in his design. If you want more you have it in the fact that any of our modern London stations would be unbearable in a Melbourne summer; 110deg. in the shade by day and 90deg. at night for a month on end is not very remarkable in Melbourne in January.

I am not personally acquainted with Mr. Arnot, though I have spoken to him more than once, and think that he is quite capable of intelligently weighing local conditions, and I write this notwithstanding that I am no lover of the Cornstalk, and would be glad to see him politically independent of this country.

As showing the sort of work that passes muster in "colonial engineering," I may give two instances:—

1. An 8-10in. countershaft in a Melbourne tramway engine house was running with about 1in. of wobble on it, and the nuts had to be kept off the pedestal cap. I saw this myself, and was told that the shaft was bent in slinging and had never been straightened.

2. A small screw steamer built on the Yarra; when steam was turned on the engines spouted tallow at every joint. I had this on good authority.

I was once employed to take charge of and repair a small central station in New South Wales, which I still dream of when I have a nightmare, and if you can spare the space a description may amuse your readers.

The "station" consisted of a corrugated iron shed for the "machinery" about 30ft. × 10ft., with a lean-to for a coal store. In one corner was a recess, which was the "resident engineer's" quarters, and contained a rectangular frame with three old sugar bags nailed on to it and a filthy blanket (my quarters were not there) which I did *not* use. The plant consisted of—

(1) A Robey boiler (loco. type), supposed to be up to 12 H.P., which was fed (by a leaky pump on the engine) with the drainings off a road near by. The boiler, when I saw it, had been working eight months, and I have reason to believe that it had never been washed out since it was started. There

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were two safety (?) valves, one a spring balance, which was set up "as far as it would go." I may say that there was no danger, since the valve leaked a trifle. The other was a lock-up valve, but the padlock had been broken off, and the valve screwed hard down. The "central station" was not "lock up," and when I asked the driver—who informed me that he was a "born and bred millwright"—for an explanation, he said that "the children had done it!" On that morning I had taken nine shovels of damp ashes out of the smoke box (full size, not an ordinary fire shovel). The "children" had evidently *not* done that. At full load it was customary to use a supplementary lever on the lever of the safety valve—the "pricker" was mostly used for this with a brick on the end of it. The last I heard of the place was that a "bucket of bricks" was substituted for the single brick.

The chimney was about 12ft. high, supported mainly by the roof, but assisted by four stays 16 B.W.G., twisted round wire nails in the eaves of the building. The engine exhaust was turned into the chimney—eccentrically, spiral draught was considered desirable for some reason. My successor hammered the pipe flat and tried a fan-shaped blast, and said the draught was much improved thereby.

(2) A Robey inverted engine with automatic expansion gear, and rated at 20 I.H.P. at 80lb. steam. Speed, nominally 150, but varied with various conditions from 80 to 200 ("shorts" excluded). The most prominent feature about the engine was the exhaust, which was nearly continuous, little or no "beat" being heard except when a "short" happened. (N.B.—It is within my own knowledge that the "children" *were* responsible for a good many of these.) Every facility was given for ashes and dust to blow over the working parts—I presume to allow them to grind to a fit. A countershaft was provided, from which the "generator"—a "Manchester" 100-lighter—was driven. There was no switchboard, the "instruments" (main switch and fuse) being spiked to the frame of the shed, the voltmeter being usually hung on a nail.

The fuse consisted of two brass pegs with copper bell wire wrapped round them, the total section being about three times that of the mains; this, however, was not dangerous, as the engine warned the driver of a "short" by slowing down. The principal use of the "main switch" was to signal to the consumers when to light their *oil* lamps, the recognised signal being three blinks. I may say that there was a supplementary boiler feed pump—a small "Blake." It failed, however, to work properly on high pressure, and was used to deliver water into a small water tank over the boiler. *Leather* valves are hardly adapted for boiler feed.

(3) The mains were of soft drawn bare copper, so that they should "give" rather than overstrain the supports. They were calculated at 1,000 amperes per square inch. I understood that the consulting engineer had spent two months in England, and had discovered the proper method of calculating street mains. The station was at one end of the town, and the bulk of the lighting at the other end. This rather disturbed the calculator, but he reflected that the only result would be an excessive drop of pressure, and as the lamps had to be bought second-hand whenever a job lot was run against, this would give an opportunity of "grading them." It was rather awkward, however, when lamps ran short, and 110-volt lamps had to be run on 70-volt circuits, and the public grumbled if a 50 volt had been previously used. "Earths" were not considered of any consequence, and if a wire came down the first passer-by would make it fast to the nearest fence. The street lighting was by 30 16 c.p. lamps on brackets on the poles. Drip-loops on the lamp leads were evidently thought inadvisable, and provision was therefore made for the rain to run down the bracket to the lamp socket. I may say that near the "station" the lamps were usually like moons, and at the farthest circuit you had to take a lantern to find them after dark.

The repair plant and spare gear was eminently simple. Here is a list as far as I can remember it: One tube brush (*non est*—the "children" had stolen it), one fire shovel (broken) one rusty vice, one cold chisel (the smith failed to harden it), half-dozen files (all worn out and mostly broken), half a gimlet, half a file handle, one ¾in. tube cutter (with the cutter broken) one broken hammer shaft, a few pieces of insulated wire, of various makes and kinds, lengths from 1ft. to 20 yards; an assortment of broken lamp holders, &c., 50ft. of redwood casing and covering (this had the dry rot).

I may say that I was on the job for exactly 10 days. I found, however, that none of my recommendations were likely to be carried out, not even the cheapest of them, and I therefore gave it up. This job is (or *was*) at Moss Vale, on the Southern New South Wales Railway line to Melbourne, &c. The description is absolutely true. I could give a few details of some other jobs that would no doubt amuse you.—Yours, &c.,

GEO. F. PARDOE.

81, Harrow-road, Paddington, February 3, 1896.

LEGAL INTELLIGENCE.

Lazare Weiller and Co. v. Bolton and Co.

On Wednesday, in the Queen's Bench Division, Mr. Justice Mathew heard this action, which was for damages for breach of an agreement, dated November 28, 1894, the breach alleged being refusal by the defendants to accept and pay for goods delivered pursuant to the agreement. The case was opened by Mr. Bigham, Q.C., for the plaintiffs, and turned principally on the correspondence and the circumstances preceding and subsequent to the date of the agreement. The plaintiffs are manufacturers of copper wire at Angoulême, France, with an office in Paris, and the defendants are manufacturers of the same description of goods at Oakamoor, Staffs. It was alleged by defendants that the contract had been made by misrepresentation, and they claimed to have it rescinded or reformed. Messrs. Lazare and Weiller made wire for telephonic purposes, and at the end of 1893 established large works at Angoulême, which enabled them to compete in English markets against English makers so successfully that in March, 1894, Messrs. Bolton put themselves in communication with plaintiffs, who had started an agency in England, with the object of inducing them to join a ring or pool to be formed in this country by the different makers, so as to fix a price in England which would be profitable to the manufacturers. Negotiations went on for some time, and M. Weiller eventually replied that the plaintiffs' firm would not join a ring or pool, but were ready to make a contract with Messrs. Bolton under which they were to take certain quantities of the plaintiffs' manufactured goods per month for a period of five years, the plaintiffs undertaking not to compete with English manufacturers in the English market.

The JUDGE: That was to sell exclusively to the defendants?—Yes.

The defendants replied that the quantities stipulated for were too large, but that if 50 tons a month would do it they would make a contract. On November 17th, however, Mr. Rathbone, one of the partners in Messrs. Bolton's firm, called upon M. Weiller in Paris, and again suggested that a pool should be formed, but M. Weiller repeated his refusal, and said if he was to be bought out of the English markets it must be by his selling 300 tons a month. Mr. Rathbone asked him to hold his hand for the time, not to take orders in England till he (Mr. Rathbone) returned to England. Later on, after further correspondence, the plaintiffs wrote agreeing to accept the following terms: The defendants to take monthly 125 tons of copper rods at £11 net over and above the price of Chili bars, and 75 tons of wire at £15 net over and above the price of Chili bars. M. Weiller visited Mr. Bolton at Oakamoor to complete the contract on November 27th. One of the alleged misrepresentations relied upon by the defendants was that M. Weiller said the plaintiffs' sales in England amounted to 200 tons a month. It was suggested that it was because of this and other representations the contract had been made; whereas it was contended by the plaintiffs that the first suggestion of 200 tons per month was contained in the defendants' own letter. On November 28th the contract was signed, the effect of which was that the plaintiffs were to be bought out of the English markets, on condition of the defendants taking 200 tons a month from them; or, if the plaintiffs sold in the English markets, it was only to be at such prices as the defendants permitted, and to the extent that the plaintiffs did sell in the English markets Messrs. Bolton were to be relieved of their obligation to take goods from the plaintiffs under the contract. During the discussion of the contract, Mr. Bolton had shown himself fidgetty about American and German competition, and no doubt M. Weiller said he would do his best to assist the English manufacturers. After leaving, M. Weiller spontaneously wrote:—"I desire particularly to say to you that if such a case presented itself, then it would be necessary to carry the contest either against the importation or invasion of American products, or against the opposition—the unforeseen national opposition—which might show itself in any important degree, you would find me ready to lend you my assistance in order to organise the contest against such an opposition. We should have in each particular case to conform ourselves to the circumstances in order to organise with you the contest, whether by a provisional lowering of general prices, or of prices of contracts, or by the delivery by us of a part of the wire at the price of the opposition, or by other means which we should judge efficacious. If the case arises, I wish to add this declaration before saying 'Good-bye' to you, so that you may know well that the opponent of yesterday has now become the collaborator of to-day." The defendants now contended that this spontaneous communication was a part of the contract, and that it nullified the contract. If that letter

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was part of the contract, why was it not, Mr. Bigham urged, included in the contract? It was no part of the contract, and was a mere spontaneous expression of M. Weiller's readiness to assist in meeting German and American competition.

The Judge asked what was the price at which the rods were to be delivered.

Sir E. Clarke, for the defendants, said the whole contract over the period it had to run was for £600,000.

M. Weiller gave evidence in support of the foregoing statement, and denied that he had made the representation that plaintiffs' business in the English markets was increasing. But if he had made the statement it would have been true. Nor had he represented that their sales were 200 tons a month. He had written the letter quoted when inspired by grateful sentiments in regard to Mr. Bolton's charming hospitality. It was in his own language, had no reference to the contract, and was quite spontaneous.

The case was adjourned to this day (Friday).

Electrical Installation Company v. Francis and Spilsbury.

This case was heard on Friday last at the Westminster County Court. The plaintiffs are electrical engineers in business at Victoria-street, Westminster, and sued the defendants, who are dealers in electrical appliances at Queen Victoria-street, London, to recover the sum of £6 odd alleged to have been overpaid in respect of a quantity of electric lamps supplied to order. The plaintiffs' case was that in July last an order was sent to the defendants to supply several hundred lamps of various patterns. The goods were delivered in due course, but upon the case being opened and unpacked it was found that there was a deficiency in the number of lamps to the extent of about 75. The defendants were written to on the subject, but in the meantime they were pressing for payment of their account, and, by a mistake, a cheque was sent for the full amount of their claim. Several applications were subsequently made to complete the order but declined, and consequently the plaintiffs had to go direct to the Edison and Swan Company for the goods. The effect of that had been that the plaintiffs had had to pay twice over for the 75 lamps in question, and they now sued the defendants to recover the cost.

For the defence Mr. FRANCIS was called, and said his firm acted as agents for the Edison and Swan Company, and the order in question was in due course sent on to them. He had every reason to believe the Company sent on the correct number of lamps, and that was why he disputed liability in this case.

Two witnesses were called from Messrs. Edison and Swan, and both of them were able to say positively that the whole of the lamps included in the plaintiff's order were duly packed and dispatched.

Mr. LUMLEY SMITH, Q.C. (the judge), in giving judgment, said it was extremely difficult in cases of this kind to say who was right, but, under the circumstances, he thought it was probable that a mistake had been made in the packing at the premises of the Edison and Swan Company, and judgment would be for the plaintiff for the amount claimed, with costs.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK will be ready next week. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d., abroad 9s. The book is greatly enlarged.

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The following New Books and Editions of "THE ELECTRICIAN" SERIES *can be obtained of the Booksellers or direct from the Publishing Offices:—*

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many origina illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The fourteenth annual issue of this publication will be ready next week, and would have been published a few days earlier but that it was the desire of the Publisher to include the revised Board of Trade model regulations. These were only issued yesterday (Thursday), and we hope to have the Directory and Handbook ready for subscribers by Wednesday next, so that it will be seen that no time has been lost. The Directory section of the book is equally up to date, and will be found to contain corrections and new names and addresses complete up to the 5th of the current month.

TENDERS INVITED.—The Vestry of St. John, Hampstead, require tenders for works and materials for one or three years for (1) coals and coke, (2) oils for machinery at electric lighting station, (3) tools, implements and other electrical engineers' stores, (4) carbons, lamps and other stores for electric lighting station, (5) removing ashes from electric lighting station. Some further particulars are given in our advertisement columns. Tenders must be sent in to Mr. Arthur P. Johnson, Vestry Clerk, by 4 p.m. of February 12th.

——— The Belper Gas and Coke Company (Limited) contemplate putting down a plant for electric lighting. Communications are to be sent to the Managing Director of the Company, at Belper.

——— The Harrogate Corporation invite tenders for the erection of an electricity generating station and chimney shaft. Tenders, by 11 a.m. on Monday next, to Mr. S. Stead, Borough Surveyor, Municipal Offices, Harrogate.

——— The Municipal Authorities of Manuel (Valencia) invite tenders for the concession for the electric lighting of the town for 15 years. Tenders to El Secretario del Ayuntamiento, Manuel (Valencia), Spain, by the 11th inst.

——— The Breslau Direction of the Prussian State Railways require tenders for the supply of a quantity of porcelain insulators and telegraph wire. Tenders to the Königliche Eisenbahn Direction, Oberschlesischen Bahnhof 21-23, Breslau, by the 10th inst.

——— The Municipal Authorities of Santa Coloma de Farnés (Barcelona) invite tenders for the concession for the electric lighting of the streets, and also for the lighting of the municipal building. Tenders to El Ayuntamiento, Santa Coloma de Farnés (Barcelona), Spain.

——— The Municipal Authorities of Béziers are inviting tenders for the concession for the construction and operation of about 8 kilometres of electric tramways in the town. Tenders to La Mairie, Béziers (Herault), France, by the 15th inst.

——— The Committee of the West Riding Asylum, Menston, require tenders for the supply and erection of telephones and electric bells for the new buildings and houses on the estate. Specifications can be obtained at the County Surveyor's Office, Wakefield, or at the offices of the Clerk of the Works, at the Asylum. Tenders to Mr. J. Vickers Edwards, County Surveyor, Wakefield, by the 17th inst.

——— The Paving Committee of the County Borough of Rochdale require tenders for the electric lighting plant required at the Works, Rochmills. Specifications, &c., can be obtained at the offices of the Borough Surveyor, and tenders must be sent in to the Town Clerk not later than noon on Wednesday next.

TENDERS ACCEPTED.—The Bolton Town Council have decided to accept the joint tender of Messrs. Hick, Hargreaves and Co. (Limited) and S. Z. de Ferranti (Limited) for a 200-kilowatt steam alternator.

——— The Bradford Corporation have placed an order for two high-speed 600 H.P. steam engines, for their new electricity works, with Messrs. G. E. Belliss and Co. (Limited), of Ledsam-street Works, Birmingham.

——— At the meeting of the Preston Town Council last week it was decided to accept the tender of the National Electric Supply Company for the erection of and supply of electric current to 300 incandescents, for lighting Church-street and Friargate.

——— The Deacons of Zion Methodist Chapel, Lindley, Huddersfield, have accepted the tender of Messrs. J. H. Holmes and Co., of Newcastle, for the electric lighting of the chapel.

——— The Shoreditch Vestry have accepted the tender of Messrs. Atherton and Dolman, of Ellerthorpe-street, Poplar, London, E., for the erection of dust destructor, engine house and offices, &c., in connection with their electric lighting and dust destructor scheme, for £8,535.

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TENDERS ACCEPTED.—The tender of Mr. Bloomfield, of Maidenhead, has been accepted by the authorities for electric bell fitting at the School for Technical Instruction, Maidenhead, for the sum of £5. 10s. 6d. Two other tenders were sent in.

LIGHTING SCHEMES INVITED.—It will be seen by our advertisement columns that the Urban District Council of Eston, Middlesboro', invite schemes for lighting the district by electricity. A plan of the district can be seen and particulars obtained on application to Mr. F. W. Stainthorpe, A.M.I.C.E., District Surveyor, Grangetown, Yorkshire, to whom schemes must be sent in not later than May 1st next. Mr. Jno. T. Belk is clerk to the Council.

SALE BY AUCTION.—Messrs. Hepper and Sons have received instructions from the Corporate Property Committee of the Leeds City Council to sell by auction at the Municipal Buildings, Leeds, on Thursday, February 13th, at two o'clock, a large quantity of electric lighting plant, including engines by Willans and Robinson and Crossley, boilers by McLaren, dynamos by Mather and Platt and Paterson and Cooper, E.P.S. accumulators, and a quantity of apparatus and instruments, forming the complete installation which was some time ago erected at the Municipal Buildings, and which is now dispensed with as current is taken from the local Electric Supply Company's mains. Some further particulars are given in our advertisement columns. Catalogues are now ready, and may be obtained of the auctioneers, East-parade, Leeds.

VACANT APPOINTMENT.—As stated in our last issue, the Corporation of Edinburgh are now prepared to receive applications for the post of resident engineer for their central electric light station, in succession to Mr. E. W. Monkhouse. Some further particulars are given in our advertisement columns, and applications have to be sent in to Mr. T. Hunter, W.S., Town Clerk, City-chambers, Edinburgh, by the 17th inst.

FAILURE.—A receiving order has been made against G. J. Reakes, electrical engineer, of Shrewsbury. The examination is to take place at the Shire Hall, Shrewsbury, on 11th inst., at 10:30, and the first meeting at the office of the Official Receiver on the 13th inst. at 11.30.

LIQUIDATIONS.—In a Trade Note in our last issue it was announced that a meeting of creditors of J. C. Howell, Limited (in liquidation), would be held on Wednesday last. The meeting was duly held, and Mr. S. F. Isitt was able to announce that the liabilities since the liquidation commenced had been reduced from £4,236. 16s. 3d. to about £1,610. Mr. Howell made a statement as to the value of the outstanding assets, and said they would produce ample funds to pay all debts in full. The following resolution was then agreed to by those present (representing £1,070 of the outstanding liabilities):—

"That the liquidator be authorised to hand all the remaining assets of the Company to Mr. Howell forthwith, upon receiving from him an engagement in writing to pay or satisfy all the liabilities of the Company within one month from this date" (February 6th).

Mr. Howell, at the close of the meeting, gave Mr. Isitt the necessary undertaking, and the securities in question were thereupon handed over to him.

——— At a meeting of the proprietors of the Acme and Immisch Electric Works (Limited), of Ferdinand-street, Chalk Farm, London, N.W., on December 30th, it was decided to wind up the Company voluntarily. This resolution was confirmed on January 15th, when Messrs. E. Wilding and James Gray were appointed liquidators.

——— A meeting will be held at 27A, Sackville-street, London, W., on March 3rd, at 12 o'clock, for the purpose of receiving an account of the winding up of the Foreign Electric Date and Time Stamp Company (Limited).

RELEASE OF TRUSTEE.—Notice is given of the release of the trustee (the Official Receiver, Mr. E. G. Clarke, Bristol), in the failure of John H. Hale, india-rubber merchant and electrician, of Old Vicarage, Stanton Drew, Somerset, and 25, St. Stephen-street, Bristol.

THE "ENGINEERING MAGAZINE."—The February issue of this excellent magazine is now ready, and fully maintains its high standard of excellence. The articles in the present issue include: "Jingoism, or War upon Domestic Industry," by Edward Atkinson; "The Trade and Industry of South America," by Emilio M. Amores; "Gold Mining in the Southern States." by H. B. C. Nitze; "The Commercial Exploitation of Electricity," by Burton E. Greene; "Limits and Possibilities of the Gas Engine," by George Richmond; "The Railroad Accident and Emergency Service," by W. L. Derr; "Locating a Public Water Supply," by Daniel W. Mead; "Architectural Sculpture in the United States," by Russell Sturgis; "The Free Port of Copenhagen," by P. Vedel; "The Stubborn Opposition to Inventions," by W. C. Dodge. The usual exhaustive review of the World's Press is also given. This number, as well as all the back numbers, may be obtained at the offices of the European edition, 1, 2 and 3 Salisbury-court, Fleet-street, London, E.C.

CASSIER'S MAGAZINE.—The contents of this popular magazine for February include articles on "Modern Shipbuilding Tools," "A Steam Plant for a small Electric Light and Power Station," "Saving Fuel in a Large Oil Refinery," "Long-Distance Electric Power Transmission in the United States," "Water Power," "Carborundum," and other articles of interest to many of our readers. Many of the writers are well-known American engineers.

"THE NEW LIGHT."—Under this title the publishers of the *Photogram* have just issued a special edition for February, containing a translation of Prof. Röntgen's original Paper on "The New Kind of Rays," together with contributions on the subject by several other observers. The pamphlet is well printed, nicely illustrated, and well calculated to meet the popular demand just now for information on this phenomenon. The publishers are Dawbarn and Ward, Farringdon-avenue, E.C., and the price 3d.

DYNAMO AND MOTOR PRICE LIST.—We have received from the Electrical Company (Limited) of 122 and 124, Charing-cross-road, W.C., a copy of their 1896 price list for continuous and alternating current dynamos and motors, and a few accessories. Machines of the first-named kind are made from 1 H.P. upwards. The smaller machines are of the bipolar type, the larger being multipolar machines. Prices for starting and regulating switches are given, as also for equalisers, which are required when a three-wire system is fed from one dynamo without accumulators. In the alternating current section of the catalogue particulars are given of single and three-phase generators, motors, transformers and starting and regulating devices. The catalogue is well compiled and illustrated, and contains, besides the various prices, a quantity of useful information. The dimensions are given in metric measurements and the weights in kilogrammes.

ABERDEEN.—The question of payment of a royalty for the use of the three-wire system by the Corporation was discussed at its last meeting, the subject being taken in consequence of the application of the owners of the patents for an extension of time. It was pointed out that under present arrangements the royalty would entail an annual charge of £250, which will be largely increased when the Corporation's electric lighting system is extended. It was decided to call a special meeting of the Council to consider the matter, it being stated that the Corporations of Edinburgh, Glasgow and Belfast had invited Aberdeen to join them in opposing the application for extension of time.

ALTRINCHAM.—At the last meeting of the Urban District Council the question of the application by the Altrincham Electric Supply Limited for lighting the township of Ashton-on-Mersey was discussed, and it was decided that steps be taken to protect the interests of the Council in the matter.

BELFAST.—At the last meeting of the Belfast Corporation the report of the Council in Committee on the Tramways Bill of the Belfast Street Tramways Company, to enable the Company to introduce a system of electrical or other mechanical traction on their lines was considered and discussed. The Committee reported that as such powers would seriously affect the interests of the ratepayers they had instructed the Town Clerk to prepare and lodge a petition against the Bill. The Committee's report further recommended that a special committee be appointed to visit some of the chief towns and cities on the Continent where electric traction is employed in order to obtain full particulars of the various systems and to present a report thereon to the Council. After discussion the Committee's report was adopted.

BIRMINGHAM.—The Town Council have decided by 36 votes to 16 to endorse the recommendations of the Works Committee to allow the Birmingham Central Tramways Company to introduce the overhead system of electric traction on their Nechelles Tramway route.

BOLTON.—The Town Council have appointed the borough surveyor and the electrical engineer to prepare and present a report upon (1) the probable cost of the introduction of the overhead electric traction system on the local tramways; (2) the comparative cost of horse and electric traction, (3) the financial position of the Corporation with regard to the sinking fund on the first cost of the permanent way of the tramways, and the additional cost of the overhead system; (4) the amount of the annual payment for sinking fund and interest, and the rent the Corporation would have to receive in order to make the new system a financial success; and finally as to the general advantages of a system of electric over horse traction.

BOYLE (IRELAND).—Messrs. Curtis Bros., of Dublin, recently submitted a scheme for lighting the principal streets of the town electrically. This scheme was considered at the last meeting of the Town Commissioners, and provided for the erection of six 2,000 c.p. arcs, 40 32 c.p. incandescents, and for the supply of about 500 16 c.p. lamps for private lighting. The cost of the necessary plant was put at £2,405, and the approximate maintenance cost at £200 per annum. After some discussion the Commissioners decided to postpone the matter for the present.

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COLCHESTER.—The Town Council have appointed a special Electric Lighting Committee.

CORK.—The City Council have now decided to ask Mr. E. Manville to prepare a report on the electric lighting of the city.

DERBY.—The Town Council have increased the salary of their electrical engineer (Mr. J. E. Stewart) from £250 to £300 per annum. At the last meeting of the Council the chairman of the Electric Lighting Committee (Alderman Leech) gave a lengthy explanation of the expenditure of the Committee, and £5,600 was voted for electric light purposes during the coming year.

DOUGLAS (ISLE OF MAN).—Much interest is evinced by prominent men at Douglas in the proposal now before the Douglas City Council to light the town by electricity. The disputants for and against the introduction of the electric light, so far, are Mr. G. Gillmore, electrician and local manager of the National Telephone Company, and Mr. E. Berry. Mr. Gillmore is opposed to the introduction of the electric light, at any rate for the present. Mr. Berry, on the contrary, advocates the immediate introduction of the light, and in reply to assertions that the cost of electric lighting is three times that of gas adduces Mr. Trotter's famous Hastings report, which appeared in our columns in December last. This report is certainly a hard nut for gas enthusiasts to crack, and Mr. Berry appears so far to have considerably the best of the argument. The discussion is not devoid of humour, and one gentleman, Mr. Clucas, a candidate for local honours, provides the droll element by an original but not particularly lucid manipulation of a few figures he has worked out, that the cost of the electric lighting of the town of Douglas would work out at £14,074. 1s. 9d. per annum against the charge of £1,030, the present cost of the gas, but then Mr. Clucas is a candidate for Council.

DUNDEE.—A report has been presented to the City Council by Mr. W. Brownlee, and was discussed at the meeting on Tuesday. The report states that on the 21st ult. two accidents occurred at the electric lighting station, causing the suspension of the supply of current for five hours. About 10 a.m. the steam pipe supplying the pump engine burst, rendering the engine useless. The injector in the boiler house was then used for feeding the boilers until 5:45 p.m., when the plug of the overflow valve gave way, stopping the further supply of water to the boilers. The accumulator battery was then brought into requisition, and kept up the supply of current for about half-an-hour, after which, the water in the boilers having fallen to the lowest level consistent with safety, the fires had to be drawn. Repairs were effected as quickly as possible, and current was again available at 11:15 p.m. The Board of Trade Surveyor has investigated the cause of the accident, but no report is yet to hand. Mr. Brownlee proposes that, in order to avoid similar accidents in future, a third means of feeding the boilers should be provided, preferably in the shape of an electrically-driven pump. Certain improvements suggested by Messrs. Carmichael and Co., who carried out some of the repairs, have been adopted.

ECCLES.—At the last meeting of the Town Council, the Town Hall and Electric Lighting Committee recommended that application be made to the Local Government Board for sanction to borrow the sum of £20,000 for electric lighting purposes, and after considerable discussion this recommendation was carried by the casting vote of the Mayor.

EDINBURGH.—At the last meeting of the Town Council the Plans and Works Committee recommended that the electric light be installed in the police cells at an estimated cost of about £180. Mr. Cranston moved disapproval of the minutes, but, as there was no seconder, the motion fell through.

HALIFAX.—At the meeting of the Markets Committee of the City Council last week the scheme for the electric lighting of the new markets was discussed and finally approved. The markets are to be lighted by means of incandescent lamps.——The electric light has just been introduced into the Theatre Royal, Halifax.

HULL.—At the last meeting of the Electric Lighting Committee the accounts of the department for the past year were submitted. Mr. Holder, the chairman, in commenting upon the success of the undertaking, said that they had sold 246,277 units of electric current against 163,857 units in 1894, an increase of 82,420. Up to the present their total capital expenditure amounted to £45,429. The revenue from all sources during the year had been £6,532, out of which they had paid £1,250 for interest and £1,113 had been set aside for sinking fund purposes. After paying all working expenses, &c., they had a balance of £1,263 profit, or sufficient to pay 9 per cent. interest on the capital expenditure. The number of customers had increased from 271 in 1894 to 399 in 1895, while some of their old customers had been so satisfied with the light that they had extended it to other parts of their premises. Mr. Holder also complimented the late and present engineers, Messrs. Gibbings and Barnard, upon the success of the undertaking, and said there were very few stations in England that could boast of such a low cost of production per unit. If the demand for current continued to increase at the present rate, he thought that if they were to keep within the limits of safety they would have to refuse to take any more customers at the latter part of next winter. Their station would not permit enlargement of their area so profitably as would the laying of a station or stations in outlying districts. The maximum output of the engines when working at full load was 5,950 amperes. This year their largest output was 3,340 amperes. The stand-by in case of the breakdown of one engine should never be less than their largest amount of production—viz., 1,600 amperes—and they could, therefore, only supply a maximum of 4,350 amperes. During the last year the increased customers applied for 1,629 amperes, and the corresponding increase during the present year would make their maximum output 4,969 amperes; he thought, therefore, that the Committee would have to decide upon some means of enlarging their works. The engineer had had the matter under his consideration, but he was hampered by the fact that they did not know whether the trams were to be worked electrically or not, and if so whether current would be supplied from the electric light station. If that matter were settled they could easily arrange for the supply of current to the principal streets of the town. In any case applicants for current were urgently applying from all parts of the town and something must be done to meet their wishes; therefore he thought it would be well to ask their engineer to consider and report upon what districts should be supplied, from what centres, and what system he thought most suitable to the present and future requirements of the town. It was decided to enter the Chairman's report in the minutes, and to consider the accounts at the next meeting.

ISLINGTON (LONDON).—On Friday last the electric light was experimentally turned on for the first time. The Vestry Hall and a number of shops on the opposite side of Upper-street were lighted. On Saturday considerable addition was made to the number of lamps lighted in business premises. Already the Lighting Committee has orders for the equivalent of 15,000 8 c.p. lamps, which is really a larger number than can be supplied from the existing plant. There is even now talk of extensions, and calculations roughly made indicate that even on the first year's working, unless some unforeseen difficulty should arise, an equilibrium between revenue and expenditure will be arrived at. It is stated that a considerable demand has arisen for factory lighting in the neighbourhood of the Regent's Canal, which passes through the Islington district.

JAPAN.—It is stated that a submarine cable is to be laid by the Japanese between Formosa, the newly acquired island, and Japan. The length is 594 nautical miles, and the contract price £65,980. The contract is stated to have been secured by a Japanese firm. Great progress is reported in electrical matters generally, the latest project being the construction of an electric tramway between the towns of Uraga and Tokosuka.

KIDDERMINSTER.—A meeting of the Town Council was held on Friday last for the purpose of considering the question of the proposed construction of an electric tramway from Kidderminster to Stourport. The General Purposes Committee presented a report on the scheme, and recommended the Council, subject to certain modifications in the plans which the promoters of the Bill had agreed to make, to approve of the Bill, and this recommendation was adopted.

LEEDS.—At the meeting of the City Council on Wednesday Mr. Hannam moved the adoption of the report of the Highways Committee on the question of equipping the local tramways electrically. An abstract of the Committee's recommendations was given in our last issue. After considerable discussion an amendment that "that portion of the minutes recommending the adoption of the conduit system of electrical traction in Boar-lane, be referred back," was carried by a large majority. The other portion of the report, which recommends the use of the overhead system over the remaining portion of the line, was adopted.

LLANDUDNO.—At a special meeting of the Urban District Council last week Mr. A. H. Preece was appointed consulting electrical engineer to the Council for the purpose of preparing a report on the electric lighting question.

MAIDSTONE.—The District Council have decided to adopt the recommendation of the Electric Lighting Committee to transfer their Provisional Order to a company which is being formed by Mr. Thomas King, electrical engineer, of Brighton and Maidstone.

MORLEY.—A letter from the Tradesmen's Association as to the adoption of an electric lighting scheme has been referred to the Electric Light Committee for consideration and report.

PETERBOROUGH.—At the last meeting of the Town Council the proposal to borrow £20,000 for electric lighting purposes was discussed. The engineer to the Council had estimated that this sum would be the probable cost of an installation for street and private lighting. The matter had been discussed in Committee, and the proposal had been made to dispose of the Corporation's powers under the Provisional Order to a company, but this had been defeated, and

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the motion that the £20,000 be borrowed had been carried by nine votes to six. At the Council meeting Alderman Percival moved the non-confirmation of the Committee's minutes. Ultimately the Committee's decision was approved by eleven votes to six, and we are able to announce that Dr. J. A. Fleming has been appointed to advise the Council as their consulting electrical engineer.

PITLOCHRY.—At a meeting of the local gas company a scheme for introducing the electric light to this town was submitted by Prof. G. Forbes, whose estimate provides for a 200 H.P. turbine, and the necessary plant and apparatus to extend the mains as far as the Atholl Hydropathic, with branches to Oakfield, &c., at a total cost of £5,100, but as some portion of the scheme would remain in abeyance, Prof. Forbes considers that an expenditure of £4,000 is all that would be necessary for the present. This will provide current for an equivalent of 6,000 8 c.p. lamps. The up-keep is estimated at about £150 per annum. It was decided to delay decision until it was ascertained what number of lights would be taken up at once. The owner of the Hydropathic offers to take 800 lights forthwith.

PORTRUSH (IRELAND).—In addressing the shareholders of the Giant's Causeway Electric Tramway Company, at their annual meeting a few days back, the Chairman called attention to the item in the accounts having reference to the accident which occurred on the electric tramway, by which a cyclist met his death. The Directors, while denying any liability in the way of damages, decided to be liberal in the matter, which largely accounted for the somewhat considerable item of £159. 1s. under the heading "compensation." One result of the accident referred to has been that the Board of Trade have required the Company to adopt the overhead system instead of that of the present conductor rail. The change over to the overhead system is estimated to cost about £5,000, but the Company will by this outlay have considerably increased electric power available. The Chairman called attention to the anomalous state of affairs by which the obtaining of cheap money or absolute gifts from the English Exchequer was confined to those parts of Ireland which do nothing for themselves, while in the north of Ireland, where private enterprise has done and is doing so much, money can only be obtained at 4 per cent. The Company's line had not only opened up the old district from Portrush to the Giant's Causeway and developed the tourist traffic, but it afforded one of the best and cheapest outlets for the enjoyment and recreation of the working classes of Belfast and other commercial towns in the north of Ireland. During the year they had run their electrical cars at a cost of 4d. per mile, against 10½d. per mile, the cost of their steam cars, and the cheapness of electricity as a locomotive power was still fully maintained.

PORTSMOUTH TELEPHONES.—The Roads and Works Committee, on Monday last, had before them the consideration of the tenders sent in for laying the telephone wires in Portsmouth underground. The tender of Mr. Quick has been accepted by the Committee, but as the National Company are paying for the work the tenders have been sent to the Head Office, with a recommendation that Mr. Quick's offer be accepted.

PRESTON.—At the last meeting of the Town Council the Streets and Buildings Committee recommended that the contract made in June, 1892, with the National Electric Supply Company for the erection of 12 arc lamps in Fishergate, and the supply of current thereto, should be renewed, and that 30 additional 500 c.p. lamps should be erected in the principal streets of the town. The Company agreed to erect and supply current to these lamps at an inclusive charge of £14. 10s. per lamp per annum. The recommendation was adopted.

RIPON—The City Council have referred the question of formulating an electric lighting scheme for the City, to the Gas Committee. At the last meeting of the Council the Mayor said that the Dean and Chapter of the Cathedral, had agreed to postpond further consideration on the question of lighting the Cathedral electrically until their July meeting.

SLIGO.—The Town Council are making inquiries into the relative cost of electric and gas lighting, and a committee, consisting of the Mayor and Messrs. Foley and Gilcriest, has been appointed to collect information.

STAFFORD.—The County Council have decided to wire for the electric light the judge's lodgings at Stafford, providing the cost does not exceed £200.

SWANSEA.—The Town Council have received the report of Mr. W. H. Preece, who was recently appointed to give an opinion on the joint electric lighting, dust destructor and tramway scheme of the Corporation. It is stated that Mr. Preece's report is favourable to the carrying out of the scheme, and that practically all opposition to the Council's proposals will now cease.

WORCESTER.—At the last meeting of the City Council the Electricity Committee presented a report recommending the Council to apply to the Local Government Board for sanction to borrow a further sum of £5,000 for electric lighting purposes, the loan to be repayable in 30 years.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

January 18, 1896.

1,310. H. HIRST and A. E. ANGOLD. London. Improvements in electrical igniting apparatus.

January 20, 1896.

1,396. W. W. HULSE. London. Improvements in machinery or apparatus for transmitting motion from electric motors to other machinery.

1,401. A. A. NAVILLE, P. A. GUYE, and C. E. GUYE. London. Improvements in electrical gas-reaction apparatus.

January 21, 1896.

1,427. H. MARCUSE. Manchester. Improvements in and connected with telephonic apparatus.*

1,457. C. F. STEARN. London. Improvements in or connected with incandescence electric lamps. (C. F. Topham, Switzerland.)

1,487. P. CHAROLLOIS. London. An improved microphonic transmitter.

1,488. W. GRIMES. London. Improvements in or relating to electric batteries.

1,511. F. E. W. BOWEN. London. Improvements in the manufacture of filaments for electric incandescence lamps.

1,518. H. EDMUNDS. London. Improvements in means for the distribution of electricity simultaneously to circuits requiring current of uniform pressure and to circuits having variable load. (G. Mengarini, Italy.)

January 22, 1896.

1,559. J. H. DUNN and J. PARSONS. London. Improvements in making gases and steam by electricity.

1,563. R. PEARSON. London. Improvements in gravity electrical contact makers.

1,564. D. G. FITZGERALD and C. N. STEWART. London. An improved process for utilising peroxide of lead in the manufacture of elements for voltaic batteries.

1,565. T. HARPER. London. Improvements in electric switches.

1,574. SIEMENS BROS. AND CO. (LIMITED) and J. NEBEL. London. An improvement in electricity meters.

1,575. SIEMENS BROS. AND CO. (LIMITED). London. A process for the electrolytic production of zinc from its ores. (Siemens and Halske, Germany.)*

COMPANIES' MEETINGS AND REPORTS.

St. James' and Pall Mall Electric Light Company (Limited).

The ordinary general meeting of this Company was held on Tuesday at the offices of the Company, Carnaby-street Central Station, Golden-square, W., Mr. Eustace J. A. Balfour (Chairman) presiding.

The GENERAL MANAGER and SECRETARY (Mr. Frederic J. Walker) read the notice calling the meeting.

The CHAIRMAN: Before formally moving the adoption of the report and accounts, there are two or three observations I should like to make, chiefly in reference to the working of the Company since last the Directors had the pleasure of meeting the shareholders. I think we may fairly congratulate ourselves on the result of the year's working. We propose a dividend of 7¼ per cent. on the Ordinary shares, as against 6½ per cent. last year and 4½ per cent. the year before, and I am glad to say that the hope I expressed last year that there would be something to divide among the holders of the Founders' shares have been fulfilled. We propose on these shares a dividend of £?. 19s. 6d. each. During the year we have increased the number of lamps connected by 22 per cent., which is satisfactory, but what is still more satisfactory is the increase during the present year. Since January 1st we have had application for no fewer than 6,000 lamps, but in addition to that we have actually increased our gross revenue during the first four weeks of this year by £1,200. The actions for alleged annoyance from the plant at Mason's-yard station have been arranged. The Directors have arrived at the conclusion that it would be necessary to replace the whole of the engines there by new engines of the type similar to those in use at our Carnaby-street central station. This change was postponed as long as possible in order to ascertain the results of experiments carried on by ourselves and other companies, with the view of discovering the best method of overcoming the difficulty and trouble. Unfortunately no definite conclusion could be come to in time to stop the legal actions arising out of the annoyance. From the first, however, the Directors have been fully satisfied that the cure must be sought in the engine itself; in other words, it must not vibrate. Therefore, following up the experience gained at the Carnaby-street Central Station, we have proceeded to replace the plant at Mason's-yard. During the period under review rather more than one-half of it has been sold at a loss of £2,000, which has been charged to the revenue of that year, and, satisfied with the success of the new engines, the Directors have now decided to sell the remainder of the old engines and plant, and completely re-equip the station, and a further loss of about £1,500 must

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be expected as a charge on the current year's working. At the same time steps have been taken at both stations to put a stop to all possible complaint from the emission of smoke and dust from the chimneys, and we feel confident that we can carry on the business of the Company without annoyance to our neighbours. In November a further issue of £20,000 of Debenture stock, making the whole issue up to £50,000, was made to the shareholders, and was considerably over-subscribed. Unless some unforeseen events should occur the Board do not anticipate that there will be any necessity for raising further capital during the present year. We expect shortly to receive an order from the parish of St. James to light the principal thoroughfares in this district, and this we are prepared to carry out. Last year we were able to announce that the cost of working had been reduced ¾d. a unit, and great credit is due to the staff for effecting a further reduction of ¼d. during the past year. Efforts have been made to come to an arrangement with the Founders shareholders, but unfortunately the offer of the Board, which, of course, was made subject to your approval, was not unanimously accepted, and it therefore fell to the ground. I regret to have to announce the resignation of my brother, Mr. Gerald Balfour, but on his appointment as Irish Secretary he did not consider himself justified in retaining his seat on the Board. Finally, I have again to thank Mr. Walker and Mr. Dobson and the whole staff for the zeal and ability they have shown this past year as in former years, and think we may, unless some unforeseen event occurs, look forward to the increased prosperity of the Company in the future. I now beg to move:—

That the report and accounts for the year ending December 31, 1895, as submitted by the Directors, be received and adopted, and that the dividends recommended therein be declared and paid on February 14th.

Mr. LATIMER CLARK, F.R.S. (Vice-chairman), seconded the motion.

Mr. FRANCIS BOURN expressed regret that the Directors had not been able to effect a settlement with the Founders' shareholders. Was he to understand that the holders of Founders' shares regarded their shares as priceless?

Mr. C. R. FRY said that as one who took a prominent part in the negotiations for bringing about an arrangement with the Founders' shareholders, he should like to be allowed to explain how matters stood. The proposal which emanated from the Board he considered a most fair and reasonable one, and he felt confident that the Ordinary shareholders would not have agreed to better terms being offered. Among the holders of the Founders' shares there were three or four gentlemen—all wealthy men—who evidently expected that some day their shares would be worth £500 or £600, and as it was impossible to get them to alter their views they refused to accept the offer made to them by the Directors. If the Founders' shareholders had agreed to dispose of their shares on the terms offered to them their position to-day would have been better than it was, and he believed the same might be said of their position during the next five years after making allowance for the progress of the Company during that period. As there were a few of the Founders' shareholders who refused the Board's proposal the negotiations fell through, as, unfortunately, the Articles of Association appeared to be drawn up in such a way as to make it possible for one objecting shareholder to defeat the whole thing.

Mr. FRANCIS BOURN asked if it would not be possible to alter the Articles of Association. Of course, they must not overlook the fact that the Founders' shareholders had their rights, but it was undoubtedly in the interest of the Company that the Founders' shares should be bought up. He would strongly urge, even if a large price had to be paid, that the Founders' shares should, if possible, be purchased.

Dr. WEBB observed that the Founders' shares had always been a millstone round their necks, and he should be glad to see them bought up, not at an exorbitant price, but at an extravagant price if necessary. The life of electric companies was only about 40 years, at the end of which time they might have to comply with various demands on the part of the public authorities before they obtained a renewal of their concession, or they might have to relinquish it on terms which would not restore to the shareholders their original outlay of capital. Therefore it would be a good thing if the Founders' shares could be bought up, in order to enable the Company to build up a reserve which at the end of 40 years would be sufficient to guarantee that they or their representatives would receive a return equivalent to the amount of money they had put into the Company.

The CHAIRMAN, in reply, said: I am entirely in sympathy with your desire to come to an arrangement with the founders. I think it is most important in the interests of the Company that we should do so, but of course it is a question of the balance of advantages. There is a point beyond which the Directors would not be justified in advising the shareholders to go in buying the Founders' shares. In our opinion the offer we made was the utmost limit we could reasonably advise you to agree to, and I concur with Mr. Fry in believing that the shareholders would not, as a body, have sanctioned any larger offer. That being so, we have come to the end of the matter. Of course our offer, or a similar offer, is still open to the Founders' shareholders. For myself I have longed to get this question settled, and as long as I am Chairman I shall use every endeavour to bring it to a successful termination. As to altering the Articles of Association, I may point out that to do that requires the same unanimity among the Founders' shareholders as the acceptance of our offer, so that we cannot get any further with that than with the other. It is unfortunate that such is the case.

Mr. FRANCIS BOURN: May I ask what the offer to the Founders' shareholders was?

The CHAIRMAN: This is the letter that was addressed to Mr. Fry, the Chairman of the Founders' Shareholders Committee:—

"July 3, 1895.

"Dear Sir: Your letter of June 20th was before the Directors at their meeting yesterday, and I am instructed to kindly ask you to inform the Committee of the Founders' Shareholders that the Board are prepared to advise the Ordinary shareholders to consent to the offer of an allotment of 80 ordinary shares at par for each Founders' share, but that they do not see their way to any increased offer. This, of course, is subject to the understanding that all the Founders' shareholders agree.

"F. J. WALKER,
"General Manager and Secretary."

The meaning of that is that at the then market value the founders would have got £280 per share, and at the present market value £400 per share.

Mr. FRANCIS BOURN said that, looking at the prospects of the Company, he considered that a very low offer.

The CHAIRMAN: I should point out that the market value of the Founders' shares was then £150, and we were offering £280.

Mr. FRY pointed out that if the offer had been accepted the founders would have received a consideration equal now to £360, whereas the market value of the Founders' shares to-day was £200.

The resolution was then carried unanimously.

The CHAIRMAN proposed the re-election of Mr. Bennett Fitch, M.Inst.C.E. and Mr. Walter Leaf as Directors.

Mr. FRY seconded, and the motion was agreed to.

On the motion of Mr. WAY, seconded by Mr. PIERCE, the auditors (Messrs. Deloitte, Dever, Griffiths and Co.) were re-appointed.

A vote of thanks having been accorded to the Chairman, the Board of Directors and the staff, the proceedings terminated.

Waterloo and City Railway Company.

The fourth half-yearly general meeting of this Company was held on Thursday at the Waterloo Station, London, Mr. Wyndham S. Portal (Chairman) presiding.

The SECRETARY (Mr. F. J. Macaulay) read the notice calling the meeting.

The CHAIRMAN: It may be of interest to you to know that the shareholders now number 553 against 541 at the last August meeting, and 494 at this time last year. I think I may say we meet the shareholders to-day under very favourable circumstances, as the engineers report that during the past six months there has been a continuous and substantial progress in every direction. The position of the undertaking is in every way satisfactory. At the close of the last half-year the tunnel was about 100 yards Citywards of the river Thames, but the engineers report they have now reached a point in Queen Victoria-street, nearly opposite St. Nicholas Church, a distance driven in the six months of 530 yards of double tunnel. These tunnels have been driven under the low level sewer, the Metropolitan Railway and Queen Victoria-street without mishap. They are in the solid London clay, and the rate of progress has been at the rate of 75ft. per week. These railway tunnels are now about 400 yards distant from the commencement of the City station, which will probably be reached in June next. Towards Waterloo the tunnels were, on July 22nd last, entering Stamford-street, but as they have had to encounter ballast and water, and have had to be worked under compressed air, the progress has been much slower. The average distance of the tunnels from the crossing of the Waterloo-road is about 120 yards, and the present rate of progress is about 23ft. a week. The length of the double tunnel driven in this direction since the last half-yearly report is 300 yards. The contract for the low-level station at Waterloo has been let at the engineers' estimates, and the works have been commenced by Messrs. Perry and Co., the contractors. The total length of single tunnel driven since the commencement of the works is 3,036 yards, being 69 per cent. of the entire length between the Waterloo station and the City station. With regard to the City terminus, which would be in the open space in front of the Royal Exchange, he might say that they had made arrangements with the Central London Railway Company, and were now in negotiation with the City authorities with every prospect of a successful result, and there was no reason to doubt that the undertaking would be completed within the time sanctioned by the Company's Act. On the 17th of last month His Majesty the King of the Belgians visited the works, and seemed to be extremely pleased with all that he saw. It might be hoped that when the undertaking was completed other royalties would do them the honour of visiting it, and, perhaps, of opening what was an exceptional and extraordinary work, combining both science and art. The accounts showed that the total amount of share capital received was £216,000, and the total expenditure £122,736. The sum expended in the past six moths was £62,321, and the estimated further expenditure of capital to June 30th next was £105,000, to meet which they would, in all probability, have to make another call. There was nothing more for him to say except to congratulate the engineers, Mr. Galbraith and Mr. Greathead on the progress they had made so far, and on their wonderful immunity from accidents of all sorts, and to assure them of the earnest hope of the Board that things would go on to the end with the same satisfaction to themselves and to the Directors as they had done from the beginning to the present time. He then moved—

"*That the report of the Directors and statement of accounts for the half-year ended December 31, 1895, be, and the same are hereby received and adopted.*"

Lieut.-Col. Hon. H. W. CAMPBELL (Deputy-Chairman) seconded the resolution.

Mr. BEAVIS asked if, in making the next call, the Board would give to those shareholders who wished to do, the option of paying up the full amount uncalled on the shares.

The CHAIRMAN: We can only give that option on the same conditions as I mentioned at a previous meeting. If you like to pay up in full you may, but it must be without interest being paid.

Mr. L. H. RUEGG said the report was an admirable one, and they would find some difficulty in saying too much in favour of the Board. They

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were very happy in having on the Directorate so many members of the South-Western Company. He ventured to predict, in regard to this line, that it would ultimately be a more valuable property than the South-Western Railway.

The CHAIRMAN, replying to a shareholder, who asked if the works might be inspected, said the engineers would readily accede to the desire of any shareholder to visit the undertaking during construction, but only a few could be accommodated at the same time.

A SHAREHOLDER: No liability will attach to the Company for accidents, I suppose?

Sir CHARLES SCOTTER: No, each shareholder's visit must be at his own risk.

The resolution was then carried unanimously.

The retiring Directors, Mr. W. S. Portal, the Right Hon. Sir Algernon West, K.C.B., and Mr. P. Mortimer, were re-elected.

A special general meeting followed, at which, on the motion of the CHAIRMAN, seconded by Lieut.-Col. Hon. H. W. CAMPBELL, the following resolution was carried:—

"That this meeting having considered the Bill now pending in Parliament intituled 'A Bill to confer further powers on the Baker-street and Waterloo Railway Company,' approves thereof with such modifications, if any, as may be agreed to by the Directors and sanctioned by Parliament."

Yorkshire House-to-House Electricity Company (Limited).

A meeting of this Company was held on Tuesday. Mr. Grosvenor Talbot, the Chairman, presiding.

The CHAIRMAN said that out of capital they had expended £12,468 during the year, bringing up their total capital expenditure to £76,526. They had made very considerable extensions in mains, and of those they had expended £6,080, on machinery £3,380, £2,240 on new transformers and meters, and the balance had been spent on buildings. The profit available for dividend amounted to £6,483. In July they declared an interim dividend at the rate of 4 per cent. per annum, which took exactly £1,000. The Directors now recommended a dividend at the rate of 6 per cent. per annum for the half-year just ended, making 5 per cent. for the whole year. That required £1,675. 7s. 7d. The Directors proposed to carry to reserve, depreciation, and other purposes, £3,300, leaving £517. 16s. 4d. to carry forward. In addition to the dividend, during the year, by a recent issue of shares, shareholders had as many new shares offered to them at par as the number which they then held, and as the £5 shares were now selling at £7 to £7. 7s. and those on which £1 had been paid were selling at £2. 7s. 6d., the Directors felt that that was equivalent to a very handsome bonus. They also felt that it was very desirable that they should accumulate a considerable reserve fund. Up to the present time they had no reason to regret a single step that they had taken in the erection of the plant and machinery, but there were possibilities in electrical science which they must always bear in mind, and which possibly might render advisable expensive alterations that they would more willingly entertain if they had in hand a considerable reserve. Last year the business had been satisfactory. The total receipts had been £11,431, compared with £7,457 in the previous year; and their expenses had been £4,617, against £3,747 in 1894. The net profit was £6,780, compared with £3,700 in 1894. Thus the total revenue had increased by 57 per cent., and the expenses had only increased by 25 per cent., while the available profit was 82 per cent. more. In 1891 they had an installation of 19,858 8-candle power lamps; in 1895 they had 32,539 lamps. In 1894 their total output was 291,113 units, and in 1895 it was 525,629 units, showing the great desire there was to use the electric light in the city of Leeds. The cost of coal had been only £670 for the year, which beat the record per unit of any station in the United Kingdom. The electric light had, he thought, been amply proved to be the safest now in use, and its great safeguard against fire should enable their customers to obtain more advantageous rates with the insurance companies. As to new plant, the Directors had ordered two vertical engines of 500-H.P. each, running at 355 revolutions, with direct coupled alternators. This involved to a certain extent a new departure, as there was no station in England where a plant was in existence similar in every way to what they required in Leeds, and running under such stringent conditions. The new engines and alternators would run in parallel with the old plant, also with themselves alone when needed, and the whole plant would be practically noiseless. He had to convey to their engineer, secretary and staff the appreciation of the directors for the manner in which the Company's work had been performed during the year.

Cuba Submarine Telegraph Company, Limited.

The report of the Directors of this Company for the half-year ended December 31 last, to be presented at the forty-ninth ordinary general meeting of Shareholders, held at the offices, 58, Old Broad-street, London, E.C., on Wednesday next, at 12 o'clock, states that the gross receipts amount to £25,663. 16s. 11d., and the gross expenditure to £6,034. 14s. 4d., leaving a sum of £19,579. 2s. 7d., which, added to the balance of £3,539. 19s. 9d., brought forward, leaves £23,119. 2s. 5d. at the credit of revenue account. The sum of £10,000 has been added to the reserve fund, which now stands at £120,000. The dividend on the Preference shares will absorb £3,000, and leave £10.119. 2s. 5d., out of which the Directors recommended the payment of a dividend on the Ordinary shares at the rate of 8 per cent. per annum, free of income tax, the balance, £3,719. 2s. 5d., being carried forward. The Company's cables have continued in good order throughout the half-year, but during the present month the Cienfuegos-Santiago 1875 cable has broken down and been repaired by Mr. Keith.

In consequence of the insurrection in Cuba, which still continues, the Spanish Government suggested to the Company to connect the town of Manzanillo with one of the two existing cables running from Cienfuegos to Santiago; but as these cables were laid in 1875 and 1881 respectively, the Board considered it undesirable to disturb them. Further proposals then followed from the Government, resulting in the Company obtaining a concession to lay a cable between Cienfuegos, Casilda, Tunas, Jucaro, Santa Cruz, and Manzanillo, with a subsidy of £2,000 per annum, from 1st January, 1896, till 27th August, 1910, which is the date when the original concession expires. This cable has been successfully laid by the contractors and duly taken over by Mr. Keith on behalf of the Company. It is about 300 nautical miles in length, and the Directors trust it will not only prove useful to the Government, but to the general public. As the new line extends the greater part of the route traversed by the cables of the Cienfuegos-Santiago section, it will require only the laying of the short length between Manzanillo and Santiago to give a new line of communication between the first-mentioned points, but it is not proposed to do this until the failure of either of the old cables should render such a step advisable. The cost of the new cable, approximately about £45,000, will be charged to the reserve fund in the current half-year's account.

The position of the Company's suit against the Spanish Government at Madrid remains the same as at the date of the last report.

Westminster Electric Supply Corporation (Limited).

The following report is issued by the Directors of this Company and will be presented to the shareholders at the meeting to be held at the offices, Eccleston-place, S.W., on Wednesday, the 19th inst., at 11 o'clock:—

The business of the Corporation continues to make satisfactory progress. The supply of current, which on December 31, 1894, was provided for the equivalent of 167,705 lamps of 8 c.p., had increased by December 31, 1895, to the equivalent of 210,982, and at the present time there are on circuit the equivalent of 216,822 lamps of 8 c.p., and applications have been received for a further 6,478. The length of roadway in which mains have been laid now exceeds 39 miles, making about 156 miles of ways, into which upwards of 123 miles of copper (strip and cable) have been drawn. The plant and machinery have been working satisfactorily throughout the year, and have been fully maintained from revenue, and a further reduction has been effected in the cost per unit, in generating, distributing, and general expenses. In consequence of the increase in the business of the Corporation the Directors have found it necessary to acquire additional property at Eccleston-place and Millbank-street. In dealing with the revenue of the past year the Directors have, after writing off bad debts, a portion of preliminary expenses, and placing £953 to credit of sinking fund, added a sum of £9,780 to the depreciation account. The net revenue of the year amounts to £23,731. 11s. 9d., out of which an interim dividend, at the rate of 5 per cent. per annum, for the half-year ended June 30th last, has been distributed. The Board now recommend the payment of a dividend at the rate of 9 per cent. per annum, less income tax, for the past half-year, making 7 per cent. for the year ending December 31st last, carrying forward £1,333. 14s. 10d. The holders of Founders' shares becoming entitled to a share of the surplus profits after payment of a dividend of 7 per cent., this balance will be carried forward as follows:—

Ordinary Shareholders' undivided profit account ...	£1,004	1 2
Holders of Founders' shares " "	334	13 8

The Premium of £3,000 received on the issue of new shares has been carried to the credit of the reserve fund, and invested.

Messrs. J. H. Powell and J. Browne Martin offer themselves for re-election as Directors.

Liverpool Overhead Railway Company.

The following report of the Directors of this Company for the half-year ended December 31st last is issued, and will be submitted to the fifteenth half yearly general meeting of shareholders to be held at the Law Association Rooms, Cook-street, Liverpool, on the 11th inst. at three o'clock.

The gross revenue receipts amount to £31,590. 6s. 11d., and the working expenses to £18,893. 19s. 3d. The number of passengers carried each half-year since the opening of the railway is as follows:—

	June 30, 1894.	Dec. 31, 1894.	June 30, 1895.	Dec. 31, 1895.
First Class	277,653...	362,179...	400,260...	444,762
Second Class	1,246,975...	2,228,224...	2,114,462...	2,374,794
Workmen (Special Return Tickets)	1,336,809..	1,050,976...	945,338..	960,819
	2,861,437...	3,641,379..	3,460,060...	3,780,375

The works in connection with the Southern Extension are making good progress, and it is anticipated that the additional line will be open for traffic in the autumn of 1896.

The revenue account shows receipts from passenger traffic £31,080. 16s. 3d., and miscellaneous receipts £509. 10s. 8d.; total £31,590. 6s. 11d. Working expenses £18,893. 19s. 3d. and interest on Debentures £2,500. This leaves, with balance brought forward (£1,302. 18s. 11d.), £11,499. 6s. 7d. available for dividend. Out of this balance the Directors recommend dividends at the rate of 5 per cent. per annum on Preference shares, absorbing £2,600, and 3½ per cent. on Ordinary shares, taking £6,825, leaving £2,074. 6s. 7d. to be carried forward.

Sir W. B. Forwood (Chairman) and Mr. H. Brocklebank offer themselves for re-election as Directors, and Mr. George Nicholson as auditor.

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NEW COMPANIES, STATUTORY RETURNS, &c.

SIR W. G. ARMSTRONG AND CO. (LIMITED).—This Company was registered on January 31st, with a nominal capital of £4,000,000, in 200,000 £4 per Cent. Cumulative Preference £5 shares and 3,000,000 Ordinary £1 shares, to acquire the business and undertaking of Sir W. G. Armstrong, Mitchell and Co, Limited (incorporated in 1882), to enter into an agreement with the old Company for that purpose, and to carry on the business of hydraulic, electrical and general engineers, ordnance and gun makers, torpedo manufacturers, shipbuilders, machine and engineering tool makers, &c. The first Directors are:—Lord Armstrong, Sir A. Noble, K.C.B., Adm. Count Albini, W. D. Cruddas, M.P., Col. Henry C. S. Dyer, Hon. Edward F. L. Gower, Saxton W. A. Noble, George Rendel, H. O. Rendel, Lord Rendel, H. F. Swan, J. Vavasseur, P. Watts, P. G. B. Westmacott and Lt.-Gen. C. W. Younghusband.

COX THERMO-ELECTRIC COMPANY (LIMITED).—This Company was registered on February 3rd, with a capital of £100,000 in £10 shares, to apply for, purchase, or acquire any patents, patent rights, licences, concessions, and in particular inventions relating to the direct generation of electricity from heat by means of thermopiles or thermo-electric generators, and to the construction, maintenance, improvement or working of thermopiles or thermo-electric generators of any kind; to enter into an agreement with Mr. H. B. Cox, engineer, and Messrs. R. W. Wallace and F. J. Webster, and to carry on the business of manufacturers of and dealers in thermopiles and thermo-electric generators, mechanical engineers, machinists, dynamo makers, manufacturers of cars, vans, carriages and vehicles of all kinds, suppliers of electricity, manufacturers of and dealers in electrical apparatus, metal founders, &c. The subscribers, with one share each, are: H. B. Cox (engineer), Mrs. Clara L. Cox, W. Churcher, J. Macfarlan, T. Dunsdon, E. Dry and H. Elliott. Mr. H. B. Cox is to be a life Director of the Company.

ERNEST SCOTT AND MOUNTAIN (LIMITED).—The annual return has just been filed. Out of a capital of £70,000 in £10 shares, 5,763 have been taken up, and 2,200 have been issued as fully paid. The full amount has been called on 1,082, £6 5s. per share on 1,981, and £5 per share on 500

EPSTEIN ELECTRIC ACCUMULATOR COMPANY (LIMITED).—The annual return to December 31st has just been filed. The capital is £101,000 in 1,000 Founders' and 100,000 Ordinary shares of £1 each. All the former and 70,307 of the latter have been taken up, and 1,000 Founders and 70,007 Ordinary shares have been issued as fully paid. The full amount has been paid on the remaining Ordinary shares.

EUROPE AND AZORES TELEGRAPH COMPANY (LIMITED)—The annual return to December 31st has been filed. The capital is £200,000, in £10 shares, and 16,704 of these have been taken up. 5,568 have been issued as fully paid, and the full amount has been paid on the remaining 11,360 shares.

FOREIGN AND COLONIAL ARC ACCUMULATOR COMPANY (LIMITED).—The annual return, to December 6th, has been filed. The whole capital of £1,000, in £1 shares, has been taken up, and 993 have been issued as fully paid.

TELEGRAPH IMPROVEMENT COMPANY (LIMITED).—The annual return, to December 27th, has been filed. Out of a nominal capital of £100,000, in £1 shares, 15,006 have been taken up, 15,000 have been issued as fully paid, and the full amount has been paid on the remainder.

CITY NOTES.

MEMORANDA—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30⅞d. per oz. (Feb. 6th). Consols (2¾ per cent.) 108 1/16 – 108 1/16 for money, 108 1/16—108 5/16 for account; 2½ per cent. 104⅞—105⅛ (Feb. 6th). Stock Exchange Settling Days: Consols, March 2nd; Stocks and Shares Continuation Day, Feb. 11th; Ticket Day, Feb. 12th; Pay Day, Feb. 13th; Mining Share Carry-over Day, Feb. 10th.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended February 2nd were £991, against £1,021 in the corresponding week of 1895, a decrease of £30. The total receipts for the half-year amount to £5,026, against £5,020 for the corresponding period of 1895, an increase of £6.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of January were £2,578, against £1,878 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of January amounted to £78,886, against £70,674 in the corresponding period last year.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of January amounted to £49,693, and to £41,315 in the corresponding period 1895.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The Directors of this Company resolved on a payment on account of the dividend of the current year, at the rate of 5 per cent. per annum, less income tax, on the A shares of the Company, in respect of the half-year ended December 31st last. This works out as follows: On 89,261 £5 shares (£3 paid), 1s. 6d. per share; on 17,139 £5 shares (fully paid), 2s. 6d. per share. Dividend warrants will be issued on the 18th instant.

GIANT'S CAUSEWAY AND PORTRUSH ELECTRIC TRAMWAY COMPANY (LIMITED).—The annual meeting of the shareholders of this Company was held on the 31st ult., when the Directors' report and accounts for the past year were approved. The report stated that during the year there had been an increase in the number of passengers carried of 5,700, the total for the year being 99,616. The receipts from this department rose from £2,873. 13s. 11d. to £3,107. 9s. 5d., while the receipts from the carriage of mineral rose from £12. 5s. 1d. to £14. 8s. 7d. The total receipts were £3,156. 1s. 6d., against £2,914. 6s. 5d., and the expenditure amounted to £2,426. 5s. 2d. against £2,189. 8s. 3d. in 1894. The increased expenditure was principally caused by a right-of-way lawsuit in which the Company became involved.

GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).—Notice is given of the drawing of 100 1883 Debentures (Series B) of £100 each, for payment on March 1st next. The Debentures will be paid by Messrs. C. J. Hambro and Son, 70, Old Broad-street, London, E.C. This Company's traffic receipts in January were £22.490, against £21,000 and £23,200 in the corresponding month of 1894 and 1895 respectively.

GREAT NORTHERN TELEGRAPH COMPANY.—The receipts of this Company for the month of January amounted to £22,400, as against £23,200 for the corresponding month of 1895, and £21,000 for that of 1894.

JOHN FOWLER AND CO., LEEDS (LIMITED).—During the week the Law Debenture Corporation invited, on behalf of this Company, applications for £200,000 Four per Cent. First Mortgage Debentures of £100 each, repayable on January 1, 1926, at £105, and redeemable, at the Company's option, on six months' notice at any time on or after Jaunary 1, 1911, at £110 per cent. Holders of current Four and a-Half per Cent. Debentures to the amount of £96,500 have applied for Debentures of the present issue in exchange for the old Debentures. The issue price was at the rate of £105, payable £10 on application, £45 on allotment (£5 premium), and £50 on March 9th. The prospectus states that the Company has recently given increased attention to the manufacture of plant for the generation of electric light and power, and the paid-up capital amounts to £374,430 (£284,430 in £10 fully-paid £5 per Cent. Preference shares, and 18,000 Ordinary £10 shares, £5 paid).

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended the 2nd inst. amounted to £1,044. The amount for the corresponding week last year was £924. Increase, £120.

MANITOBA ELECTRIC AND GAS LIGHT COMPANY.—A notice is issued by holders of one-fifth in value of the Debentures of this Company announcing that the trustees, under the trust deed of December 8, 1886, having made default in calling a meeting of the debenture holders, it has been decided that a meeting shall be held at the offices of Messrs. R. A. McLean, of 1, Queen Victoria-street, London, E.C., on Friday, the 18th inst., at 12 o'clock, for the purpose of passing resolutions to remove one of the trustees under the said trust deed, and to prescribe regulations for the future calling of meetings of the debenture holders. A large number of the Company's Debentures are held in this country.

NATIONAL TELEPHONE COMPANY (LIMITED).—The Directors of this Company recommend the payment of dividends for the half-year ended December 31st at the rate of 6 per cent. per annum (less income tax) on the amounts paid up on the First and Second Preference shares, at the rate of 5 per cent. per annum (less income tax) on the amounts paid up on the Third Preference shares, and at the rate of 6 per cent. per annum (free of income-tax) on the amounts paid up on the Ordinary Shares. £35,000 has been placed to reserve, and about £5,000 carried forward. The transfer books of the Preference and Ordinary shares of this Company are closed from the 7th to 20th inst., inclusive, preparatory to the payment of dividend for the half-year to December 31st.

TOWN AND VILLAGE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—This week a prospectus has been issued inviting subscriptions for 15,440 Ordinary shares of £5 each, payable £1 on application, £2 on allotment, and the balance in calls not exceeding £1 as may be required. The capital of the Company is £100,000 in 19,800 £5 Ordinary shares, and 1,000 £1 Founders' shares. 4,360 shares are to be allotted to the vendors in part payment of the purchase money, and the Founders' shares will not rank for dividend until 10 per cent. per annum has been paid on the Ordinary shares, after which they will be entitled to one-half of the profits. The Company has been formed for the purpose of acquiring certain letters patent for the United Kingdom, Germany, Austria, Canada, and the United States, from Messrs. G. J. and G. J. T. J. Parfitt, for an improved method of electric lighting in series and apparatus therefor, together with the freehold lands, plant, stock-in-trade and existing contracts of the Western Counties Electric Light and Power Syndicate, Limited. Our readers will find this system of electric lighting was described in our issue of May 10, 1895. The Directors of the new Company are: Messrs. T. H. Harrison, M.I.M.E., A.I.E.E. (London manager of Messrs. Davey, Paxman and Co.), E. B. A. James, John Lowles, M.P., W. Pierce and A. Thompson. Mr. G. J. T. J. Parfitt is electrical engineer-in-chief; the secretary is Mr. H. A. Tobias, and the offices are at 11, Queen Victoria-street, E.C. The list opened on Wednesday, and closed yesterday (Thursday) for town, and closes at noon to-day for the country.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—This Company's traffic receipts for the week ended January 31st, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,990.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half month ended January 31st are £3,007, against £2,747 in the corresponding period of 1895.

WESTERN UNION TELEGRAPH COMPANY.—Numbers are published of 13 bonds, six of £100 each and seven of £200 each, which were drawn on the 15th ult., for redemption on March 2nd next of the Company's Six per Cent. Sterling Loan. Messrs. Morton, Rose and Co. are agents for the loan.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Divi-dend.	Name	Previous Week's Price, Jan. 29.		Price Wednesday, Feb. 5.		Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending Feb. 1. Highest	Lowest
			TELEGRAPHS.								
£1,012,890	Stock	19/0	Anglo-American	47	49	47	49	4 11 10	Jan., Apr., July, Oct.	..	..
£2,993,560	Stock	20/0	Do. Preferred	87½	88½	88	89	5 10 0	" "	89½	87½
£2,993,560	Stock	5/0	Do. Deferred	7½	8	7½	8	..	" "	7⅞	7⅛
£178,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	100	104	100	104	3 17 1	January and July	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	9½	10½	9½	10½	..	..	..	..
180,000	£10	3/0	Brazilian Submarine	13½	13½	13⅝	14	5 7 2	Mar., June, Oct., Dec.	13½	13½
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110	114	110	114	4 8 1	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	160	170	160	170	4 2 4	Jan., Apr., July, Oct.	..	..
16,000	10	3/0	Cuba Submarine	13½	13⅝	12½	13⅝	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20⅝	21⅝	20⅝	21⅛	4 18 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	4	5	4	5	4 0 0	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10	10½	10	10½	4 5 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104½	107%	104½	107%	4 4 4	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877	8½	9	8⅝	9½	4 6 6	Jan., Apr., July, Oct.	..	..
400,000	10	2/6	Eastern	16½	17½	17	17⅝	3 14 4	" "	17⅝	16⅝
70,000	10	6%	Do. 6 per Cent. Preference	18	18½	18	18⅜	3 4 10	" "	18⅛	18
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	126	129	126	129	3 2 6	May and November	128⅛	128
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1892 xd	107	110	105	108	4 12 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17⅛	18	17⅛	18	3 17 9	Jan., Apr., July, Oct.	17⅝	17⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock xd	129	133	127	130	3 1 7	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	100	104	100	104	4 16 7	January and July	103½	101
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	100	104	100	104	4 16 7	" "	103	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) xd	107	110	105	108	3 4 1	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112%	115%	112%	115%	3 9 10	May and November	..	..
180,227	10	1/6	Globe Telegraph and Trust	9½	10⅛	10	10½	3 18 6	Jan., Apr., July, Oct.	10⅛	9½
180,042	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	" "	14½	16⅛
150,000	10	5/0	Great Northern	22	22½	22	22½	3 15 7	Jan., April, and July	22½	22
£18,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	104	107	104	107	4 15 0	March & September	104	..
17,000	25	12/6	Indo-European	46	49	46	49	5 2 0	May and November	47	..
37,513	10	..	London Platino-Brazilian	..	..	..	..	..	..	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	106	110	107	111	5 10 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	108	111	108	111	3 12 3	" "	..	..
11,839	8	4/0	Reuter's	4½	5½	4½	5½	..	April and October	4⅞	..
8,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	126	131	127	132	4 10 11	" "	130	129½
15,609	10	2/0	West African Telegraph	6½	6½	5½	6½	..	January and July	..	..
£333,300	100	5%	* Do. 5 per Cent. Debentures (red.)	101	104	101	104	4 18 0	March & September	103½	..
80,000	10	2/0	West Coast of America	1	2	1	2	..	January and July	..	..
£150,000	100	3%	Do. 3 per Cent. Debentures, 1902	94	99	94	99	3 3 4	June and December	..	..
33,321	10	1/3	West India and Panama	¾	1½	1	1½	..	..	1⅛	1
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½	11½	10⅜	11½	5 6 8	May and November	11	10⅛
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	9	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108	111	103	111	4 10 6	June and December	..	..
64,248	15	3/0	Western and Brazilian	9	9½	8⅝	9½	5 5 8	May and November	9½	9½
33,129	7½	5/0	Do. 5 per Cent. Cumulative Preferred	6½	6⅝	6⅝	6⅝	..	—	6⅝	6⅛
33,129	7½	1/6	Do. Deferred Ordinary	3	3½	3	3⅛	..	—	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910 xd	104	108	102	103	5 13 2	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910 xd	104	108	102	106	5 13 2	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	118	118	113	118	6 0 5	May and November	..	..
£164,800	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	102	105	102	105	5 17 8	March & September	..	..
			TELEPHONES.								
44,000	5	2/6	Chili Telephone (fully paid)	3½	3¾	3½	3⅞	..	—	—	—
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛	¼	⅛	¼	..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	⅛	¼	⅛	¼	..	Yearly	..	..
491,597	5	2/6	National	6⅛	6⅝	6⅝	6⅞	3 12 9	June and December	6⅞	6⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16	18	16	18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	16	17	13	17	3 10 7	" "	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6½	6⅞	6½	6⅞	4 8 11	—	6⅞	6⅝
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	104	107	101	107	3 10 8	January and July	106	105⅛
58,000	5	3/0	United River Plate	2½	3	2½	3⅛	..	" "	..	..
£146,788	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	90	95	93	93	5 2 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	5/0	City of London Electric Lighting (fully paid)	13½	14½	14	15	1 13 4	—	14	13⅜
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15½	16½	16	16½	3 12 9	—	16⅜	15⅛
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	134	138	134	138	3 12 9	June and December	..	..
19,990	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	—	..	..
£39,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½	5⅝	5½	5⅝	..	—	..	..
£57,400	£100	6%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	—	..	..
3,175	£8	..	County of London & Brush Prov. Ord (fully paid)	8	9	8	9	..	—	..	..
10,000	£10	9½d.	Do. Pref. (£8 paid)	10½	11	10½	11	..	—	..	..
8,322	£5	..	House-to-House Electric	..	..	..	..	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	—	—	—	—	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	..	..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞	8⅛	7⅞	8⅛	3 13 10	—	..	..
111,000	5	..	London Electric Supply	..	..	..	..	..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	11½	12½	11½	12⅛	3 12 0	—	12½	12⅛
131,000	Stock	4½%	* Do. 4½% Debs.	116	118	116	118	3 16 6	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½	9	8½	9	..	—	..	..
..	..	..	Rand Electric	¼	½ prem.	⅛	¼ prem	..	—	..	..
19,930	£5	2/0	St. James and Pall Mall	8½	9½	9	10	..	—	9½	9
20,000	£5	7%	Do. 7 per Cent. Preference	9	9½	9	9½	3 13 8	—	..	..
52,900	5	2/6	Westminster Electric Supply (fully paid)	8½	9½	9	9½	3 18 11	—	9½	9
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	2	1/6	Brush Electrical Engineering	1	1½	1	1½	12 1 0	—	1½	1½
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝	1⅞	1⅝	1⅞	6 8 0	—	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112	115	112	115	3 19 10	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2	2½	2	2½	..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1½	1⅝	1½	1⅝	..	..	..	..
£1,100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104	107	104	107	4 4 5	..	..	..
£10,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	—	—	—	—	..	..	..	..
110,000	2	..	Electric Construction	⅝	¾	⅝	¾	..	..	..	..
12,845	2	2/9½	Do. 7 per Cent. Cumulative Pref.	2	2½	2	2½	5 11 0	..	..	..
91,195	2	..	Elmore's Patent Copper Depositing	⅝	¾	¾	1	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	½	¾	½	¾	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	20½	21½	21½	23½	3 6 8	February & August	22½	21½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	102	104	103	103	4 7 5	March & September	..	..
15,995	£10	..	International Okonite Ordinary	..	..	..	..	..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	—	—	..	..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	½	¾	½	¾	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	44	46	44	46	5 4 5	March and July	46	45
£150,000	100	5%	* Do. 5 per Cent. Bonds	102	105	102	105	4 15 8	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	..	..	..	..	..	—	..	..
41,098	£5	..	Do. Preference (fully paid)	..	..	..	..	..	—	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	13½	14½	13½	14½	4 2 9	—	13	..
£30,000	10	7/0	Do. 7 per Cent. Preference	15½	16½	15½	16½	4 4 0	—	..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108	111	108	111	4 2 7	—	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1½%	City and South London Railway Con. Ordy. xd	40	42	40	41	2 16 6	May and Novembe	41	⅛
7,630	10	5%	Do. 5% Perpetual Preference xd	14½	15½	14½	15	3 6 8	" "	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130	132	130	132	3 0 7	May and Novembe	..	..
37,500	£10	2½%	Liverpool Overhead Railway	12⅝	12½	12⅝	12½	1 6 5	—	..	..
10,000	10	5%	Do. 5% Preference	15½	16	16	16½	3 1 6	—	..	..
145,000	Stock	4%	Do. 4% Debenture	113	114	113	114	3 10 2	January and July	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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THE ELECTRICIAN:

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NOTES.

ALTHOUGH, in view of the recent Conference at Westminster, the Board of Trade, when sending out copies of the new Electric Light Regulations to the various parties concerned, has not deemed it necessary to *invite* comments and amendments, the Regulations, until they are issued officially as Board of Trade bye-laws, so to speak, are not beyond reach of further revision if such can by any possibility be necessary after the ample discussion to which they have been subjected. Only two points appear to call for notice. When Regulation 23, relating to the mode of suspension of high-pressure overhead lines came up for discussion at the Conference, Mr. CROMPTON argued vigorously that hard-drawn copper wires were less likely to tumble down when suspended direct than when suspended from corrodible steel wires by means of leather thongs. This point, it was promised, should be carefully considered—it has not been conceded. When the Conference rose, it was understood that the point at which electric light undertakers were to cut off a consumer's supply or to refuse to connect up, was to be determined by a k/n law, n being the number of points for taking off current, k being a constant member of megohms, 75 being the favourite figure with the meeting. In the regulations as they now stand the cut-off point is defined as having been reached when the leakage current from wires and fittings exceeds "one ten-thousandth part of the maximum supply current to the premises." A somewhat different principle and a much lower standard.

AMID the hurly-burly caused by the almost daily discovery of X-rays, Y-rays, or Z-rays, with conflicting properties and puzzling characteristics, we are in some danger of forgetting our indebtedness to the original discoverers of the scientific field, the cultivation of which is to-day yielding results that have set the world of science agog with half-baked hypotheses, and have caused even the most sober-minded to become hopeful of the immediate solution of some of the fundamental enigmas of physics.

To the public science is "as tedious as a twice-told tale, vexing the dull ear of a drowsy man," unless it makes a discovery of obvious practical utility or one which is reducible to something concrete, like a shadow-picture of the human interior. Intensely interesting as the structure and deformities and diseases of the human hand must be to all of us, the thought that we may be on the brink of an experimental verification of the existence of longitudinal etherial vibrations within sight of a solution to the gravitation mystery, or about to extort from Nature the well-kept secret of the true nature of Electricity, renders the physicist temporarily oblivious to the exact condition and configuration of his phalanges or metacarpal bones. In view, therefore, of the grand scientific possibilities of X-rays and cathode-rays and the like, do not let us forget CROMWELL VARLEY, the prime discoverer in this great affair. Electrical engineers also should be especially mindful of the labours of CROOKES, who, as their President in 1891, treated his audience to probably the most fascinating Presidential Address of the five and twenty delivered since the foundation of the Institution of Electrical Engineers. Members who had the good fortune to hear that glowing discourse on "Electricity in Transitu: from Plenum to Vacuum," to see the molecule-mill revolve and to follow the speaker's triumphant disproof of HITTORF's and PULUJ's objections, are in no danger of imagining that the cathode ray species was born fully fledged in Continental laboratories. Those desirous of apportioning the credit where it is due will do well to read the extract from Lord KELVIN's 1893 Anniversary Address to the Royal Society, which we publish in another column. In this will be found not only references direct or indirect very nearly completing the history of all that has been done since the time of FARADAY in the investigation of the transmission of electricity through highly rarefied gases; but also a vaticination of the then President of the Royal Society, which, in the light of the RÖNTGEN rays, is most instructive reading: "If a first step towards understanding the relations between ether and ponderable matter is to be made, it seems to me that the most hopeful foundation for it is knowledge derived from experiments on electricity in high vacua. . . . ."

ON Wednesday morning we received a telegram from Prof. BORGMAN, of St. Petersburg University, which, on being interpreted, reads as follows:—

RÖNTGEN rays discharge rapidly positive electricity, slower negative. *At short distances they give negative electrification.* They increase spark-gap. Aluminium sheet does not hinder either action.

THE phenomenon of the discharge of negatively *and positively* electrified bodies by RÖNTGEN rays was pointed out in our columns last week by Prof. J. J. THOMSON and Prof.

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Oliver Lodge, and this week we publish a brief abstract of some experiments in the same direction by MM. Benoist and Hurmuzescu. The interest of Prof. Borgman's telegram lies, therefore, in his discovery that Röntgen rays, like cathode rays, negatively electrify bodies, that, like Hertzian waves, they increase the sparking distance for a given potential difference, and that they discharge positively electrified bodies more quickly than they do negatively-electrified ones; a statement, by the way, the direct contrary of that of MM. Benoist and Hurmuzescu.

The extent of the elevator industry in America, and, in consequence, its importance in providing a day load for hydraulic and electric supply stations, may be gathered from the fact that in New York there are no less than 5,000 elevators, and, as Mr. F. J. Sprague graphically puts it, "more people are carried vertically than there are horizontally." We are not quite so fond of the "lift" in this country as they seem to be in America. Nevertheless, in our largest cities there is quite a respectable amount of passenger and goods elevator work going on, which, if it could be wholly annexed by the electric supply concerns, would go a long way to fill up the annoying and expensive valleys in the load diagrams In London the hydraulic power stations had last year an aggregate capacity of 3,400 h.p., and at Manchester, Liverpool and Glasgow the amount of power was in each case 800 h.p. A Paper recently read by Mr. F. J. Sprague before the American Institute of Electrical Engineers, on "Electric Elevators," an abstract of which we publish this week, attempts to show that by comparison with the hydraulic elevator the electric elevator is superior. While not forgetting that comparisons which hold for the United States are not necessarily true for this country, it is to be regretted that Mr. Sprague has omitted to give any figures showing the actual relative costs of hydraulic and electric elevation. From the large amount of electric elevator work done in the States we gather that the comparison would be more favourable there than here. So far as London prices are concerned, Mr. E. B. Ellington (see *The Electrician*, Vol. XXXV., p. 485) has shown that in regard to works costs hydraulic power can be generated (by steam) at 25 per cent. less cost than electric power (also by steam). Comparison between the distribution expenses are difficult to make; but it has been shown that with hydraulic power supplied at 1s. 6d. per 1,000 gals.—the London price—a useful horse-power at the motor pulley will cost 3d. per hour. Possibly those electric supply concerns which charge only 3d. per unit for power in the daytime might rival this, if the motor were efficient and well loaded. But it will be evident that unless electric power is quite as cheap as this the superior efficiency of the electric motor, upon which M. Sprague lays so much stress, will not in this country suffice to beat the hydraulic elevator out of the field.

Recent research has thrown a good deal of light on the electrical origin of comet tails. These appendages of nebulous hydrocarbon are not a permanent possession of a comet, but, as has long been observed, are developed only when the comet is near perihelion. As the comet recedes from the sun the tail gradually condenses. Moreover, the axis of the tail is always extended radially away from the sun, giving evidence of what has been thought to be electrical repulsion. In a recent number of the *Astrophysical Journal* Prof. Fessenden suggests that the ultra-violet rays falling upon that side of the nucleus which is turned towards the sun cause negatively-charged particles to be emitted, the nucleus remaining positively charged. Researches by Prof. J. J. Thomson indicate that the solar chromosphere is negatively electrified; and the spectra of cometary tails, resembling as they do the candle spectrum, support the hypothesis of negatively electrified tails. There will, then, be four forces acting on the particles projected from the inner surface of the nucleus—namely, the solar electrical repulsion, the mutual electrical repulsion, the electrical attraction of the nucleus and gravitation. These forces will determine the form of the tail; and it would seem that all the special differences in comet structure are capable of explanation on this hypothesis. A solar potential of about 15,000 volts is apparently required.

Electric Mountain Railway in Austria.—The Austrian Government authorities have given permission for the preliminary work in connection with the proposed electric railway up the Schneekoppe, a mountain 5,320ft. high.

Oil Fuel in the Navy.—It is an interesting testimonial to the quick steam-raising and forcing powers of oil firing for boilers that the Admiralty have authorised its adoption in the "Gladiator," a cruiser which is now being built at Portsmouth.

Lord Kelvin's Jubilee.—Lord Kelvin reaches this year his jubilee as Professor of Natural Philosophy in the University of Glasgow. The event, says *Nature*, will be recognised by a joint celebration, in which the City, University, and students will take part, on June 15th and 16th.

Cable Interruptions and Repairs:—

	Date of Interruption.
Puerto Plata—Martinique	December 19, 1895
Perim—Obock	January 2, 1896
Odessa—Constantinople	January 17, 1896

Obituary.—The tragic death of Lieut. Swift, of the United States, is announced. He was considered one of the most expert telegraphers in the United States Army. One of his favourite achievements was to send a message with one hand while he wrote down a received message with the other. Another trick he would perform was to take a message from an instrument with one hand, while he copied another message with the other hand.

Amazon Telegraph Company.—This Company inform us that cable communication between Pará and Manaos, the capital of the province of Amazonas, has been successfully completed. Messages of congratulation have been exchanged between the Directorate in London and the Brazilian Government. The line is now open for messages between these two places, thus bringing Manaos in direct telegraph communication with Europe and the rest of the world.

Finsbury Technical College Conversazione.—The students of the Finsbury Technical College are holding their biennial conversazione on Thursday, February 20th, for which Prof. Silvanus Thompson has been induced to prepare a lecture on "Invisible Light and its Photography." The lighter portion of the programme consists of a concert and dance, while the whole of the College not used in the entertainment is to be given up to exhibits of model machinery, electrical appliances and chemical manufactures.

Niobium Filament Lamps.—Experiments are being carried on by Mr. J. W. Aylsworth, of Newark, N.J., on the manufacture of incandescent lamp filaments of niobium and other refractory rare metals. The method which he adopts consists in deposit-

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ing the metal on a carbon filament, the process being continued until a filament of the required thickness is produced. The deposition of the metal is brought about by incandescing the carbon filament in a bulb containing halogen compounds of the metal, a current of hydrogen being passed through at the same time, the salts being heated by a Bunsen burner.

Gas Engine Station for Block Lighting.—The following, says the *Gas World*, are the data of an electric station at Frankfort-on-the-Main, where a block of buildings is supplied with current from a 70-H.P. gas engine, without any of the costs of distribution to a distance. The lamps are about one to every 2½ square yards of ground area. Storage batteries are used. The number of lamps correspond to 2,200 16-c.p. lamps, of which 1,800 are at work simultaneously during business hours. The consumption is 490,000 ampere hours, corresponding to 445 hours per lamp. The costs are:—Gas, £424.; oil, &c., £52; water, £41.; storage battery insurance, £100; distilled water and sulphuric acid, £16; rent and charges, £80; wages, £160; repairs, &c., £22.; total, £895; or per 16-candle lamp per hour, 0.200d. The undertaking has paid 7½ per cent. after writing off depreciation, &c.

Errata.—In our editorial Note on p. 469, last week, on the Röntgen rays, the phrase "the photographic plate, in addition to being merely qualitative or at any rate directly quantitative," should have terminated instead with "at any rate *not* directly quantitative."——In the Note at the bottom of the first column on the same page, Prof. Michelson is made by the printer to end his "declamation" in an incoherent fashion, whereas what he really said was: "This their problem: to penetrate, as far as it is permitted to human reason, that mysterious whole we call matter, whose solar systems are molecules, whose worlds are atoms."——In Dr. Lodge's article in our last issue, on p. 472, line 5 from top, there also occurs an obvious misprint. The last sentence of the paragraph should read "Bells and plates of atomic size would vibrate at about the required pace —viz., 400 to 800 million *million* vibrations per second."

Royal Society.—The following Papers were down for reading yesterday:—Dr. J. N. Collie and Prof. Ramsay, F.R.S., "On the Behaviour of Argon and Helium when submitted to the Electric Discharge;" Lord Kelvin, F.R.S., "On the Generation of Longitudinal Waves in Ether;" Prof. J. J. Thomson, F.R.S., "On the Discharge of Electricity produced by the Röntgen Rays, and the Effects produced by these Rays on Dielectrics through which they pass."——The date fixed for the next "meeting for discussion" at the Royal Society is April 23rd, when the subject will be "Colour Photography," and the discussion will be opened by Prof. Lippmann.——The Bakerian Lecture will be delivered before the Royal Society on the 20th inst., the lecturer for the year being Prof. Roberts-Austen, and the subject, "The Diffusion of Metals." The Croonian Lecture will be given probably on March 12th, by Dr. A. D. Waller, who has chosen for his subject, "Electrical Changes in Isolated Nerve."

Gas Engine Central Station in Chicago.—The gas engine electric supply station in Chicago, of which we have previously given some particulars, is now in operation. The engines are double-acting and of English manufacture, their rated power being 80, 130 and 200 H.P. respectively. The largest engine is of the tandem 2-cylinder type, and all three are belted to the dynamos. The station is used for lighting six of the city blocks, and has a capacity of 4,000 lamps of 16 c.p. An interesting feature in this station is the use of natural gas for driving the engines, the gas being pipe-lined from Indiana gas fields, some 175 miles from Chicago. We may state that American natural gas has a very high thermal value, the gas having twice or more heating power than good coal of equal weight. About 30,000 cubic feet of the gas equals one ton of good coal. As compared with producer gas, natural gas is much cleaner in burning in a gas engine. This station should therefore develop some interesting and economical results.

Expiring Patents.—On Saturday next, the 15th inst., will expire patent No. 370, granted to C. A. Faure for "Improvements in Apparatus for Measuring and Registering Electric Currents." The claims are for—(1) Apparatus for measuring and registering an electric current, in which a conductor carrying the current rotates about a magnet, and controls another circuit in which is included an electromagnet, or like instrument, propelling a mechanical counter; and (2) apparatus for measuring electric currents, in which the current to be measured is caused to pass through the coils of an electromagnet, and through a conductor, which then revolves under the influence of the current and of the said magnet, overcoming the resistance of a fluid." On the same day will expire patent No. 740, granted to Solignac and Co., for "Improvements in electric lamps or regulators, and in generators for use therewith." One of the inventions claimed is the use of glass rods in an arc lamp, so arranged that by the gradual melting of the rods the carbons shall feed together at the proper rate.

The Filing of Trade Catalogues at the Patent Office.—In *The Electrician* of October 18, 1895, some correspondence appeared on this subject, and the attention of the London Chamber of Commerce was called to the matter. The following communications have passed between the London Chamber of Commerce and the Patent Office:—

To Sir Henry Reader Lack, Comptroller-General of Patents. January 27, 1896.

SIR: The attention of this Chamber has been called to the fact that the Librarian of the Patent Office of the United States of America is making a collection of illustrated and other trade catalogues, price lists, circulars and other similar publications for reference by those instituting inquiries in regard to patents, designs and trade marks, or making use of the Patent Office library. I am desired to say that in the opinion of this Chamber such a collection of records in your department would be exceedingly valuable, and am directed to bring the suggestion before the authorities of H.M. Patent Office as one which it would be well to adopt. By this means there would be permanently preserved an enormous amount of extremely useful material, which might on occasion elucidate the meaning of many trade terms and usages. If such a collection and filing were adopted by the Patent Office it would no doubt be extremely serviceable, and be largely resorted to by those interested in patents, designs and trade marks. I am desired to express the hope that this suggestion will receive the careful consideration of the authorities of H.M. Patent Office, and I shall be glad to learn their decision in the matter.

(Signed) KENRIC B. MURRAY (Secretary).

To the Secretary, the London Chamber of Commerce.

SIR: I beg to acknowledge the receipt of your letter of the 27th inst., suggesting, on behalf of the London Chamber of Commerce, that a collection of illustrated and other trade catalogues, price lists and similar publications should be made and filed in the Patent Office Library, and in reply to inform you that the nucleus of such a collection was formed some 20 years ago, and has since that date been gradually extended. In view, however, of the suggestion of the London Chamber of Commerce, I shall be happy to consider how far it may be possible to render this collection more complete and to make it more easily accessible for public reference.

(Signed) H. READER LACK (Comptroller-General).

German Glow Lamps.—Says the *Elektrotechnische Zeitschrift*, in its issue of February 6th, "We have received, from an authoritative source, a letter, in which allusion is made to the campaign which English lamp manufacturers have started against the German product in their technical journals:—

"What enormous damage has been done by the remarks of the Commission of the Association of Representatives of German Electric Supply Companies, appointed to draw up rules in connection with the supply of glow lamps, is shown by the advertisements now appearing in English technical journals, and which, in view of the existing wave of public feeling, will not fail of effect. Although this is not the place to go fully into the matter, it may be permitted to remark that the mischief to the industry would have been avoided had this important question been solved by the Verband Deutscher Elektrotechniker, or any other responsible body. May it be a lesson to all who are inclined to dispose light-heartedly of things which should be left to the judgment of those thoroughly acquainted with the matter! A not very important London company, consisting mostly of Germans, employs in the most audacious manner a literal translation of those remarks for the purpose of running down the German product in the eyes of their pseudo-countrymen."

The endeavours of English manufacturers to stifle German competition is comprehensible. Under the rule of a monopoly which was based on the very patents which the owners successfully fought in other countries, the price of lamps in England up to about a year ago could be kept at a height that was out of all proportion to the prime cost. This, without a doubt, has caused great difficulty in the development of the electric light in England. In Germany, under the influence of free competition, great progress was made in the manufacture of lamps, and after continuous improvement we have been successful in producing a lamp which in no respect is surpassed by any foreign make. Naturally, the importation of German lamps

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into England is inconvenient to the manufacturers there. The representatives of electricity works by the publication of their deliberations never dreamt of forging weapons which would be used against native products, as their remarks and observations did not apply in particular to German lamps, but to glow lamps in general; lamps imported from Austria, Holland, Sweden, &c. It was only intended to stimulate the drawing up of standard rules with regard to glow lamps. That the drawing up of such rules is best left in the hands of the Verband is pointed out in the letter quoted above, as in that body all interests are represented, from the combined action of which a useful result might be hoped for."

The Dolbear Patent for Hollow-Core Air-Dielectric Cables. Before the Judicial Committee of the Privy Council on Tuesday (present Lords Shand, Watson and Davey and Sir Richard Couch) motion was made to fix a day to hear the petition for the prolongation of Dolbear's Patent for IMPROVEMENTS IN ELECTRICAL CABLES, No. 1,368, of March 21, 1882. The Committee appointed March 18th as the day on which to take the case. The following is an abstract of this important patent :—

My invention relates to electrical cables and is designed to provide cables of greater efficiency than those heretofore constructed for the transmission of messages or signals. In electrical cables heretofore constructed the conductor is coated or covered with a non-conductor (which is usually a substance of high specific inductive capacity) and the amount of surface contact between the conductor and non-conductor is at its maximum or nearly so. The rapidity with which a cable may be worked depends upon the rate at which it may be charged or discharged, and this rate of charge and discharge depends upon the specific inductive capacity of the material used as a coating for the conducting wire of the cable and upon the extent of surface contact between the conductor and the non-conductor by which it is insulated, other things being equal; now according, to my invention I reduce this contact to a minimum; and thereby accelerate the working of the conductor. The best possible form of cable would be a non-conducting pipe or tube with the conducting wire held centrally in it, the outer surface of the wire being in contact with nothing but the air filling the pipe ; and the nearer the actual cable approximates to this ideal cable the better will be the result. I therefore construct my cable with a central conductor (of one or several strands) surrounded by a tube whose inner diameter is considerably greater than the outer diameter of the conductor. Around this is twisted in an open spiral, a cord of cotton or the like, preferably hard twisted. Its office is to prevent the collapse of the pipe by supporting it at intervals along its interior, and when the pipe is sufficiently strong I dispense with this spiral for there is obviously more surface contact between the conductor and the spiral than there would be between the conductor and the inner surface of the pipe were the spiral omitted. I find it advantageous to manufacture my improved cable as follows—that is to say, the conductor is composed of copper wires as usual, twisted into a strand. The cord is wound spirally around the conductor, as it is fed along by proper mechanism ; and the tube or pipe is formed of several thicknesses of paper rendered waterproof, and cemented by india-rubber cement to ensure strength and toughness after the spiral is put upon the conductor. The claim is :—In an electric cable the hollow core or tube *d* containing the conductor *a*, whose diameter is less than the inner diameter of the core *a* substantially as, and for the purpose described.

'Bus Bars and Cables in the Niagara Power House.—A detailed description of these is given in the *Electrical Engineer* of New York of November 20th. About 1,200ft. of cable has been used in carrying the current from the dynamos to the board, after test under 45,000 to 48,000 alternating volts. There are 427 copper wires in the cable, consisting of 61 strands laid up in reverse layers, each strand consisting of seven wires. Next to the strand of copper is a wall of rubber $\frac{1}{4}$in. thick, double-coated. Over this is wrapped absolutely pure rubber, imported from England and known as "cut sheet." Then come two wrappings of vulcanisable Para rubber ; over that a wrapping of "cut sheet," and on top of that two more rubber coats. It is then taped, covered with a substantial braid and vulcanised. This cable weighs just over 4lb. to the foot, of which 3lb. are copper and 1lb. is insulation. The Niagara 'bus bars are eight in number, and 50ft. 4in. long, each having 10 offsets. The bars are made up of five components. The centre and the intermediate components are seamless copper tubes made up by drawing a $\frac{1}{4}$in. tube over another of the same size, the wall being $\frac{1}{2}$in. thick. The end components are solid bars of copper $1\frac{1}{4}$in. thick. The diameters of these great 'bus bars are as follows: Centre component, 8ft. long, 3in. outside diameter, 2in. inside. Intermediate component, 8ft. 6in. long each (two of them), 2in. outside diameter, 1in. inside. The ends, solid (two of them), 10ft. 11in. long each, $1\frac{1}{4}$in. in diameter. These bars are screwed together, with a length of entrance of 10in., then thoroughly soldered, and the entire outside tinned. There are no corners or projections whatever. Each component has two offsets, consisting of split sleeves accurately fitted, screwed together with long-headed screws, the heads filed off flush, and finally soldered to the bar. The elbows, being the terminals of the cables, are taper-fitted to the ends of the offsets, and fastened with a counter-sunk screw. The entire system is then insulated by wrapping a perfectly pure rubber compound and pure rubber in alternate layers, building up a wall $\frac{4}{32}$in. in thickness ; then covered with thin rubber-covered cotton tape, and wrapped outside with a rubber-covered drill tape. The bars were vulcanised in a special apparatus. The effective pressure guaranteed on the cables is 10,000 volts alternating. The $\frac{1}{4}$in. wall when tested under water broke down at about 48,000 volts, and cables having a wall of $\frac{5}{16}$in. and $\frac{3}{8}$in. withstood a test of 52,000 volts, this being the extreme range of the testing apparatus, contact being kept on for one minute without effecting any perforation.

The Alternate-Current Transformer.—At the opening of his fourth and last Cantor lecture, Dr. Fleming continued the subject of transformer measurements. The Wheatstone bridge method was, he said, applicable to the measurement of the primary copper resistance (the secondary being short-circuited meanwhile to render the self-induction of the primary negligible). To measure the copper resistance of the secondary, on the other hand, the fall of potential method had to be used. As the temperature coefficient of the copper usually employed in transformer coils was about 0·4 per cent. per degree Centigrade, we can accurately determine the rise of temperature of a loaded transformer by ascertaining its cold and hot copper resistances. Having determined and plotted the *total* loss in a transformer at various loads, and its copper losses at these loads, we can deduce the hysteresis loss, since it is practically the difference between the ordinates of the curves of total and copper loss. The secondary drop of a loaded transformer, usually amounting to about three or four volts, due to magnetic leakage and the C R losses, was then discussed ; and a method of accurately measuring the same was described in which the indications of an electrostatic voltmeter were the actual dropped volts from which, after the C R losses had been deducted, the drop due to magnetic leakage could be deduced. Dr. Fleming then alluded to Mr. Mordey's ingenious method of detecting magnetic leakage by placing two thermometers, one mercury and one spirit, within the stray alternating field. As the former has eddy currents generated in it, and the latter not, the difference of the temperature indications of the two thermometers is a measure of the magnetic leakage. Magnetic leakage was, the lecturer pointed out, sometimes deliberately encouraged, as in the T.H. and Ferranti transformers, in which it is desired to obtain a constant current from a constant potential. Dr. Fleming then dealt with the time increase in the core loss of transformers, first pointed out by Mr. G. W. Partridge in *The Electrician* of December 7, 1894. The cause of this phenomenon was somewhat obscure, but it was shown by Mr. Mordey to be apparently due to the heating of the transformer rather than to any magnetic cause. He (the lecturer) had come across an instance in which the core loss had increased to four times its original value in a short time. The danger (due to electrical resonance) of suddenly switching transformers on to and off high-pressure circuits possessing appreciable inductance and capacity was then emphasised, and several instructive mechanical analogues were exhibited. The lecturer stated that almost all concentric cables he had tested had come out with a capacity of about one-third of a microfarad per mile. The specific inductive capacity of the impregnated paper used by the British Insulated Wire and other companies was about three, as compared with four for india-rubber. The distribution of alternate currents in thick conductors was then touched upon; with currents of about 100 ∽, solid copper conductors of more than $\frac{1}{4}$in. radius were useless. The lecturer concluded with an explanation of the utilisation of clock-face diagrams for the solution of alternate-current problems. The following formula for determining the condenser current in a circuit having a capacity C farads, and traversed by a current of frequency n, at a pressure V volts, was given amongst many others. Current $= C/10^6 \times V \times 2\pi n$.

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THEORY AND CALCULATIONS OF ASYNCHRONOUS ALTERNATE CURRENT MOTORS.

BY A. HEYLAND (BUDAPEST).

PART I.—POLYPHASE MOTORS.

I.—*Deduction of Theory*

This method of calculation is based upon the practical adaptations of certain peculiar results, at which the author arrived in submitting the phenomena of mutual induction to a graphical treatment. The research was published in the *Elektrotechnische Zeitschrift*, 1894, p. 561, No. 41. This graphical treatment of induction phenomena will prove particularly applicable to the purpose in all cases in which we have to deal with a considerable straying of the lines of force; for the method enables us to group the rather complex stray field phenomena in a very simple and lucid manner. As the action of polyphase motors is chiefly determined by these stray lines, the idea naturally suggested itself to base a method of predetermination upon such considerations. The attempt has proved quite successful. The relations between the various quantities—dimensions of iron, power factor, load limit, &c.—can clearly be established, and the calculations of the polyphase motor be expressed in a few simple formulæ.

A few introductory explanations. The *polyphase motor* has been treated as a *transformer with rotating field*. The exciting armature forms the inducing or primary circuit, the short-circuit armature the induced or secondary circuit. This parallel between motor and transformer is permissible, under the supposition that the total reaction of the polyphase currents produces a rotatory field of constant intensity. In that case we may substitute for the primary or secondary alternating cur-

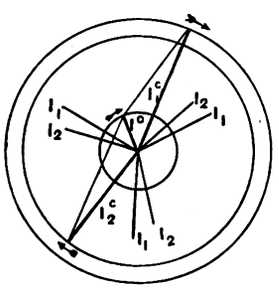

FIG. 1.

rents, whose amplitudes may be $I_1\ I_1\ I_1$ or $I_2\ I_2\ I_2$, equivalent continuous currents I_1^c or I_2^c, whose directions will revolve in the motor with the speed of the rotatory magnetic field (*see* Figs. 1 and 2).

The directions of $I_1\ I_1\ I_1$ and $I_2\ I_2\ I_2$ determine at the same time the positions of the primary and secondary coils, and hence also the relative positions of the two armatures. We recognise that the momentary positions of the two armatures do not influence the induction, since each of the two systems reacts upon the other like a uniform circuit. I_1^c and I_2^c then combine to form the magnetising current I^c, which produces the rotatory field. The velocity of the field we will call V, that of the short-circuit armature, which we assume to be the revolving part, v. Thus we gain a clear idea of the effects of electrical induction and mechanical rotation. As long as the armature is at rest, its coils, as well as the coils of the exciting armature, will be cut by the lines of force of the field with the velocity V. These lines will induce currents in the short-circuit armature, and impart a turning moment to it. The frequency of the induced currents in the armature is the same as in the primary circuit, which we will call p_1. When the armature yields to the turning moments with the velocity v, the armature coils will more and more recede from the lines of force, and they will only be cut with the velocity $V - v$.

The frequency of the armature currents will decrease. Let it become p_2, so that $\frac{p_2}{p_1} = \frac{V - v}{V}$. The E.M.F. in the armature will likewise decrease. As the resistance of the coils remains constant, the current relations will be the same as if we let the armature remain at rest, which would mean, let the motor act as a transformer, while increasing the armature resistance, this increase to be in the inverse ratio of p_2/p_1; that is to say, we add an external armature resistance which has the ratio $(p_1 - p_2)/p_2$ to the internal resistance. The internal losses will in both cases be the same. The mechanical work done by the motor under these conditions will be equal to the useful electrical work which a transformer of the same arrangement would perform in its external circuit.

These considerations demonstrate that, under the suppositions we have made, the polyphase motor may be regarded as a transformer. It may be interesting to point out in this place that the accuracy of the calculations in question does not, as might be assumed, depend upon the degree of approximation of the current curve to a sine curve. The accuracy is only influenced by the constancy of the combined effects of the polyphase currents in the motor.

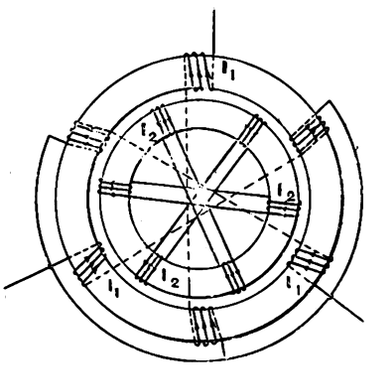

FIG. 2.

There is an essential difference between polyphase motors and our modern transformers. A well-built transformer with uniformly distributed coils has practically no self-induction in its several circuits. If we connected the primary and secondary coils, which we will suppose to be of equal number, opposed in series, they would behave like a bifilar resistance, and would not produce any phase difference in the circuit. This means that at full load, when the secondary ampere-turns of the transformer become almost equal to the primary ampere-turns, the phase shifting may practically be neglected as of no account. This circumstance renders transformer calculations very simple.

In the motor, the primary and secondary coils lie on separate armatures, with iron and air intervening. Hence there is

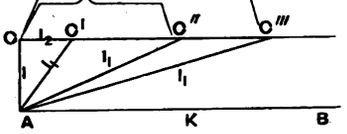

FIG. 6A.—Diagram for a Transformer without Stray Field, $\tau = 0$. (The Modern Transformer.)

self-induction in each single conductor, and the E.M.F. of this self-induction increases with the current intensity in both conductors. The result is that the phase difference between the secondary current I_2 and the E.M.F. grows continuously. The phase difference between the primary current I_1 and the P.D. at the terminals, K will at first decrease at a slower rate than in the case just mentioned; it will attain a *minimum*, and then rise rapidly.

For the modern transformer the current relations may, if we neglect hysteresis and Foucault currents, be represented in the well-known manner of Fig. 6A, lower down. I, the combined effect of I_1 and I_2, constitutes the magnetising current. At right angles to the magnetisation and the magnetising current lies the E.M.F., and, with sufficient accuracy for practical purposes, also the potential difference at the terminals, K. $I_2 = O C'$, $O C''$, $O C'''$ falls in the direction of the E.M.F., and, therefore,

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also perpendicular to I = A C. I_1 results then, for every load, as the hypothenuse of the right-angled triangle whose cathetes are I and I_2. Within the limits of constant magnetisation, the point C′ C″ C‴ . . . will therefore move in a horizontal line, parallel to the potential difference K = A B at the distance I.

For the polyphase motor, the difference of phase between I_2 and the E.M.F. increases owing to the stray field with the load, and the point C′ C″ C‴ moves on a curve which must turn upwards (Fig. 6B). In that figure C″ marks the minimum of phase difference between I_1 and the P.D. at the terminals K. The *minimum of phase difference* between the *primary current and the P.D. at the terminals* affords, however, as will be shown, a direct measure for the *quality and the suitability* of the polyphase motor. The first point to be discussed is the relation between this minimum and the dimensions of the motor.

The article alluded to in the first lines of this paper showed how the dependence of the variable electrical quantities of a transformer (polyphase motor), the amplitudes of the primary voltage, secondary E.M.F., and current intensity, and their phase differences, upon the change of load, can be represented diagrammatically. The primary difference of potential, whose amplitude and phase should be constant for all loads, is represented by the constant base of the diagram, while the diverse vectors mark amplitude and phase of the other quantities. A very simple law was established. *The extremities of these vectors, which are the movable corners of the diagram, describe circles when the loads of the transformer vary within the limits of constant permeability of the iron.* These diagrams

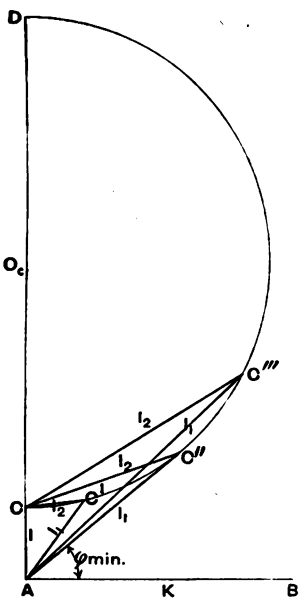

FIG. 6B.—Diagram for a Transformer with Stray Field, $\frac{A C}{C D} = (1+\tau)^2 - 1$.
(The Polyphase Motor.)

are reproduced in Figs. 3 and 4. The coefficients of induction, as used in the original deduction, have not been applied here as unsuitable for practical purposes. Nor have, for the present, the losses by hysteresis and Foucault currents been taken into consideration; these losses would exercise no influence upon the character of the diagram. In order to simplify the graphic treatment, the ratio of transformation has been assumed as 1 : 1. If any other ratio, $s_1 : s_2$, is to be employed, the secondary quantities have to be reduced with the help of the following coefficients:—

For the secondary current intensity, $\frac{s_1}{s_2}$,

" " tension and E.M.F., $\frac{s_2}{s_1}$,

" " resistance, $\frac{s_2^2}{s_1^2}$.

Fig. 3 represents a transformer without stray field, in which all the lines of force enclose primary and secondary coils. Approximately this illustration applies to the modern transformer. In Fig. 4 there is a stray field. Not all the lines of force enclose both coils uniformly; part of the lines enclose only primary, or only secondary coils. In Fig. 3:

K is the primary difference of potential at the terminals.
E the E.M.F., both of the primary and the secondary circuit, as the ratio of transformation is 1 : 1.
I_1 the intensity of the primary current.
I_2 the intensity of the secondary current.
I the combined effect of I_1 and I_2, *i.e.*, the magnetising current.
W_1 the primary resistance.
W_2 the secondary resistance.

In polyphase systems these same letters refer to one phase.

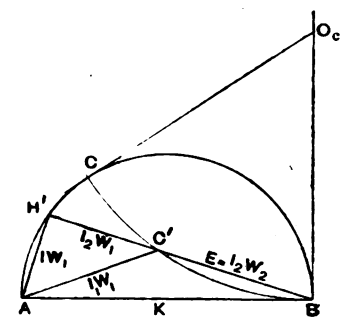

FIG. 3.—Diagram of the Relations between the Potential, the E.M.F., the Current and the Phase Difference in a Transformer without Stray Field. (The Modern Transformer.)

In the primary circuit the potential difference K = A B at the terminals is balanced by the back-electromotive force E = B C, and by the effect of resistance $I_1 W_1 = A C'$.

In the secondary circuit the current I_2 is opposite in direction to E, and $I_2 W_2 = E = B C'$.

If now B C′ is produced until it cuts the semicircle on A B in H′, the triangle A C′ H′ will indicate the directions of I_1, I_2 and I. I_1 lies in the direction of $A C' = I_1 W_1$; I_2 in the direction of C′ H′, the production of E; I in the direction of A H′, which is at right angles to B C′ = E, since the E.M.F. is perpendicular to the magnetisation. As now I is the resultant of I_1 and I_2, these three currents must correspond to a closed

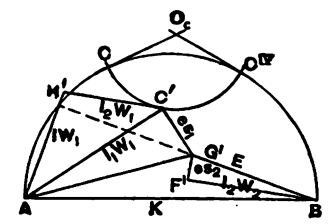

FIG. 4.—Diagram of the Relations between the Potential, the E.M.F. the Current and the Phase Difference in a Transformer with Stray Field. (The Polyphase Motor.)

triangle whose sides represent the three quantities in the ratio —A C′ : C′ H′ : A H′ = $I_1 : I_2 : I$.

As, further, A C′ = $I_1 W_1$, and
C′ H′ = $I_2 W_1$,
A H′ = $I W_1$,
we obtain A C′ = I_1 in the measure W_1,
C′ H′ = I_2 in the measure W_1,
A H′ = I in the measure W_1.

The diagram finally gives us the ratio

$$W_2 : W_1 = I_2 W_2 : I_2 W_1 = B C' : C' H'.$$

W_1 is constant, W_2 variable; hence the ratio $W_2 : W_1$ variable. When we alter this ratio—*i.e.*, when we change the load of the transformer—the shape of the diagram will also change, and it has already been demonstrated that, within the limits of constant permeability, the points C′ and H′ will move uniformly on the inscribed circles. The limit signifies, as long as the magnetisation, and therefore also the E.M.F., remain proportional to the magnetising current, or as long as the ratio E : I :: B C′ : A H′ is constant.

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C′ and H′ coincide at C, when I_2 becomes = 0, and $W_2 = \infty$.

The triangle A B C is the diagram of open transformers.

At B, W_2 becomes = 0; $I_2 = I_1$, that is to say: For the theoretical case $W_2 = 0$, the diagram is reduced to the straight line A B, with which $I_2 W_1$ and $I_1 W_1$ coincide.

The points C and B lie on a semicircle described on A B as diameter. The centre of the circle on which C′ moves is determined as intersection of the tangents to the semicircle drawn at B and C.

In Fig. 4 we find the same quantities as in Fig. 3, and besides those due to the stray field—the E.M.F. of self-induction of the primary circuit e_{s_1}, and of the secondary circuit e_{s_2};

e_{s_1} is at right angles to I_1 and causes I_1 to lag behind the resultant of K and E;

e_{s_2} is at right angles to I_2 and keeps it behind E.

This type of graphic representation is well known.

The triangle A C′ H′ again represents the three currents I_1, I_2, I, and we have

$$I_1 W_1 = A C'$$
$$I_2 W_1 = C' H'$$
$$B F' = (I_2 W_2)$$
$$I W_1 = A H' \text{ (perpendicular to E)}.$$

The corners F′ G′ C′ H′ of this diagram likewise describe circles within the limits of constant permeability, as has also been demonstrated in the article in the *Elektrotechnische Zeitschrift*. This paper confines itself to the circle which is the locus of C′. The loci of F′ G′ H′ have not been marked. The C′ circle is determined similarly as before in Fig. 3. The circle cuts the semicircle on A B in two points, C and $C^{IV.}$ (Fig. 4A), so that triangle A B C is the diagram for $W_2 = \infty$, *i.e.*, of the transformer without load. Triangle A B $C^{IV.}$ depicts the theoretical case $W_2 = 0$. The centre of the circle

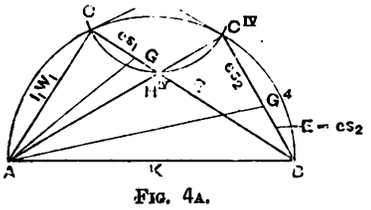

FIG. 4A.

is again the intersection of tangents drawn to the semicircle on A B at the points C and $C^{IV.}$. In the just mentioned case, $W_2 = \infty$, when the triangle A B C is the diagram, we have $I_2 = 0$; $I_2 W_1$ and I W_1 coincide with A C, *i.e.*, $I = I_1$; the E.M.F. E, at right angles to I, and the self-induction e_{s_1} at right angles to I_1, coincide likewise as regards direction; and it results,

$$B C = B G + G C = E + e_{s_1}.$$

In the diagram, triangle A B $C^{IV.}$, W_2 is = 0, therefore $I_2 W_2 = 0$. We see, now, from Fig. 4, that in triangle B E′ G′, e_{s_1} and E must coincide, whilst the infinitely small line $I_2 W_2$ would be perpendicular to e_{s_2}; E falls in the direction perpendicular to $I_1 W_1$ and I W_1, and hence also $I_2 W_1$ in the direction of $I_1 W_1$ and I W_1; e_{s_1} is at right angles to $I_1 W_1$, and has the direction of e_{s_2} and E. The current triangle is hence reduced to the straight line A $H^{IV.}$ C^{IV}, and

$$A C^{IV.} = I_1 W_1,$$
$$C^{IV.} H^{IV.} = I_2 W_1,$$
$$A H^{IV.} = I W_1,$$

while the electromotive forces would be indicated by the line B $C^{IV.}$, which forms the other side of the triangle A B $C^{IV.}$. Here we have

$$B G^{IV.} = E = e_{s_2};$$
$$G^{IV.} C^{IV.} = e_{s_1}.$$

There is a simple connection between the triangles A B C and A B $C^{IV.}$.

The magnetising current generates the main magnetic field, which we will designate by H. Each of the currents I_1 and I_2 generates a number of stray fields, which we summarise as the primary stray field h_1, and the secondary stray field h_2. We know that E is proportional to H, e_{s_1} proportional to h_1, and e_{s_2} to h_2, or

$$E : e_{s_1} : e_{s_2} = H : h_1 : h_2 \quad . \quad . \quad . \quad . \quad (1)$$

For constant permeability we have further: H varies proportionally to I, h_1 to I_1, and h_2 to I_2. The fields H_1, h_1, h_2 are not as the currents I, I_1, I_2; we have to consider the magnetic resistances of the various fields before we can settle their mutual relations. We may write

$$H : h_1 : h_2 = I : \tau_1 I_1 : \tau_2 I_2, \quad . \quad . \quad . \quad (2)$$

where τ_1 and τ_2 remain constant for constant permeability, and may be ascertained from the dimensions of the iron, &c.; lower down, when we come to the practical part, the τ will be further defined. Equation (2) gives

$$\frac{h_1}{H} = \tau_1 \frac{I_1}{I} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3A)$$

$$\frac{h_2}{H} = \tau_2 \frac{I_2}{I}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (3B)$$

Further, from (1)

$$\frac{e_{s_1}}{E} = \tau_1 \frac{I_1}{I}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (4A)$$

$$\frac{e_{s_2}}{E} = \tau_2 \frac{I_2}{I}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (4B)$$

or

$$\frac{e_{s_1}}{I_1} = \tau_1 \frac{E}{I}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (5A)$$

$$\frac{e_{s_2}}{I_2} = \tau_2 \frac{E}{I}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5B)$$

Now in $\triangle$ A B C

$$\frac{B C}{A C} = \frac{B G}{A C} + \frac{G C}{A C} = \frac{E}{I_1 W_1} + \frac{e_{s_1}}{I_1 W_1};$$

but $I_1 = I = A C$,

hence:
$$\frac{B C}{A C} = \frac{E}{I W_1} + \frac{e_{s_1}}{I_1 W} = \frac{E}{I W_1} + \tau_1 \frac{E}{I W_1},$$
$$\frac{B C}{A C} = \frac{E}{I W_1}(1 + \tau_1).$$

Secondly, in triangle A B $C^{IV.}$

$$\frac{B C^{IV.}}{A C^{IV.}} = \frac{B G^{IV.}}{A C^{IV.}} + \frac{G^{IV.} C^{IV.}}{A C^{IV.}} = \frac{E}{I_1 W_1} + \frac{e_{s_1}}{I_1 W_1}.$$

As now here $E = e_{s_2}$, it follows from (4B) that

$$\tau_2 \frac{I_2}{I} = \frac{e_{s_2}}{E} = 1, \text{ and } I_2 = \frac{I}{\tau_2},$$

Further,
$$I_1 = I + I_2$$
$$I_1 = I + \frac{I}{\tau_2} = I\left(1 + \frac{1}{\tau_2}\right).$$

Substituting,

$$\frac{B C^{IV.}}{A C^{IV.}} = \frac{E}{I W_1 \left(1 + \frac{1}{\tau_2}\right)} + \frac{e_{s_1}}{I_1 W_1} = \frac{E}{I W_1}\left(\frac{1}{1 + \frac{1}{\tau_2}} + \tau_1\right);$$

$$\frac{B C^{IV.}}{A C^{IV.}} = \frac{E}{I W_1}\left(\frac{\tau_2}{1 + \tau_2} + \tau_1\right).$$

By dividing we obtain an equation containing the four quantities:—

$$\frac{\frac{B C^{IV.}}{A C^{IV.}}}{\frac{B C}{A C}} = \frac{\frac{\tau_2}{1 + \tau_2} + \tau_1}{1 + \tau_1} = \frac{\tau_1 + \tau_2 + \tau_1 \tau_2}{1 + \tau_1 + \tau_2 + \tau_1 \tau_2}. \quad . \quad . \quad (6$$

We shall see that τ_1 and τ_2 are very small fractions; we may hence replace them by τ, as defined by the equation

$$\tau = \frac{\tau_1 + \tau_2}{2}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

We then obtain finally

$$\frac{\frac{B C^{IV.}}{A C^{IV.}}}{\frac{B C}{A C}} = \frac{2\tau + \tau^2}{1 + 2\tau + \tau^2} = \frac{(1 + \tau)^2 - 1}{(1 + \tau)^2}. \quad . \quad . \quad (8)$$

II.—*Practical Application of the Deduction.*

By applying in practice the formulæ deduced we can deal with polyphase motor problems in the same simple manner in which Kapp's graphic method solves transformer problems. A few lines suffice to depict the current relations.

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The magnetisation is kept low in practice; the internal resistances W_1 and W_2 are also chosen as small as possible. The line A C (Fig. 4A), which represents the magnetising current as expressed in W_1, will hence be short compared to A B = K, and the point C will fall close to A. We may, therefore, regard A C as at right angles to A B, and the tangent at C, which contains the centre of the circle O_c, may also be considered as a perpendicular; thus C O_c at right angles to A B. This has been done in Fig. 5.

Under these conditions, point $C^{IV.}$ will shift considerably to the left. We now produce B $C^{IV.}$ and C O_c until they intersect at D. The circle described about O_c as centre will pass through D, C D being a diameter. We have then

$$\frac{A'B}{AD}=\frac{BC^{IV.}}{AC^{IV.}}, \text{ and } \frac{AB}{AC}=\frac{BC}{AC};$$

further, from (8),

$$\frac{AC}{AD}=\frac{\frac{AB}{AD}}{\frac{AB}{AC}}=\frac{\frac{BC^{IV.}}{AC^{IV.}}}{\frac{BC}{AC}}=\frac{(1+\tau)^2-1}{(1+\tau)^2},$$

and

$$\frac{AC}{CD}=(1+\tau)^2-1. \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Equation (9) signifies: The ratio between the *diameter* C D and the *magnetising current* I is determined by τ. Fig. 6B

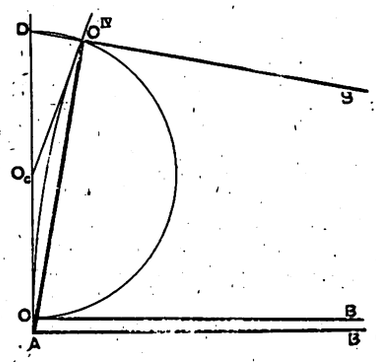

Fig. 5.

contains the essential parts of the diagram. The primary tension K falls in the horizontal; at right angles to it, the magnetising current I = A C, and the diameter of the circle C D. The latter results, as I = A C, from

$$CD=\frac{AC}{(1+\tau)^2-1}.$$

The influence of the stray fields we recognise by comparing this figure with a Kapp diagram, Fig. 6A. In this figure the magnetising current I = A C has been assumed as constant. The E.M.F., and practically also the P.D., at the terminals K, indicated by the base A B, will be at right angles to A C. I_2 = C′ C, C″ C, C‴ C . . . falls in the direction of the E.M.F., and I_1 results as hypothenuse A C′, A C″, A C‴ of the right-angled triangle whose sides are I and I_2.

With continuously growing I_2, the difference of phase between I_1 and K will soon become very slight.

In Fig. 6B, A C = I again stands for the magnetising current at no load. For heavier loads this current would change its direction, but this circumstance little concerns the present considerations.

With increasing I_2 the lag of I_2 will increase, and the points C′ C″ C‴ . . . will travel further upwards, moving the circle just constructed. The first case (Fig. 6A) may directly be deduced from the second case (Fig. 6B). In the first case we have no stray fields, h_1 and h_2, and τ becomes zero, so that the diameter $CD=\frac{AC}{2\tau}=\infty$. The circle passes into the straight line C C′ C″ . . . parallel to A B (Fig. 6A). The diagram (Fig. 6B) hence demonstrates how the difference of phase between the current intensities and the P.D. varies with the load, owing to the magnetic leakage. The lag of I_2 continues to increase with increasing load.

* τ^2 being very small, therefore $(1+\tau)^2=1+2\tau$ and $CD=\frac{AC}{2\tau}$.

The difference of phase ϕ between I_1 and K is the angle C′ A B, C″ A B . . . We recognise that ϕ diminishes at first, but less rapidly than it would do without any leakage; it then attains its minimum at C″, rapidly to increase again afterwards.

The work done upon each of the m primary circuits is K . $I_1 \cos\phi$; the total energy absorbed by the motor is the total work done upon these circuits, $A_1 = m \,.\, K \,.\, I_1 \cos\phi$. This $\cos\phi$ is known as the power factor. $I_1 \cos\phi$ represents that portion of the current which coincides with the P.D., and does work; it is the useful current. The other component $I_1 \sin\phi$ does not perform work. The relation between these quantities is expressed by $\cos\phi=\frac{\text{useful current}}{I_1}$.

As a rule it will be advisable to choose the *normal load* so that the ratio $\frac{\text{work done}}{I_1}$ is a maximum, when $\frac{I_1\cos\phi}{I_1}=\cos\phi$ itself will be a maximum. For this case, ϕ is a minimum The condition is fulfilled in Fig. 6B for ϕ = C″ A B when C″ A is tangent to the circle. We will designate the maximum power factor by $\cos(\phi_{min})=(\cos\phi)_{max}=f$.

(To be continued.)

HIGH-PRESSURE PROTECTED-CONTACT SWITCH.

In the course of one of his recent Cantor lectures Dr. Fleming exhibited a varied assortment of high-pressure switches and fuses, and amongst others a double-pole, high-pressure, "protected-contact" switch, made by the British Thomson-Houston Company.

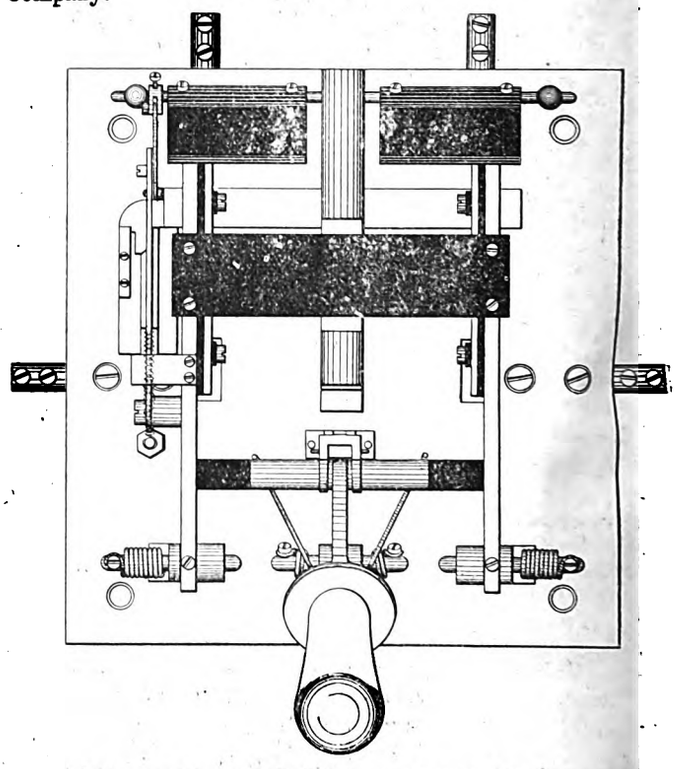

Fig. 1.—Thomson-Houston High-Pressure Protected-Contact Switch. Front view, with circuit-closed.

A front elevation of the switch with circuit closed is given in Fig. 1, and a side elevation with circuit opened in Fig. 2. The base of the switch is a block of marble about 10in. square and 1in. thick. The two conductors, it will be seen from Fig. 1, are led in on either side to bare screw-terminals, and out at the top. The two arms of the switch are 7½in. long, and 5½in. apart, insulation being afforded by two 1in. lengths of vulcanite. The two lower jaws of the switch are protected from accidental cross contacts when the switch is open by the switch frame itself, and by the interposition of a wall of marble (*see* Fig. 2) 1in. high and ⅝in. thick. The two top jaws are similarly separated, but to still further ensure freedom from accidental cross contact they are covered by vulcanite

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shutters or shields 2½in. by 1½in. by ¼in. thick, lined with mica. These two shutters are fastened on to a common spindle actuated by a brass piece movable around a projection on the side of one of the arms of the switch (*see* Fig. 2). This brass piece slides, as the switch is depressed, in a slotted carriage until it comes in contact with an end stop; as the switch is still further depressed this carriage is pushed along against the backward pull of a powerful spring, rotating the shutter spindle by means of a bell-crank lever, and raising the shutters. At the moment the circuit is closed, a stud on the brass piece is released from under a cam, the brass piece rides up over the end of the sliding carriage, this is immediately pulled back by the spiral spring, and the shutters are pulled down onto the top of the switch arms. On depressing the handle and raising the switch arms free from the shutters, these are immediately pulled further down by the spiral spring, this time covering right over the contact jaws sunk in the base beneath.

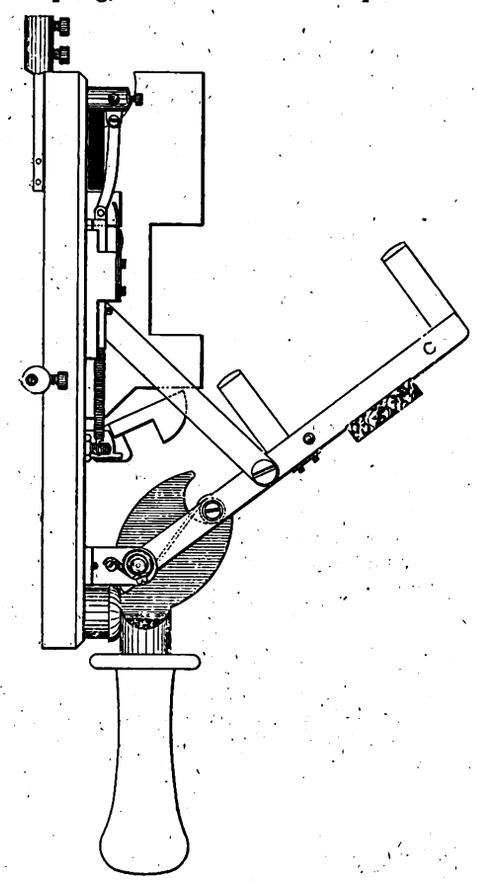

FIG. 2.—Thomson-Houston Switch. Side Elevation, Circuit opened.

THE REICHSANSTALT STANDARD WIRE RESISTANCES.*

BY K. FEUSSNER AND ST. LINDECK.

In 1888 investigations were commenced in the electrotechnical laboratory of the Reichsanstalt, with the object of constructing almost invariable standards of resistances suitable for practical use, and to obtain a surer foundation for electrical measurements of precision.

Upon this investigation many communications from the Reichsanstalt have been published.† In the *Wissenschaftl. Abhandl. der Reichsanstalt*, 2, S. 503 (Julius Springer, Berlin, 1895) is a comprehensive account of this research, from which the following is abstracted. For an account of the investigations upon "Metals for Standard Resistances," and the communication on the "Permanence of Wire Resistances," the original Papers must be referred to.

I.—THE CONSTRUCTION OF THE STANDARD RESISTANCES.

The standard resistances are intended in the first place for the standardisation and checking of other resistances. For this purpose the Reichsanstalt has constructed a series of single resistances which range from 0·0001 ohm, with a number of intermediate values, to 10,000 ohms. In addition to check measurements they are intended to serve other purposes, as, for example, ratios for Wheatstone's bridge, or as resistances for current measurement by the potentiometer. For the latter purposes there are particular forms of resistances, the so-called ratio coils (*see* below) and the large main resistances.* In the present communication the standard resistances of 0·1 ohm and upwards only are considered, which are constructed of wire. For the lower standard resistances a new form has recently been devised in which a number of thin plates, preferably of manganin, are used as the main resistance. A full description of these latter resistances will be given when greater experience has been obtained with the new forms.

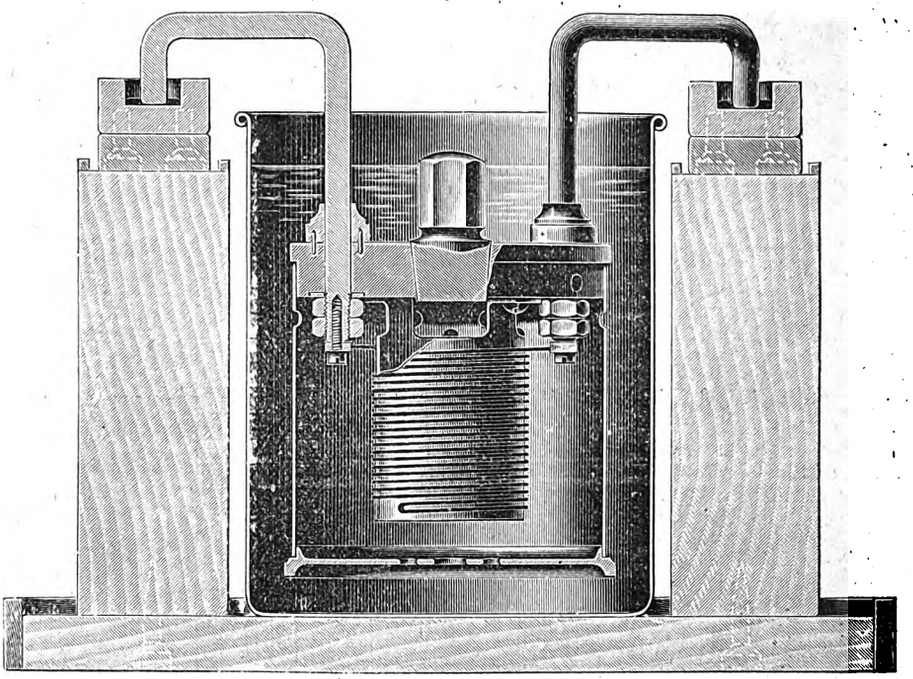

FIG. 1.—Reichsanstalt Standard Wire Resistance. Sectional Elevation.

Fig. 1 shows a standard resistance coil of 1 ohm, which is immersed in a paraffin oil bath in the usual manner. It hangs by the two leads from the mercury cups, and swings freely in the bath, so that the paraffin oil has free entrance on all sides. For the circulation of the liquid, the top, bottom and sides are perforated. The resistance wire, for reasons which are discussed in the original article, is, as a rule, of manganin. It is wound on a brass cylinder 4cm. in diameter in a single bifilar layer. For the 0·1 ohm standard a second wire having one-tenth of the section and ten times the length is joined in parallel with the main wire. This is for the purpose of enabling the value of the resistance to be more easily and accurately adjusted. The main wire is made approximately 1 per cent. higher than the final value of the resistance. An alteration of 1 metre in the length of the shunt is equivalent to one of 1mm. in the main wire.

For the connection of the ends of the coil with the leads the main wire is silver-soldered to the side of small square copper washers. These washers are screwed to the ends of the leads. The contact surfaces, having been previously tinned, are raised to the melting temperature by a soldering iron, while the screw is tightened up. This is the only connection which has been found sufficiently good for wires of less than four or five metres in length. If the wire is soldered directly to the copper leads, in course of time a marked alteration of the resistance results, as the solder alters its structure, and small crevices are formed round the soldered wire, which increase its working length. By this method of connection the advantage is secured that the resistance coil can be removed from the apparatus without destroying the adjustment.

The two terminals forming the working ends of the resistance lie in the copper blocks on each side underneath the bottom of

* "Die Elektrischen Normal-Drahtwiderstände der Physikalisch Technischen Reichsanstalt." Mittheilung aus der Physikalisch Technischen Reichsanstalt. *Zeitschrift für Instrumentenkunde*, Nov. and Dec., 1895.

† Dr. K. Feussner and Dr. St. Lindeck: "Metalllegirungen für elektrische Widerstände," *Zeitschr.-f-Instr.*, 9, S. 233, 1889; Dr. St. Lindeck: *Tageblatt der Naturforscher-Versammlung*, Heidelberg, 1889, S. 726; Dr. K. Feussner: "Die Konstruktion der elektrischen Normalwiderstände d. P. T. R.," — 10, S. 6 and S. 425,1890; K. Feussner: "Ueber den Leitungswiderstand der Legirungen von Nickel und Kupfer," *Verh. der Physik. Gesellsch. zu Berlin*, 1892, S. 109; K. Feussner: "Neue Materialien für elektrische Messwiderstände," *Elektrotechn. Zeitschr.*, 13, S. 99, 1892; Dr. St. Lindeck: Report of the Electrical Standards Comm. British Ass., 1892, Appendix IV.

* *See* the *Zeitschrift für Instrumentenkunde*, 10, S. 425, 1890

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the mercury cups, in which the leads stand. To the resistance of the manganin wire, therefore, is added that of the two copper leads and of the mercury contacts. The latter is made very small, since the flat ends of the leads stand on the flat bottoms of the mercury cups. If these parts are well made and amalgamated, the variation of the contact resistance, on account of its small value, may be neglected. The resistance of the two leads together in the case of the 0·1-ohm coils is about 70, and for the 1-ohm coils about 140 microhms, and is in consequence so small that it does not sensibly affect the temperature coefficient of the whole apparatus; nor, when differences of temperature exist between the coil and the leads, do they appreciably affect the total resistance.

To prepare the resistance bobbin for the wire the ebonite cover is removed, and the bobbin covered with shellaced silk tape, and dried at 140°C. Then the double-white-silk-covered wire is wound doubled on itself, tied with silk thread, and covered with shellac varnish. The coil is then heated in a drying oven for 10 hours, at a temperature of 140°C. The shellac covering protects the wire during heating and in subsequent use, so well that no perceptible oxidation ensues. It also serves to hold the wire fast on the bobbin, so that no alteration of position can take place. From the long-continued heating the shellac becomes hard even at high temperatures. The insulation between wire and bobbin is of the order of one million megohms. In order to attain this high insulation, and at the same time to prevent the occurrence of polarisation effects, the wire should not be touched by hand while winding, but should be allowed to run through a clean cloth. The heating also eliminates the alteration of the specific resistance with time. In order to achieve this result most easily it is also important that

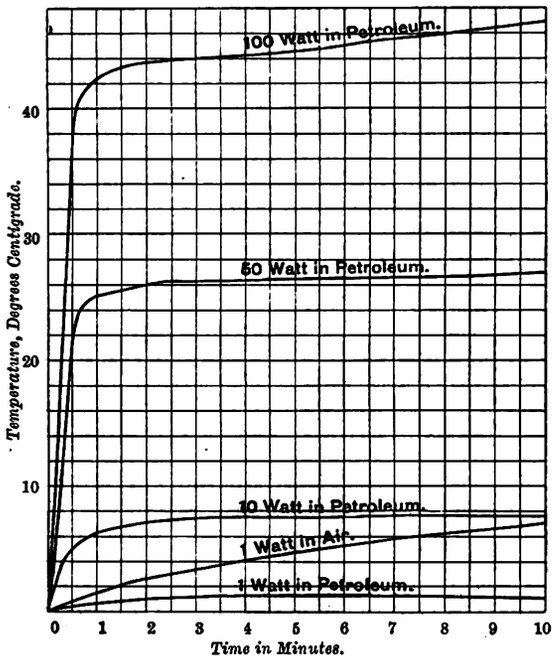

FIG. 2.

the wire should only be wound on cylinders having fairly large diameter. Obviously all unnecessary bending of the wire either before or during winding is to be avoided. It also appears advisable, for the same reason, that no very thick wire should be employed, but preferably that two or more wires in parallel should be used. Finally, an important consideration in the construction is that the apparatus should be so designed as to be capable of dissipating a large amount of electrical work in heat. The greater this is, the greater the range of use of the apparatus, and also the greater is the accuracy of the measurements.

The energy dissipated from the apparatus per second is expressed by the formula

$$Q = 0{\cdot}24\, J^2\omega \text{ cal} = (t_1 - t_2)\, F\, E,$$

where t_1 is the temperature of the wire, t_2 that of the surrounding medium, F the surface of the winding, and E the heat in calories dissipated per square centimetre surface per second per 1°C. difference of temperature. Our object is to secure a moderate heating of the wire for considerable values of Q. The surface F is therefore made as large as the dimensions of the whole apparatus will admit. We have a cylinder 4cm. diameter, with a wound length of about 4cm., making altogether about 100 sq. cm. radiating surface. It is therefore obvious why only one layer of wire is used; thus all parts of it are equally exposed to the surface, and can give off their heat. In order that the cooling of the surface should be great it is surrounded by an insulating mobile liquid. The best liquid for the purpose appears to be petroleum, since it is highly insulating, does not attack metal when pure, and leaves the shellac almost unaffected. Its large expansion with temperature ensures a good circulation from the coil round the whole bath. In order to assist this circulation, a fan is revolved in the bath, and a cooling worm can also be introduced to keep down the temperature.

A series of observations were made to determine the effect of these methods of cooling and to find a value for the quantity E under different conditions. The temperature of the wires was determined by a thermo-electric junction, while various currents were passed through the apparatus and the amount of cooling was varied. A standard resistance of 1 ohm, such as the one shown in Fig. 1, was immersed in a paraffin oil bath, 11cm. broad and 48cm. long, filled with liquid to a depth of 12cm., and provided with a fan fixed in the above manner. To one of the middle windings a copper wire and a constantan wire of 0·3mm. diameter were soldered. These wires rested on almost the same section main wire, were silk covered and enclosed in an ebonite *tube* of 1mm. diameter, which reached almost to the soldered joints, to prevent cooling. The copper wire was connected to a galvanometer, and from this a similar wire was joined to the end of the constantan wire coming from the coil. This second thermo-electric junction was immersed in a special petroleum both, the temperature of which was taken by a sensitive thermometer. Before each set of observations the galvanometer deflection given by a known difference of temperature between the two junctions was determined. Then various currents were passed through the coil so that 1, 10, 50 and 100 watts were dissipated by the instrument. The galvanometer deflections were observed every minute. The current in the resistances could be quickly reversed by a mercury commutator in order to eliminate the influence of the drop of potential in the main wire by observations with both directions of the current. In our apparatus the position of the thermo-electric couple was accidentally such that reversing the current produced no sensible effect.

The principal measurements* are shown in the curves (Fig. 2) and the corresponding Table I.

The curves show the variation of the temperature of the wire with time, for different expenditures of energy in the resistance. For large currents a constant temperature is reached in about 1min.; for smaller heating, and especially in air, a much greater time ($\frac{1}{2}$ to 1 hour) is required.

In Table I. W denotes the power expended, d the difference of temperature between the wire and liquid, and λ the calculated radiation per square centimetre per 1°C. temperature difference.

The resistance used in the investigations was constructed as shown in Fig. 1 (except that the diameter of the case was 70mm. instead of 85mm., as in the form shown), and was perforated in the same way with 5mm. holes in the bottom and sides. The fan in the bath was not rotated during the observations given above, as when moved the results were inconsistent. The increase of cooling when the fan *was* rotated was not great, sometimes even a decrease was observed. This is accounted for by the large coefficient of expansion of the paraffin oil, which causes hot streams of liquid to rise and escape by the holes in the cover, while the fan causes irregular currents. In any case, care must be taken that the current in the fan tube is directed downwards. But even then the cooling may be less rapid with the fan than without.

TABLE I.

W.	d.	λ
In air 1 watt	9·5°C.	0·00034
In paraffin 1 „	1·1°C.	0·0022
Do. 10 „	6·7°C.	0·0035
Do. 50 „	25·0°C.	0·0048
Do. 100 „	44·0°C.	0·0055

The casing of the apparatus is found to have considerable influence on the heating of the wire, since it opposes the motion of the air or liquid. Investigations were therefore made firstly without case, secondly with perforated, and thirdly with closed case. The following temperatures were observed:—

TABLE II.

—	Temperature in air after 30min.	Temperature in petroleum.	
	1 watt.	10 watts.	50 watts.
Without case	5·5°	6·5°	23·3°
With perforated case ...	9·5°	6·7°	25·0°
With closed case..... ...	12·7°	8·2°	32·8°

It is thus seen that the perforated case only alters the temperature of the wire by a small percentage, while a closed case causes a 30 to 40 per cent. greater rise in the temperature.

From column 3, Table I., it is seen that λ is not constant in petroleum (*i.e.*, the radiation from the surface is not proportional

* The investigation is given due to Herr Krannhals.

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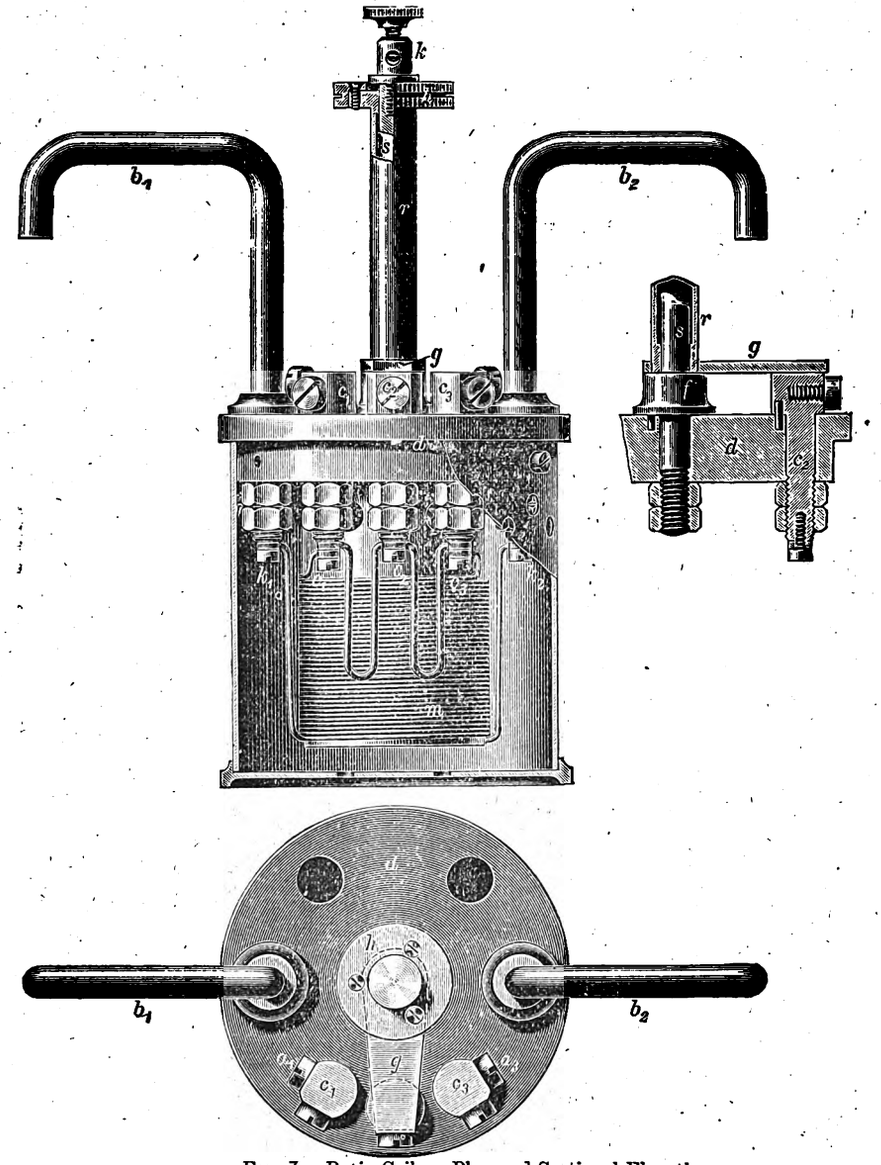

FIG. 3.—Ratio Coils. Plan and Sectional Elevation.

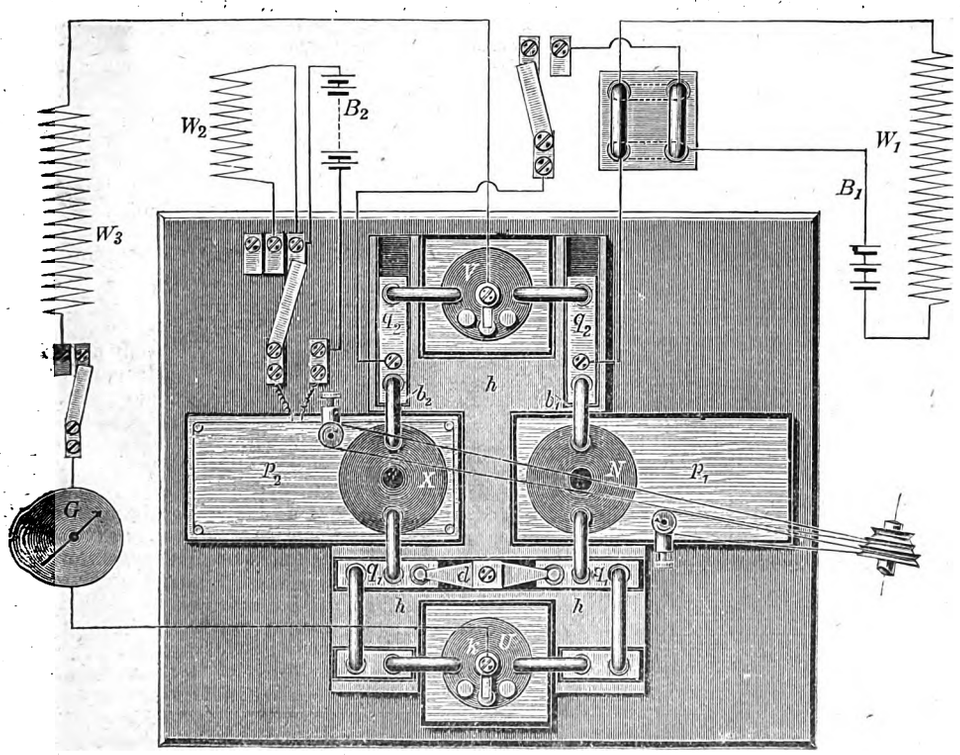

FIG. 4.—Apparatus for Standardising Resistances.

to the temperature difference *d*), and further, that the increase from 20°C. to 40°C. is greater than that from 0°C. to 20°C. This is easily accounted for by the greater mobility of paraffin at high temperatures.

The investigations described show that the standard paraffin bath resistances are capable of dissipating a large amount of heat. Originally these are wound with "patent nickel," and constructed for a maximum load of 1 watt. If the resistances are to be used as standards of precision, it is advisable, in order to make certain of their permanence with time, not to exceed this value, even with the new low-temperature coefficient alloys. For resistance comparisons there is usually no necessity to exceed this value. For *practical* measurements—for instance, the measurement of current by the potentiometer method—it is advisable to allow much greater energy dissipation. Resistances which should only be used for this purpose, and in which an accuracy of ½ per cent. is sufficient, can be loaded much more. From the above-mentioned measurements and the experience of the constancy of the resistance when maintained for a long time at a temperature of 100°C., as described in the original communication, it is found that for commercial standards of the above construction 100 watts may be allowed. Naturally care must be taken that the whole bath does not increase more than 10°C. in temperature. Either the current must only be passed for a short time (for the above size of bath containing about 4 litres, not more than 20min. with 100 watts), or powerful cooling of the paraffin must be adopted.

For measurements with the highest permissible current and high resistances the magnitude of the potential difference must be considered. It is advisable not to exceed 100 volts with this construction. We thus have the following values :—

TABLE III.

—	Highest permissible current.	
	Precision standards.	Commercial standards.
Ohms.	Amperes.	Amperes.
0·1	3·2	32·0
1·0	1.0	10·0
10·0	0·32	3·2
100·0	0·10	1·0
1,000·0	0·032	0·1
10,000·0	0·010	0·01

II.—PROCEDURE FOR THE COMPARISON OF STANDARD RESISTANCES.

The Thomson modification of the Wheatstone bridge which we have used for a number of years, with good results, for the accurate comparison of wire resistances with standards *of the same nominal value* will now be described.

(*a*) *Ratio Coils.*—Fig. 3 shows in plan and elevation the form of ratio coils used, which contain the two equal ratio resistances of the Wheatstone's bridge; between which resistances a small resistance is introduced for interpolation, which, for measurements of precision, is the thousandth part of each ratio resistance. For all practical cases two different classes of ratio coils are used, one with resistances of 100 ohms with an interpolation resistance of 0·1 ohm for the accurate comparison of higher resistances, from 0·1 ohm upwards; the other with ratios of 10 ohms and interpolation resistance of 0·01 ohm for the measurement of smaller

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resistance down to 0·0001 ohm. A sliding contact connected to the galvanometer can be connected with three points of the interpolation resistance, viz., to the middle or to either end. It is thus in general not possible to bring the galvanometer deflection to zero as in a wire bridge; the relation of the resistances compared are interpolated from the deflections observed in the three possible positions of the contact.

As is shown in Fig. 3, the design of the ratio coil is in part the same as that of the wire standards (Fig. 1). The two ratio resistances are wound on the large brass tube m, and treated with the same care as the standard resistances, especially in the thorough ageing by heat. The outer end of each ratio resistance is soldered at k_1 and k_2 to the leading-in rods b_1 b_2, the inner ends to the contact blocks c_1 and c_3 fixed on the ebonite top. Between the contacts c_1 and c_3 the interpolation resistance (a wire or strip of 0·1 or 0·01 ohm) is soldered, the mid-point of which is connected with the contact c_2 in the same way. These contact blocks, c_1 c_2 c_3, are arranged on the ebonite top as shown in the figure, each about 1cm. diameter. In the middle of d a long thick rod, s, is fixed, which carries the terminal k for the reception of a galvanometer lead. Upon this rod a tube, r, loosely fits, to which below, where it slides upon a flange, f, the sliding contact g is brazed. Above, on the tube, is fixed a small ebonite-covered flange, upon which works a round nut separate from the terminal k. By turning the nut the pressure with which the sliding contact is made on the upper faces of c_1, c_2, or c_3 can be regulated. By turning the ebonite milled head h a sliding contact can be made on any one of the three blocks. Two stops on c_1 and c_3 prevent overturning. The rod s is made so long that the whole coil may be immersed in a petroleum bath, so that the contacts are about 1cm. under the surface of the liquid. The screws attached to the contact blocks, seen in the plan, which do not serve as stops, are used for measuring the single resistances. By these screws, also, high resistances may be connected in parallel with the ratio coils.

The comparison of the resistances with the given value can be performed with great accuracy; for example, for one of the Reichsanstalt ratio coils of manganin the following values were obtained:—

* *Ratio Resistances.*

Between k_1 c_1	100·013 ohms at	17·1deg.
,, k_2 c_3	100 012 ,,	17·3deg.

Interpolation Resistance.

Between c_1 c_2	0·0499 ohm at	17·5deg.
,, c_2 c_3	0·0498 ,,	17·5deg.

The minute inequalities in the resistances are eliminated by commuting—*i.e.*, by reversing the leads in their cups.

(*b*) *Wheatstone-Thomson Bridge for the Comparison of Standard Resistances.*—The use of the ratio coil requires no further explanation. The resistance to be measured, and a standard of the same nominal value, are connected together at one end, without any interposed resistance, by dipping their leads in the same mercury cup. From the mercury cups in which the other two leads dip, short thick copper wires are connected to the ends of the ratio coil, which completes the Wheatstone bridge. The leads to the galvanometer are connected to the terminal k of the ratio coil, and to the junction of the standard resistance and the resistance to be measured. The battery wires are connected in such a manner that the resistance of the thick, almost equally long, connections, when comparing resistances below 100 or 10 ohms, are added to the resistances of the ratio coil of 100 or 10 ohms, and thus, even in the most accurate measurements, may be neglected. In this simple method of connection, the ratio coil can be conveniently used for the calibration of rheostats, and for the comparison of one coil with a standard. For the rapid testing of resistance boxes, potentiometers, &c., this simple and convenient method is always used in the Reichsanstalt.

As has been seen above, screws are provided in order to allow high resistances to be connected in parallel, and thus to obtain known ratios. Thus it is possible, by shunting a 100-ohm ratio coil with 35,000 ohms, to alter the ratio of the two resistances, reckoned from c_2 in the ratio of 106·0/106·3; thus resistances which are adjusted in *legal* ohms may be compared with those based on the new *international* ohm without getting too great deflections when the contact g is on the block c_2. The shunt connection is so arranged that a small inequality in the ratio coils can be eliminated by commuting. In many cases, however, the resistance to be measured and the standard cannot be arranged with an end of each in the same mercury cup—for example, when the unknown resistance is to be tested at different temperatures, or if, as in the case of standard resistances of low value,* the resistance of a coil is not reckoned from the *outer* ends of the leads. In this case the bridge can be easily transformed as in Thomson's method.

In Fig. 4 is shown the arrangement for standards of the Reichsanstalt model, but which is easily adapted to allow wire resistances of any magnitude and also plate resistances of 0·01 or 0·001 ohm (the so-called small pattern) to be compared with standards of the same nominal value, and their temperature coefficient tested. The standard N and the resistance X to be measured are immersed in *separate* petroleum baths as before described.* In p_2 a rectangular frame of perforated brass sheet is immersed which carries an insulated winding of resistance wire wound from the bottom to the top of the liquid. This serves for the heating of the bath by current, for testing temperature coefficients. The required current is provided by the secondary battery B_2, which is also used for the galvanometer lamp and for driving a small electromotor. By means of a rheostat W_2, in the base of the apparatus, a uniform temperature is attained in p_2 in a short time. If, on the contrary, a lower temperature is required a cooling worm is inserted in p_2, through which cold water is passed. The petroleum in both baths is kept in constant motion by two small pumps driven by an electromotor. The two resistances N and X are on one side connected by a thick copper plate, d, which makes contact with its amalgamated ends in small cups in the mercury cup blocks q_1 q_1, and carries a terminal in the middle. Since the resistance of this connector is very small the galvanometer is connected directly to the terminal d when comparing high resistances at the temperature of the room. If the baths p_1 and p_2 are at very different temperatures, a 10-ohm ratio coil U in a small petroleum bath is connected up, bridging over d, and the galvanometer connection is made to the terminal k on the coil U. The influence of thermo-electric forces is thereby greatly diminished, and the resistance of the connector itself, when N and X are 0·001 ohm or less, is eliminated, as in Thomson's modification of Wheatstone's bridge. The leads b_1 and b_2 of N and X rest in long mercury cup blocks, q_2 q_2, between which a ratio coil, V (for comparison of resistances of 0·1 ohm upwards, usually a 100-ohm, and for lower resistances a 10-ohm coil) is connected in the same way, which is also immersed in a separate petroleum bath. In the battery circuit are one or more secondary cells, B_1, a commutator, switch, and regulating resistance, W_1; a similar resistance, W_3, is inserted in the galvanometer circuit.

The whole of the measuring apparatus is immersed in petroleum, the temperature of which in p_1 and p_2 can be measured by thermometers inserted in the coils. In this manner not only the temperature of the resistances can be accurately known, but the thermo-electric forces (a source of error which need scarcely be considered when using manganin) are almost eliminated. It should be mentioned that the wooden supports for the mercury cups are not solid, but are hollowed and filled with kieselguhr.

In practice, with the above arrangement, resistances can be quickly and accurately compared to a few millionths of their value. The accuracy attained in the measurement will be illustrated by an example.†

III.—Constancy of the Wire Resistances.

In order to discover the behaviour of the type of standard resistance described in Section I., in practical use, 45 of these coils, which were tested in the Reichsanstalt in the years 1891 and 1892, were on the request of the Reichsanstalt returned by the owners and underwent a further test in June, 1894. These resistances were mostly graduated in tenths and were for the most part used in electrotechnical and physical laboratories and some of them in electrotechnical workshops and central stations. The measurements were conducted as described above, the resistances being always compared with standards of the same kind, the constancy of which had been periodically compared, directly or indirectly, with the mercury standard. The results of these measurements, published in the *Wissenschaftlichen Abhandlung*, were the following: Of all 45 wire resistances tested (42 of manganin, 3 of constantan) we have for a period of from 1½ to 3 years—

25	coils showed a variation of from		0·00	to 0·01	per cent.
13	,,	,,	,,	0·01 ,, 0·02	,,
5	,,	,,	,,	0·02 ,, 0·05	,,
2	,,	,,	,,	5·05 ,, 0·25	,,

It must be remarked that these resistances were not only used in laboratories for resistance measurements with small currents, but also for the measurement of currents by indirect comparison, so that in some cases the current density certainly exceeded the permissible values for measurements of precision. From these results the conclusion has been arrived at that *manganin has been found very suitable for wire resistances in practical use.*

Of standards wound with constantan too few have been tested to be able to pronounce definitely upon their constancy; still, it would appear from experience up to the present that constantan is equally good in this respect. The properties of constantan render it especially suitable for rough technical resistances in which less accuracy is required than for resistances of precision. The experience with these resistances will be made public later.

The above-mentioned periodic comparisons of the primary wire-standard of the Reichsanstalt, with accurately-determined mercury

* Feussner. *Zeitschrift für Instrumentenkunde*, 10, S. 425, 1890.

* Feussner. *Zeitschrift für Instrumentenkunde*, 10, S. 8, 1890.

† A lengthy example is given here in the original text.—Ed. *E.*

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resistances, give very satisfactory results as to the constancy of the resistance, and give also valuable proof of the degree of constancy of the resistance value, which may now-a-days be reached with properly made wire standards. For the first series of these comparisons the *primitive* mercury standard of the Reichsanstalt, which is described in the *Zeitschrift für Instrumentenkunde*, 11, S. 173, 1891, was used. Later the wire resistance was connected to the *ultimate* (*definitiv*)* mercury standard (*see* W. Jaeger, *Wissenschaftlichen Abhandlungen der P. T. R.*, 2, S. 1) in October, 1892, November, 1893, and May, 1894. It appears that for 7 one-ohm wire standards (5 manganin, 2 "patentnickel") the greatest resistance variation was 0 004 per cent., so that already it appears difficult to guarantee the constancy of the fundamental unit of comparison over the whole period.

ELECTRIC ELEVATORS, WITH DETAILED DESCRIPTION OF SPECIAL TYPES.†

BY FRANK J. SPRAGUE.

The time has passed when anyone can doubt that one of the most important applications of the electric transmission of power and one in the number and variety of its applications already rivalling the electric railway work which has made such marvellous strides in the past eight years, is that of the operation of all classes of hoisting machinery. Some idea of the extent of the present elevator business may be gathered from the fact that in New York City alone there are not less than 5,000 elevators of various kinds, more, in fact, than there are street cars, and more people are carried vertically than there are horizontally. Ignoring for the moment the specific methods of application, and discounting the difficulties naturally met in developing machines to do the duty required in modern office work, not alone the technical difficulties, but those commercial ones naturally met when a new company enters the lists with untried machines against the entrenched forces of existing industries, there was still much of encouragement to be derived from a backward glance at the industrial changes wrought in the last few years. The elevator field, indeed, is a large one, and if the system is electric, then, considered from a commercial standpoint, there appears the following possible classes of work :—

1. High-speed passenger service where no hydraulic plant is possible because of limited space.

2. High-speed passenger service in competition with hydraulic plants, the electric plant doing equal duty, costing less, occupying less space than the hydraulic, and costing much less to operate.

3. Substitution of new high-speed electric service in place of old steam and slow hydraulic services in buildings where the limited space and interference with operations will not permit consideration of a new hydraulic plant.

4. Passenger elevator service in buildings where the loads are comparatively light.

5. Passenger service in private houses where safety, simplicity and noiselessness are essential.

6. Freight and special classes of work.

For convenience we may classify elevator work as "first-class, that requiring speeds from 300ft. to 600ft. a minute," including the first three duties above mentioned, and as "second class" those requiring speeds of from 50ft. to 250ft. a minute," which include the remainder. In general there has been required and developed two kinds of machines to perform these services. The first is the outcome of the increased height of buildings and the demand for high speed and smooth motion, largely regardless of cost of apparatus, space occupied, or cost of operation. The hydraulic elevator was the result of this demand, and was the only one that up to a year or so ago was accepted for this service.

The second class of elevator work, that which requires lower speeds, is applied to small apartment houses and other buildings where lighter elevator duty is required. This, for a long time, has been fairly supplied by worm-gear elevators, and the replacing of the steam engine by an electric motor has enormously broadened the field for this class of machine.

Taking the drum type, and considering electrical control on a machine over-balanced for average service, the load up or down is sometimes with and sometimes against the machine. To control such a machine directly from a supply circuit (and I cannot seriously consider any other, no matter how ingenious or refined, as meeting general conditions), there is one method only, and that is the use of a rheostat in starting, and the inverse variation of the strength of the shunt field for about a two to one variation in speed. A cumulative series coil is only permissible in starting if variations of speeds are controllable, and in any event these variations are limited. Such a machine is, however, the best for second-class service.

Let us consider for a moment a hydraulic system, and institute a few comparisons. It consists primarily of a steam cylinder, or a multiplicity of steam cylinders, working ordinarily under poor conditions of steam economy—that is, with a fixed cut-out in the high-pressure cylinder of a compound pump, or no cut-off in any cylinder of a simple pump. This element corresponds to the cylinders of a steam engine in the electric system, which use steam expansively with a cut-off varying according to the load, and under pressure conditions which are somewhat better than exist in a pump. It is to duplicate the results of this system of variable cut-offs and steam expansion, that the energies of the various pump builders have been more or less ineffectually bent for a great many years in plain acknowledgment of that defect in their simple and duplex pumps, the latter of which is common to almost every hydraulic plant of any size in the United States. It is true that a so-called "high duty" pump with equalising piston is used on some of the larger elevator plants, but its use has not proven by any means entirely successful, because of the spasmodic nature of the service. Among the high duty pumps, the flywheel type, such as is used on large water pumping stations, has been attempted, but rarely, I may fairly say, with success.

The next element is the water cylinder, which corresponds to the dynamo in the electric system, and on account of the high friction due to the packing, the efficiency of a water cylinder with its valves is not ordinarily equal to that of a dynamo, which with a motor stands to-day the typical example of an efficient energy converter. The next element is the piping and the tanks, compression or roof, and perhaps an accumulator, into or through which the water is pumped for delivery to the controlling valves of the elevator, and that which corresponds to this in the electric system is its simple wiring, and if a storage battery is used, then this last in conjunction with it.

Any competent engineer knows that, measured by standard practice, a given number of pounds of energy can be delivered to the controlling apparatus of an electric elevator for less pounds of steam—that is, water evaporated—through the medium of no less than 50 combinations of engines and dynamos, than can be delivered to the valves of any hydraulic cylinder through the standard pumps permissible in average elevator service. To be specific, the average water evaporation on a compound duplex pump, which is almost universally used, will in practice be not less than about 60lb. to 70lb. per horse-power of water energy delivered to the controlling valves, whereas the electric combination will easily give the same for less than 40lb.

There are exceptional conditions in which a higher economy can be gotten in a hydraulic system, but they are few and are not typical, and under equal conditions the steam consumption in an electric system can be cut in two.

But this is not all. The fact is persistently ignored, although the attempt is made to offset it by recent experiments with a differential piston, that a standard hydraulic elevator uses the same amount of water under the same pressure for every foot of travel of a car, which volume of water and pressure are determined by the maximum load which has to be carried, although the average load on the ropes, including the excess of car over counterweight, is not over one-third of the maximum. On the other hand, the electric elevator uses, and must use, under normal conditions, current directly proportional to the work, modified in a small degree by starting and slow running. In short, over and above the friction load of the generating system, the steam consumption in the engines and the generation of electricity in the dynamo vary with the demand of the elevator machines. It is a system which is of necessity automatic. On the other hand, the hydraulic system is one of the most flagrant violators of the relation which should exist between demand and supply.

Leaving out central station supply—always, when properly equipped, to be preferred when the electric service is of a spasmodic or limited character—and considering for the present those large plants which characterise the modern office or hotel building

* This *ultimate* standard agrees with the *primitive* to 0·0001. For the production of wire copies of the latter the value of Mascart, Nerville and Benoît for the specific resistance of mercury at the observing temperature of 18deg. (σ_{18}=1·01608) was used. This latter value is, with great probability, from the measurements of Herren Kreichgauer and Jaeger (*Wied. Ann.*, 47, S. 513, 1892) on the one hand, and of Guillaume on the other, about 0·0022 too small. The absolute accuracy of 0·0001, which, up to October, 1892, was given for the Reichsanstalt standard of 1 ohm, is thus on this account also somewhat too great. For all wire standards tested after October, 1892, in *legal* ohms, the absolute accuracy can be only taken as 0·0003. By multiplication by 1·0002 the error due to the mistaken temperature coefficient of mercury can be eliminated, and thus the absolute accuracy of all these resistances would be well within 0·0001. For the resistances standardised by the international ohm the ultimate mercury standard is used as a basis (measured at 0°C.), which is not affected by any inaccuracy in the temperature coefficient of mercury. Thus the standard coils of 1 ohm may be relied on to an accuracy of 0·0001.

† Abstract of a Paper read before the American Institute of Electrical Engineers

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and in a way rival central stations, every engineer knows that the fewer the number of well-proportioned units the more alike they are, the freer the interchangeability between themselves, and the greater the extent to which any one unit can be utilised, the better the system for power generation and conversion, no matter what its character.

The best modern practice makes a three-unit direct-connected engine and dynamo plant the best for lighting a building. There is an empirical relation existing between the number of lights required in a building as ordinarily designed, and the elevator service. When, in addition to the lighting service, such a building adopts electric elevators, it is not now necessary that it shall add an independent generating plant.

All that is required is that the three units should be somewhat increased in size and, perhaps, one of them preferably divided, the mains all taken to a common switchboard with two-way switches, and every engine and dynamo thus made interchangeable on either the lighting or elevator circuits, and at times both, especially if using a slow-acting corrective converter, some of each can be run from the same engine anp dynamo. So, instead of five or six units, some water and some electric, the entire generating plant is reduced to a single system consisting of three units of one size, or two of that size and two of a half size, which can be run interchangeably, and one of which is almost always in reserve.

Just here it is well to consider the probable application of the storage battery, which, if built with plenty of lead, with large surfaces and for heavy momentary discharges rather than for long-time steady discharges, will prove a most important adjunct to elevator service, which, like railway work, is spasmodic in character.

To meet the hydraulic machine there was designed and developed what is now known as the Sprague-Pratt multiple sheave electric screw elevator, following the general lines of a tension hydraulic machine in the matter of rope movement, limit safeties, and method of control. The net result has been that this machine now stands the superior to the hydraulic elevator in that it has its speed and capacity with, if anything, greater safety, and certain advantages in its automatics. On high lifts it occupies less space, it is more flexible in its application, is more economical to operate, and it is more easily cared for.

General Description.—The machine may be described as the combination of two old elements with one new one, with specific safeties and methods of control. Briefly, it is of the horizontal multiple sheave type, with a travelling crosshead and frictionless nut driven by a screw revolved by a motor directly connected, and governed by a pilot motor and rheostat. The general construction consists of a heavy main beam, carrying the travelling crosshead and the lower screw bearing, with special castings bolted at each end, one carrying the fixed set of sheaves, and the other the thrust bearing, brake and motor. The regulating apparatus is independent and self-contained, and placed on the wall. From the car to the system of multiplying sheaves the direct multiplying machine and the horizontal hydraulic elevator are practically the same. The crosshead, however, marks the point of departure in the two types. In the hydraulic machine, this crosshead is rigidly attached to the end of a rod which terminates in a piston moving in a cylinder having an inside length equal to the lineal movement of the crosshead. This cylinder in the vertical type of hydraulics varies from 30ft. to 50ft. in length, with from 2 to 12 sheave multiplications, and in the horizontal types the multiplication runs as high as 14, with corresponding diminution of length of cylinder and increase in cross-section. Whatever the gearing, however, the length of cylinder is a function of the car travel. In this electric elevator, the crosshead being moved along a screw, stationary so far as the lineal movement is concerned, there is, with any given number of sheaves—only one variable—the length of screw; and, for all heights above about 100ft., the electric machine has an advantage in matter of length, which, with increased rises, becomes of great importance.

Looking to the needs of office buildings, there has been adopted two methods of rope multiplication, determined by the height of building, and so selected that the length of machine over all shall not exceed about 30ft. for rises approaching 300ft. actual car travel. From this the length grades down to about 21ft., so that all rises between 60ft. and 300ft. can be taken care of with an extreme variation of 9ft. or 10ft. in the length of machine, and there is thus provided limiting dimension data of great convenience and utility.

These systems of multiplication I may term direct and indirect. In the former, the entire multiplication, varying from six to ten, is done at the machine, and the ropes lead from the end sheaves over the shaft sheaves direct to the car. A free counter-weight is used, the ropes being fastened to the car frame.

Economy of operation and smoothness of movement, however, are antagonistic in their relations to the amount of counter-weight carried. The best method is probably that used when there is a single multiplication in the shaft, giving a two to one counter-weight travelling at half-speed, and carried by all the car-hoisting ropes, as is done for short-rise vertical hydraulic elevators.

For long rises I have adopted a combination vertical and horizontal machine rope practice, giving even a more compact machine, a longer life of ropes, and better counter-weight results.

Where space is limited I use a double-decked machine, and in the new Commercial Cable Building, which is to be 21 stories high, the machines will be treble decked, and about 10½ft. in height.

Details.—Turning now to the detail construction and operation of this machine, there are a number of features claiming special attention, each unique in character, and marking a radical departure from all other elevator practice. These are the nut, screw and thrust bearing, the brake, the motor and the regulator apparatus. One of the most interesting as well as important features, and, perhaps, the one which has been most frequently attacked, is the nut system. It joins the crosshead of the travelling sheaves by a conical seat. There is no fastening between the nut and the crosshead, the continual weight of the car always keeping them in contact; and the friction at this point, being greater than between the nut and the screw, enables the latter to transmit a straight-line movement in the crosshead when the screw is revolved by the motor, and also to revolve the screw and drive the motor as a dynamo when the mechanical brake releases the screw to allow the car to descend. These are the normal functions of hoisting and lowering. There are several other distinct functions of this nut which will be described in considering the "safeties."

Continuing the line of transmission of power, the only points of contact between the interlocking nut and screw are by a chain of balls which occupy a number of threads, and enter and leave the ends of the nut through tubes which are connected together so as to make a continuous conduit. This is one of the most vital points of the elevator apparatus, and herein lies one of the most potent reasons of its success—the reduction of friction by rolling instead of sliding surfaces on almost all parts under pressure—for not only is the nut so constituted, being in fact a developed spiral thrust bearing, but the thrust bearing at the motor end of the screw is taken on balls, and the sheaves are carried on ball or roller bearings.

This nut being a vital part, its development has been most thorough, and a peculiar treatment of steel which has been adopted renders its surface so hard that the wear is very small, and it is well within commercial limits.

So free is the machine from static friction that it is possible to start the car with a very slight increase of current over the normal hoisting current, providing time be taken so that the work done in acceleration is small to the work of lifting, although that is not the usual practice. The balls have an average crushing strain of 25,000lb. each, but the working pressure varies from only 50lb. to 125lb. per ball. The nut system is a compound one, for, besides the working-ball nut, there is another, called the "safety nut," to which I will make reference later, keyed to it, and between the two is a powerful spring under compression. The screw is a forged bar of high carbon steel, with a peculiarly-shaped thread, the finished screw having a tensile strength of 700,000lb. It passes through the clearance hole in the steel trunnion crosshead, which carries the travelling sheaves, then through the nut, and is carried at the outer end by a fixed bearing. This screw is sectioned, being joined to the armature shaft by a cone-seated coupling secured by a taper gib.

The in-board end of the armature shaft, which is in effect the extension of the screw, terminates in the thrust bearing, where the pressure is taken by about 200 steel balls carried in a bronze guide plate and bearing by specially-hardened steel discs. The thrust of the screw being thus taken up on the in-board end, the strain on the screw is invariably between that end and the travelling crosshead—never beyond this; hence it is always under extension strain—never under compression, and cannot buckle.

The action of the balls on the screw, which is untreated, is peculiar. They form a path for themselves, partly by wear, but principally by rolling compression of the steel, which finally becomes exceedingly hard, such that the edge of any ordinary machine tool would be turned. The balls themselves wear very evenly. Oblique forms in normal practice cannot exist. Beyond the thrust plates is keyed an iron pulley, connected by a flexible coupling with the motor shaft. The function of the brake is that of locking the screw when at rest; it is not a means of varying the speed. In case of accident it has the additional function of helping to stop the screw. It may be described as a compound electro-mechanical brake. A steel brake band, wood-lined, is anchored at one end, the hoisting-side on the motor-bed frame, and the other end is continually pulled down by a powerful spring under compression. The mechanical movement in opposition is through the medium of a peculiar magnet. It is operated by a dual circuit, one in hoisting, another in lowering. In the event of failure of current for any reason, or too high a speed on the down run, this magnet releases the brake in the latter case by a snap switch, operated by an adjustable Pickering centrifugal governor driven by the main screw—and the brake band promptly grips the brake wheel softly yet powerfully.

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Motor.—The motor, which is of the multipolar type, is carried on the same casting which contains the thrust bearing. The field magnets are of steel, and are excited by two circuits; one, known as the shunt circuit, being variable in strength at will, so as to vary the maximum speed of the machine, and the other, a series circuit, which acts to strongly compound the field. This type of elevators is differentiated from all other electrics by the fact that the action is like that of the hydraulic, for it always works against gravity. In hoisting, the motor takes current from the line, but in lowering its main circuit is cut off from the line, and the motor, rotating in an opposite direction, is driven as a dynamo by the weight of the car. A strong element of safety existed in the fact that the current in the field coils is never reversed, and consequently the machine is never demagnetised. Hence, under certain conditions of the operation of the safeties, it has a power of self-excitation which is of importance. The armature which turns in this field is of the ironclad type, and not liable to injury of any kind. It is mounted on a sleeve, is of the 2-path series winding, has a very large commutator, and, of course, multiple carbon brushes. The field coils can be removed without disturbing any other part.

Control.—Considered in its simplest form, and in connection with its action upon the motor and multiplying machine, without reference to the means of communication between the car and the regulator, this last is a very simple device. It is composed of two parts, each made up of peculiarly-shaped iron grids of various sizes arranged in circular form, connected to copper contacts on a slate disc over which passes a heavy carbon brush. The use of iron castings of a specific composition possesses great advantage over any form of wire resistance, not alone in the matter of cost. They are flexible, they expand in any direction readily, and, as made, they have a resistance of from forty to fifty times that of copper, or roughly, that of German silver. The grids are interchangeable, and any of them can be readily replaced.

One side of the rheostat is for regulation in hoisting, the other for lowering. Instead of moving this regulator by hand it is operated by a pilot motor wound with a right and left-handed field, one or the other of which only at a time can be in circuit with the armature. This pilot is connected to the rheostat arm by a single-reduction worm gear, and is operated either from the basement or the car, according to the position of the "change over" switch, by an "up" and "down" button with an automatic lever stop which normally has to be held by the operator to prevent the pilot returning to a stop position. The spindle of the rheostat arm operates switches co-ordinating in their movement, in turn controlling the magnetic make-and-break circuit switches, the down brake, and also the automatic stop lever switches which limit the pilot movement. The use of magnetic switches instead of hand-control switches not only removes the arcing from the face of the rheostat, but it gives the benefit of instantaneous cut-offs not possible by any other means of control. This, on fast machines, is of the utmost importance, and the practical application is that if a car is on the "up motion," and an operator, because of carelessness or because of fright, lets go his stop handle, the current is instantly cut off, the regulator following to stop, and the car is arrested in the shortest time practicable.

Assuming that the circuit is made for the up movement, it first meets with a resistance sufficient to about hold the car and lift the brake. This resistance is then gradually cut out, the torsional effort of the armature is increased, giving the car an upward movement with an acceleration depending upon the rate of movement of the rheostat arm, and with a final velocity determined by the point at which the arm is stopped. If, while hoisting, for any reason the current is cut off, the torsional effort ceases, the brake instantly comes into action, and the car comes to rest.

In lowering, the brake is lifted by an independent circuit, but the armature is first short-circuited on itself, and becomes a most powerful dynamic brake. As the resistance in this circuit is increased, the car runs faster. When it approaches the lower limit of movement, an independent retarding circuit is established, and gradually reduces the resistance. This brings the car to the slowest movement.

The pilot movement regulation is, to my mind, an absolute necessity of fast passenger work; and its application, although at first attended with a number of annoying difficulties, is to-day by far the most reliable method of control known.

Safeties.—On the car we use a special centrifugal which is attached to the lower section of the car frame. It consists of two long levers, short-fulcrumed at the sides of the car and operating clamping jaws which run in close proximity to the car rails, but normally out of contact with them. On the hoisting machine there are a number of safeties. One which is perfectly apparent is due to the fact that the crosshead is moved by a screw with a heavy armature on the end of it, which is driven through the medium of a nut by a car of limited driving capacity. The screw itself is of forged steel, under tension and torsion strains, with a safety factor of at least 20 to 1.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, February 14th.

KINGS COLLEGE ENGINEERING SOCIETY.

4:15 p.m. Meeting at King's College, Strand. Paper to be read: "The Time Rate of the Growth of Magnetism in Iron, and its Importance to the Electrical Engineer, with experiments," by Ernest Wilson.

PHYSICAL SOCIETY.

5 p.m. Annual General Meeting at Burlington House. Paper to be read: "On the Determination of High Temperatures with the Meldometer," by Prof. W. Ramsay and N. Eumorfopoulos.

MONDAY, February 17th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture I.: "The Chemistry of Certain Metals and their Compounds used in Building, and the Changes produced in them by Air, Moisture, and Noxious Gases, &c.," by Prof. J. M. Thomson.

TUESDAY, February 18th.

SOCIETY OF ARTS.

8 p.m. Foreign and Colonial Section. Paper to be read: "The Development of Electrical Traction Apparatus," by H. F. Parshall.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed: "The Manufacture of Aluminium by Electrolysis, and the Plant at Niagara for its Extraction," by Alfred E. Hunt.

WEDNESDAY, February 19th.

ROYAL METEOROLOGICAL SOCIETY.

7:30 p.m. Ordinary Meeting at the Institution of Civil Engineers, 25, Great George-street, Westminster.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Report of the Royal Commission on Secondary Education," by H. Macan.

THURSDAY, February 20th.

FINSBURY TECHNICAL COLLEGE.

Biennial Conversazione.

FRIDAY, February 21st.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting. Paper to be read: "Some Central Station Experience," by W. Fennell.

SATURDAY, February 22nd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Light," by the Right Hon Lord Rayleigh.

BOOKS RECEIVED.

"Computation Rules and Logarithms." By Silas W. Holman. (New York: Macmillan and Co.) Price 5s.

"Laxton's Price Book" for 1896. 79th Edition. (London: Kelly and Co.) Price 4s.

"Chemistry for Engineers and Manufacturers." By Bertram Blount and A. G. Bloxam. Vol. 1. (London: Charles Griffin & Co.)

"The Engineer's Year Book" for 1896. By H. R. Kempe. (London: Crosby, Lockwood and Son.) Price, 8s.

"Flicker" Photometry of Coloured Lights.—In the current number of the *Physical Review* of New York Mr. F. P. Whitman gives some account of the use of the "flicker" photometer in comparing lights of different colour, and states that this method approximates in convenience and accuracy to any of the ordinary photometric appliances using lights of the same colour. The chief test by which this conclusion is arrived at is that different observers whose vision is normal obtain similar results; whereas, by other methods, the comparison of coloured lights by different observers was found to give results often differing by 50 per cent. The flicker method of photometry is based upon researches made by Prof. Rood, who has shown that if a rotating disc, rotating rather slowly, is painted with two different shades, either of gray or some other colour, a flicker is produced, which, however, will gradually disappear if successive pairs of colours more and more alike are chosen. The author has adapted this principle to a photometer, which he calls a flicker photometer, in which a rotating sector disc is made to give intermittent comparisons between two coloured lights on a photometer bar. It is found that differences in colour do not, with such an instrument, affect the measurements.

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GERMAN STANDARDS.

In the lucid intervals—which have of late been very few and very far between—when the British taxpayer is permitted to withdraw his attention from Boer politics and the vagaries of South American Republics, and to give some little consideration to the affairs of his own dull domestic circle, there is one perennial question—Education—which is always to the front. The cry which is ever heard above the discordant strife of formularies, codes, schemes secondary, schemes technical, and the like, is "More Money." No one cares to spend money for "that which is naught," but most reasonable men are willing and ready to give of their substance, provided they can realise that something is produced, some good attained for themselves or others—especially the former.

We print on another page a Paper by Drs. FEUSSNER and LINDECK, which throws light on an aspect of the education question that has not, so far, been brought very prominently before the tax-paying public. To the initiated, however, the function of research as a part of the education problem, both in its relation to that increase of knowlege which concerns itself with teaching "the young idea," and in relation to that other increase which has for its object the general improvement of industrial processes and methods, is becoming every day more fully appreciated. This growing need has so far been met in this country by individual effort, with the consequence that an unknown, but certainly very large, amount of money and skill has been frittered away in needlessly repeating investigations that might have been carried out once and for all. It is true that we can point to good research work carried out by associations, institutions and societies for the common weal, though such work has been none too plentiful. But small as it has been, it has served to show how important such work is to our national industry, and how much need there is for a greater and greater development along these or similar lines. What the proper lines are is a matter which urgently calls for discussion. As an instance

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of the way in which the Germans have sought to solve the problem, we may cite the splendid fruit yielded by their national laboratory at Charlottenburg, not, be it remembered, in the high altitudes of pure research, but in the prosaic production and testing of apparatus of precision and appliances for the measurement and comparison of resistances. Assuming that our British instrument makers are on a level with those of other countries, both for precision of work and accuracy of method, it must nevertheless be acknowledged that the attainment of their high standard of excellence has been the result of an unduly lavish outlay. The English method, moreover, tends to a cast-iron inflexibility of design. Is it conceivable, for instance, that the material and form of our resistance standards would have been perpetuated for 30 years if there had been in existence a public institution charged, amongst other duties, with the investigation of the production and preservation of standards of electric resistance? The Cavendish Laboratory has been the scene of excellent scientific work of all kinds, and notably in the matter of testing electric resistances, but neither a MAXWELL nor a RAYLEIGH, with all their experimental genius, can make bricks without straw or costly researches without funds. Notwithstanding the exceeding excellence of their intentions, the British Association, since MATTHIESSEN'S work of 32 years ago, has only been able to provide its Electrical Units Committee with an extremely modest endowment. MATTHIESSEN'S work ought to have been followed up as new manufacturing processes were introduced, and reliable alloys with valuable properties were gradually evolved. That duty, however, remained unfulfilled for over a quarter of a century, until the establishment of the Reichsanstalt created the opportunity which was eagerly seized by HELMHOLTZ and his staff, and the vigour and skill with which the duty has been performed are attested by the invention of "constantan" and "manganin."

In a future issue we hope to refer more in detail to the forms of apparatus and methods described by Drs. FEUSSNER and LINDECK, and to the results quoted by them. Meanwhile, we commend the Paper to the careful consideration of educationalists and manufacturers, so that they may see how useful such an institution as the Reichsanstalt may be to *them*, not merely, we repeat once more, to the high-and-dry professor. That some such State-endowed laboratory or laboratories should be founded in this country is already abundantly evident, and the spheres of influence in which they can fittingly operate are widening every day. It is all very well to ruthlessly cry "*delenda est Germania*." Even if this feat were possible no permanent good can accrue unless we learn the lesson that German industrial rivalry repeats *ad nauseam* —to wit, the supreme necessity of adopting scientific methods throughout, from the raising of the raw product to its final transference, in return for hard cash, into the hand of the consumer. A servile imitation of German methods is neither desirable nor in all probability feasible, since the racial factor is a stubborn one, which cannot be neglected; what may suit the Teutonic temperament is scarcely likely to suit equally well the free and easy Briton. Science, to use an Americanism, has come to stay; the sooner we Britons pay a more fitting tribute to it the sooner shall we be able to dispense with the adventitious aids advocated by the economic crank. Just at present all the energy, enterprise and originality so long characteristic of the race would seem to be concentrated on the confines of the Empire, whilst those at home are lazily content to rely on big battleships and other such implements of war to "smash, pulverise and destroy" their trade rivals.

BRIGHTON CURVES.

Everyone who has had the privilege of visiting the very successful municipal electric lighting station at Brighton, under the kindly *ægis* of Mr. Arthur Wright, must have come away with the conviction that if elaborate statistic spinning and unwearied curve-tracing can ensure economical working, there is no need to go further in pursuit of the cause of the pronounced prosperity of the Brighton municipal venture. However, the now popular "Wright" method of charging for current, and the ingenious combination of low-pressure continuous-current and high-pressure alternate-current supply in one and the same outlying district, are evidences that something else than accurate measurement of outgoings and incomings has contributed to the prominent position now held by Brighton in the long list of municipal electrical undertakings. But statistics have the merit of being capable of reduction to the form of curves, and two curves from Mr. Wright's museum, which we give this week, will, we venture to think, preach to central station engineers the gospel of Brighton better than any long disquisition or wearisome analysis.

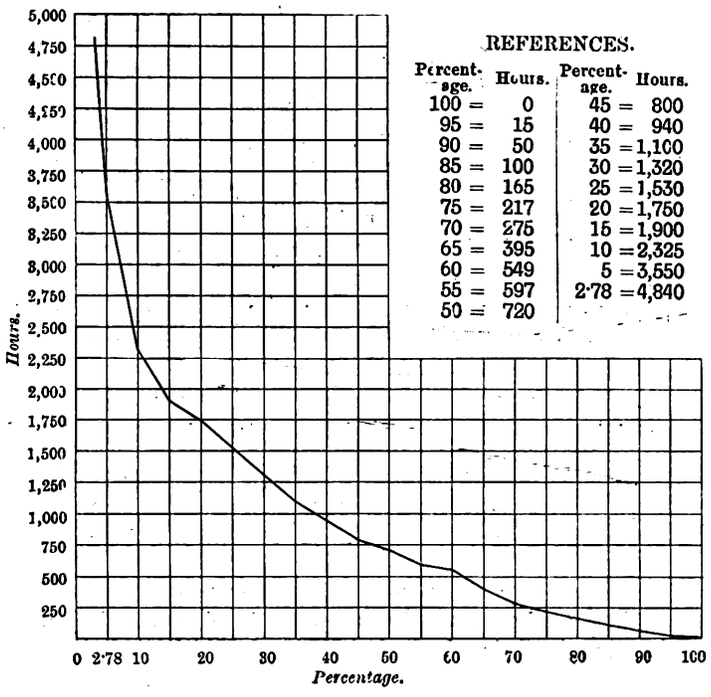

FIG. 2.—Curve showing number of hours the Load on the Brighton Station exceeded a given percentage of the annual maximum load.

The curve (Fig. 1), which has been brought up to December, 1895, shows how much more nearly the total expenditure of a municipal central station varies in accordance with the maximum rate at which this is called upon to deliver in each year, than it does on the total number of units sold in any month during that year. For instance, the solid line shows the actual sale of electricity in every month since January, 1892, taken for the purposes of the curve at the uniform price of 6d. per unit. The dotted lines show the actual total monthly expenditures during the four years, and the crosses, joined by chain-dotted lines, show the maximum load in kilowatts observed in each year. The moral of this curve is obviously that *the total monthly expenditure is very closely a linear function of the maximum rate at which electricity has to be supplied in a given year*, and that it is in no very obvious way a function of the monthly sales. Those engineers who have not studied the question from this point of view, and who advocate charging at a uniform rate per unit, may be unaware that in most of the fairly-established central stations it is generally found that the total fixed expenditure or standing charges are quite 85 per cent. of the total annual expenditure. For example, the standing charges of the Brighton station in 1895 amounted

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to about £14,000 out of a total expenditure of £16,500, showing how insignificant (even in a town like Brighton, where coal is so expensive) is the only item varying with the monthly sales when compared to the total annual expenditure.

The other curve (Fig. 2) should be especially interesting to those engineers who are studying the question of the right size of unit to be put down in a central station, and it seems to strongly justify the English practice of having the plant split up into many units of dissimilar size. This curve represents the number of hours in a complete year that a station which has arrived at a certain stage of steady growth will be called upon to supply a load exceeding any given percentage of its maximum load. For instance, it will be seen that a load equal to 95 per cent. of the highest observed in the year was only continued for five hours out of the 8,760 hours in 1895. A load equal to 75 per cent. of the maximum was only placed upon the station for some 250 hours in the year, and a load of 50 per cent. of the maximum for about 750 hours; whilst for 1,500 hours (or for nearly one-fifth of the year) the station had to deal with a 25 per cent. load, and for 3,500 hours (or 40 per cent. of the time) with a 10 per cent. load. Although the shape of this curve will be modified by any improvement of load factor, such a curve forms a very safe basis on which to discuss the proper division of generating plant.

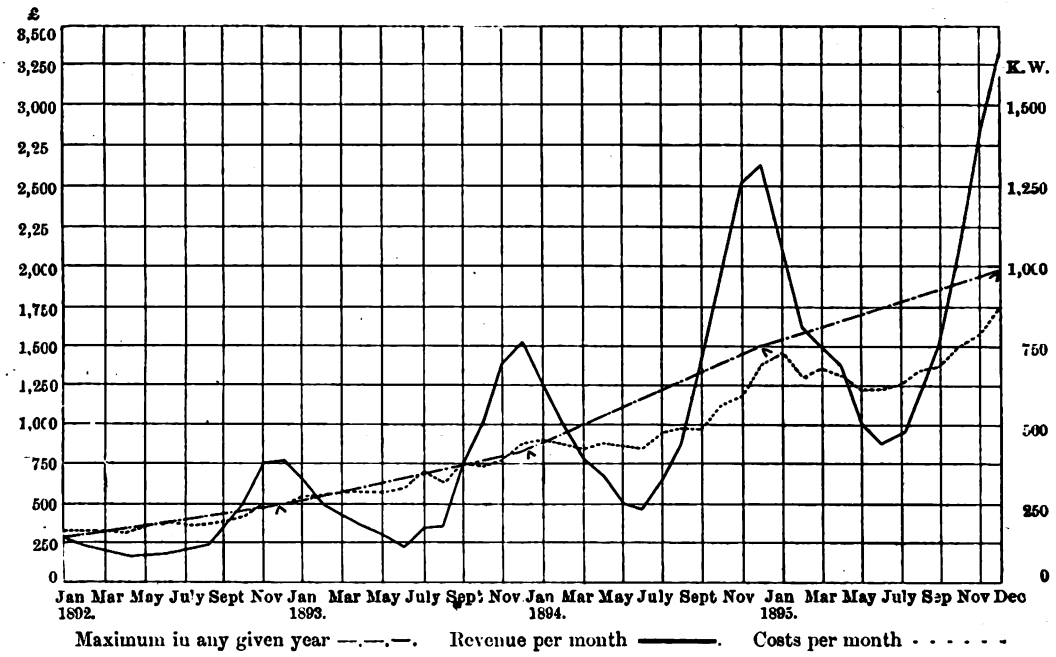

FIG. 1.—Curve showing how monthly expenditure is related with the maximum rate at which Electricity is supplied in any given year, rather than with the monthly sales.

THE NATURE OF CHEMICAL CHANGE AND THE CONDITIONS WHICH DETERMINE IT.*

(Continued from page 487.)

Whatever hypothesis be adopted, the determination of the essential qualities of an electrolyte—a correct answer to the question: What is an electrolyte?—is of fundamental importance. The electricians would say it is a substance which, whilst conducting, undergoes decomposition, which is a purely practical definition. The "ionists" say that it is a substance in a state of ionic dissociation; but theirs is a dissociation of a most mysterious kind—confined to a very limited number of substances—affecting members of the same group in a most arbitrary manner, as whilst some respond, others do not, to the call to ionise on entering into solution—in no way to be co-ordinated with their relative stability as determined by any ordinary chemical method—and conditioned by the agency of a solvent which, though by hypothesis a mere screen, yet exercises a most potent influence, as solvents generally besides this one have little if any action. I discussed the question tentatively at Aberdeen, but did not arrive at any satisfactory conclusion as regards compounds which *per se* act as electrolytes. Facts have since come to light which make me more hopeful. In the case of the metallic protochlorides, so many of which are electrolytes, whilst the corresponding perchlorides are not, electrolysis involves the chloride acting both as electrolyte and "chlorine depolariser," and it is conceivable that the occurrence of decomposition is dependent on, and in a measure condition by, the depolarisation—in other words, that separate molecules are conjointly influenced by the electromotive force, and that while under it the one molecule promotes the decomposition of the other. The readiness with which the silver and lead haloïds undergo electrolysis may be explained in a similar manner, if it be assumed that they are capable of exercising at least a temporary affinity for halogens. It is remarkable that the elements from which electrolysable haloïds are derived occur closely together in the periodic system, and it may be said within the section of the alkali metals. As the alkali metals form tri-iodides, and similar compounds have been obtained from silver haloïds, as well as tetra-haloïd compounds of lead, there is reason to believe that the power of attracting halogens here postulated is actually existent, especially at high temperatures, when the fundamental molecules may be supposed to be more or less free from mutual control, and more likely, therefore, to form compounds with other elements.

From this point of view the behaviour of silver haloïds and of other substances which act as simple electrolytes is strictly comparable with that of composite electrolytes, as I have termed conducting mixtures of dielectrics; and if such a view could be accepted, the phenomenon of electrolysis would appear to be strictly comparable with those of chemical change—both would occur within complex molecular systems. The behaviour of aqueous solutions on electrolysis may conceivably be more analogous to that of haloïds than is commonly supposed, if it should turn out, for example, that, in the case of solutions of sulphuric acid in water, the first products of electrolysis are, as I have tentatively argued (compare *Proceedings*, 1893, 190), hydrogen and *persulphuric acid*. As I will show later on, it would not be difficult to apply a similar hypothesis to other acids and generally to aqueous solutions—especially if water be the *significant* substance in all these changes.

In discussing this, it is necessary to consider the acids themselves, as the suggestion here made in a measure involves the conception that acids such as sulphuric acid are hydrates, not hydroxides. Without attempting to discuss this matter in detail, I may say that, in my opinion, there is no evidence which in any way obliges us to regard sulphuric acid as $SO_2(OH)_2$; on the contrary, all the arguments are equally compatible with the assumption that it is a compound such as may be represented by the formula $SO_3 \cdot OH_2$, in which the radicles SO_3 and OH_2 are still preserved. There is no reason why such a view should not be extended to all "inorganic" acids, and if it be assumed that solutions of the halhydrides contain hydrates, the behaviour of such solutions as acids is strictly comparable with that of acids generally. Organic acids are peculiar in so many ways that they may well also be peculiar in their constitution and different from those derived from elementary oxides.

* Abstract of an address delivered by Dr. H. E. Armstrong before the Chemical Society.

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If sulphuric acid be a hydrate, viz., $SO_3 \cdot OH_2$, persulphuric acid is probably $SO_3 \cdot O_2H_2$,* and the formation of the latter during electrolysis as the primary product would, in a sense, involve the oxidation of water, so that the change would be similar in form to that which I have supposed to occur when a silver haloïd is electrolysed. By thus extending the view that electrolysis is the outcome of the combined action of the electromotive force and of some effect which the one set of molecules exerts upon the other set while both are under the influence of the electromotive force, a clearer conception is gained of the possible nature of the effect which the one set of molecules exercises on the other set. The peculiar value of water as a solvent is also in a measure explained.

As regards the differences observed between acids, I have elsewhere pointed out in a note on the formation of salts (*Chem. Soc. Proc.*, 1891, p. 118), that "It may be supposed that in all cases the acid and the base in the first instance combine, and that the salt is formed by subsequent interactions within the molecule. In like manner, acids form dissociable compounds with water, and it is by the occurrence of change within such systems under the influence of an electromotive force that electrolysis is effected. In those cases in which the compound is highly unstable and prone to dissociate, the opportunity for change to take place within the system is but slight, and consequently the acid is a weak one, and its solution of relatively low-conducting power."

The argument here used would apply equally to alkalis and salts, although it may be doubted whether dissolved salts as such promote electrolysis: it is not improbable that they are more or less hydrolysed, and that the products condition electrolysis; on this assumption, the conductivities of salt solutions afford a measure of the extent to which hydrolysis has taken place in them.

Experience shows that action at once necessarily takes place so soon as a conducting circuit is established, provided that the sum of the changes be exothermic—thus, copper readily dissolves in cold dilute sulphuric acid if coupled with platinum in nitric acid, or in presence of oxygen, although the heat of dissolution of copper in sulphuric acid is negative. This principle is one of extraordinary importance, and I desire to draw attention to one illustration of its application which I believe to be of consequence. It is well known that Baeyer in 1870 pointed out that the resolution of glucose during fermentation into alcohol and carbon dioxide, and indeed the phenomena of fermentation generally, may be accounted for by the assumption that translocation of hydrogen and oxygen atoms is induced through the alternate separation of the elements of water and their addition in different order, changes which would involve the accumulation of oxygen atoms at certain parts of the molecule, thus constituting points of weakness where disruption of the molecule would inevitably occur.

The conception is one of remarkable beauty, and undoubtedly a sufficient explanation, as changes precisely similar to those attending fermentation may be effected by simple hydrolysis; thus glucose may be converted into lactic acid by heating it with alkali; and on boiling fructose with muriatic acid an acid is formed, *i.e.*, lævulinic acid, $CH_3 \cdot CO \cdot CH_2 \cdot CH_2 \cdot CO_2H$, the production of which clearly involves a reduction of some of the $CH_2 \cdot OH$ and $CH \cdot OH$ groups, and oxidation of others, in the manner pictured by Baeyer. The only difficulty is to account for the occurrence of such changes under the conditions prevailing during fermentation, and here Baeyer has left the problem unsolved.

It can scarcely be doubted that the truth of Faraday's doctrine of the unity of chemical and electrolytic change will ere long be generally recognised now that it has been shown in so many cases that interaction does not occur between *two* (pure) substances.

The essential moment conditioning the occurrence of chemical change, according to the view of which I am an advocate, is the formation of a conducting system in which electrolysis can occur, and within which, as already said, change will necessarily take place so soon as the system is established, if exothermic change be possible under the conditions—as in the case of any voltaic cell. Substitutions on this hypothesis are but secondary results consequent on additions.

Much has been done of late to discover that water plays an all-important part in determining many chemical changes, but the nature of the influence which it exerts has been little considered, and I am alone, I believe, in pointing out that mere moisture should be insufficient to condition change in many cases—in the formation of water, for example, from hydrogen and oxygen, the interaction of nitric oxdie and oxygen, or the action of chlorine on metals, &c., as in such cases there would not be an electrolyte present. On the other hand, it would presumably suffice to determine the interaction of ammonia and hydrogen chloride, for example, as the latter and water together form an electrolyte. I believe this to be the criterion by which the efficiency of water *per se* may be judged of; in other words, that it will *per se* condition the occurrence of an interaction between two substances only if it be capable of forming a composite electrolyte with at least one of them; in all other cases something besides water must be present which will render the water conducting by forming with it a composite electrolyte. The number of such substances is, as already pointed out, comparatively limited.

In further illustration of this argument, the rusting of iron may be referred to, as notwithstanding its importance and the amount of discussion it has given rise to, the exact nature of the change is by no means determined. According to Crum Brown (*Journal* Iron and Steel Institute, 1888, 2, 129), liquid water, oxygen and carbon dioxide are the essential elements concerned in the formation of rust. But it may well be doubted if a solution of carbon dioxide in pure water be an electrolyte, in which case perhaps the carbon dioxide initially but serves to promote the formation of acid from a trace of some salt which happens to be present, and the primary product derived from the iron is the corresponding iron salt; this last, however, being even more amenable to attack by carbon dioxide than the salt originally present, the acid is continually regenerated. On this view, it is easy to understand the protection afforded by an alkali. I have on more than one occasion urged that probably it is always necessary that liquid-water systems should be formed if change is to occur, at least in the case of changes taking place under ordinary conditions, *i.e.*, at ordinary temperatures. Apparently it is only at high temperatures or under the influence of an electric discharge, that this condition need not be secured, and in such cases it may be supposed that the conditions are such as to favour the momentary formation of what are practically liquid systems in the atmosphere within which the change occurs. It is not improbable that the influence which surfaces often exercise in promoting gaseous changes may at least in some part be due to the increased opportunity they afford for the formation of liquid systems to take place.

The absolute function which the (composite) electrolyte fulfils in such systems is obscure at present, as it is but stating a fact to say that the presence of a conductor is essential in order that a current may flow: it would seem not improbable that it in some way constitutes a mechanism whereby the discharge or degradation of the energy expended in the change is effected. The question is one of great interest and importance, especially when viewed in connection with the inquiry into the nature of valency and with the fact that an action impossible within an endothermic system at once takes place when an element (a depolariser) is introduced which constitutes the system one within which as a whole endothermic change can occur.

H. B. Dixon's observations on the combustion of carbonic oxide, as well as those of Victor Meyer and his co-workers on the formation of water, and also those of Pringsheim, followed by those of Victor Meyer and Bodenstein, on the formation of hydrogen chloride, all bring into prominence the fact that the occurrence of change in gases is dependent on conditions which are essentially of the same order as those obtaining in the case of liquids. Prof. J. J. Thomson's observations on the discharge of electricity through gases (*Phil. Mag.*, 1893, 36, 313) apparently prove that what is true of chemical change is equally true of the electrical discharges which can be produced in rarefied gases—that the phenomena in both cases, in fact, are electrolytic manifestations, and that discharge could not take place in a pure gas. It appears to me unnecessary to assume that such changes are dependent on the occurrence of atomic dissociation of the molecules of the interacting substances prior to the formation of the molecules of the substances which are the ultimate products; indeed, the observations referred to may almost be regarded as proof that such is not the case. No more striking evidence that the occurrence of a discharge in a gas is dependent on the presence of a something besides the gas—on the formation of a complex conducting system—could be given than is afforded by the beautiful experiment exhibited by Dewar at the Royal Institution, showing that the discharge at once ceases in one of Crookes's phosphorescent tubes on cooling with liquid oxygen. Such treatment cannot be supposed to cause the condensation of the residual air, but may well condition the deposition of the traces of vapour (? of conducting water) present in the gas, thereby destroying the systems within which conduction can alone occur.*

* Berthelot has actually obtained a persulphate from sulphuric anhydride and a peroxide.

* It is noteworthy that J. J. Thomson himself draws the conclusion from his experiments that the discharge through a gas does not consist in tearing the atoms of a single molecule apart, but rather in tearing atoms from off complex aggregates of molecules. I may here point out, with reference to his observation, that a much higher potential difference is required to start a discharge in a highly dried gas than is required to maintain the discharge when once it has taken place, that if a trace of air were present a trace of nitric acid would be formed, which might render the minute amount of moisture present conducting; during rest this would be attracted to the walls of the tube, and therefore it would be at first difficult again to start the discharge, as indeed he found to be the case.

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It may be here pointed out that this argument is perhaps also at least partially applicable in explanation of the erratic behaviour of the discharge in vacuum tubes. If the discharge occur within a complex system, it may well be that certain conditions will favour the formation of a conducting system including one, and others of a system including another, of several substances present in a tube—such an explanation, for example, would account for the fact that the mercury spectrum is only sometimes seen in tubes connected with a mercury pump. And having regard to the fact that a gas may exhibit several spectra, it may be that the spectrum of a given substance varies more or less according as it is included in one or other of several conducting systems.

If the occurrence of chemical change be dependent on the formation of liquid or quasi-liquid systems, the reduction of temperature sufficiently to produce solidification should prevent change. This is probably the explanation of observations such as have been made by Dewar and Pictet. There is probably no more effective method of drying, if drying be defined as the removal of liquid water, than that afforded by cooling to the very low temperatures obtained with the aid of liquid oxygen. In like manner, I am inclined to doubt whether any photographic action be possible at very low temperatures, and would attribute the slight effect observed by Dewar to the action of the phosphorescent light emitted by the plate itself on the sensitive film after the temperature has risen sufficiently for the water within the film again to become liquid. I have long been convinced that photographic phenomena and procedure can and should be treated from the electrolytic point of view (*Camera Club Journal*, 1892, 61, 124; 1893, 48, 71).

We are but beginning to recognise that what is true of ordinary interchanges, *i.e.*, that the change takes place with a complex conducting system, must be equally true of changes of the converse order, so-called decompositions, including dissociation phenomena generally. Among the chief experimental contributions to our knowledge of this subject, we may reckon first and foremost the classical work of Grove on the decomposition of water at high temperatures, and the observations of Deville, as well as those of Victor Meyer and Langer, showing that the decomposition of carbon dioxide takes place in porcelain at a temperature several hundred degrees below that at which it occurs in platinum vessels. Perhaps Frederick Siemens, more than anyone, has dwelt on the influence of conditions other than those of mere temperature on the stability of substances at high temperatures.

It must always appear paradoxical that water should undergo decomposition at a temperature which necessarily must be below that which can be developed in its formation by combustion from hydrogen and oxygen; or, assuming that the effect is primarily of an electrical character, that it should be decomposed by an electromotive force lower than that which can be developed by the interaction of the elements into which it is resolved.

The problem is akin to that involved in the electrolysis of water, which can be effected by electromotive forces much smaller than about 1·4 volts, the value calculated from the known heat of formation of water.

Two explanations are possible—one involving the assumption of dissociation, the other of an available external source of energy; it is needless to say that the former has long been the popular view. Reference has already been made to current views on the dissociation of water, and the question raised whether we are justified in concluding that water under ordinary conditions is dissociated, even to a very slight extent. But whatever the ultimate conclusion, even if pure water be undissociated and an absolute dielectric, it may well be that in the case of a conducting mixture we are dealing with systems which, although free from any elements of dissociation, may yet be prone to undergo internal changes much after the manner of those pictured by Williamson in his celebrated essay on etherification (*J. Chem. Soc.*, 1851, 4, 110), changes which, as Fitzgerald has pointed out, would in effect be of the same order as those postulated by the modern school of dissociationists. On the other hand it is not impossible that our conclusions are all based on observations made either with polarised electrodes or with media which have been to some extent impure.

In the experiment devised by Helmholtz and described in his Faraday lecture, the attempt was made, by means of an additional electrode of palladium which could be charged with hydrogen, to remove all traces of dissolved oxygen, and this object is supposed to have been effected; but I venture to doubt the possibility of securing complete depolarisation in such a manner.

With regard to its behaviour at high temperatures, if pure water be to some slight extent dissociated, even under ordinary conditions, as is suggested, it may fairly be expected that it would undergo further dissociation, to a greater extent and more readily than appears to be the case, as the temperature is raised; the important experiments made by V. Meyer and Langer on the behaviour of various gases at very high temperatures apparently also lend no support to this view. The dissociation of water takes place more particularly in contact with heated platinum—copper, although readily oxidised, appears to have no specific influence in promoting its decomposition. Platinum, however, occludes both hydrogen and oxygen and may be supposed to be always charged with one or other of these gases—so that if the decomposition of water at high temperatures by platinum take place within a circuit including one or other of these gases, the electromotive force required to produce the change will be lower than that developed in the formation of water owing to the operation of a back electromotive force. It may be that heated copper does not decompose water, both because it does not polarise as does platinum, and perhaps, also, because the heat of formation of its oxide is lower than that of water under all conditions.

H. B. Baker's observations on the influence of moisture on the decomposition of ammonium chloride by heat (*Trans.*, 1894, 65, 615) are of great importance as the first of their kind, and must serve to direct attention to the value of further experiments of a similar character. It does not appear to me that we are yet justified in assuming that if dry such a substance would not decompose if heated; should we not, perhaps, rather consider that it would decompose somewhat suddenly when a sufficiently high temperature was reached—when the temperature was, in fact, a trifle higher than that corresponding to its heat of formation? The presence of moisture would promote decomposition because it is capable of interacting exothermically with one of the products—viz., hydrogen chloride. As change is influenced in both directions by moisture, the rate at which it would proceed in a case like that of ammonium chloride would, therefore, depend on the amount of moisture present; if the amount were very small the pressure of dissociation would be attained only after the lapse of a considerable interval of time. The interesting account recently given by Rose (*Trans.*, 1895, 61, 893) of his observations on the influence of moisture on the pressure of dissociation of gold chloride—the first of their kind made to test this view—I think, clearly appears to afford confirmation of the correctness of this conclusion. With reference to this question, it may be here suggested that the occurrence of but slight decomposition when calcium carbonate is strongly heated in almost closed vessels may be due not only to the fact that under such conditions the maximum opportunity is given for recombination, but also to the almost complete exclusion of moisture under such conditions. The practice of burning chalk wet is calculated to favour the maintenance of the "back electromotive force" developed in the interaction of lime and water to the utmost possible extent, and thus to hasten the rate of change; in other words, the acceleration is not the outcome of the removal of the gaseous products of change alone. Similar considerations apply to the incomplete *per saltum* combustion of gaseous mixtures at high temperatures.

It is an interesting question whether compounds such as potassium chlorate, which decompose exothermically, will be affected by the presence of moisture or substances exercising equivalent effects; and this inquiry is clearly of special importance in connection with that into the stability of explosives. Baker's experiments have afforded negative results, but the subject is deserving of much closer experimental study. In such cases we are dealing with closed systems in a measure comparable with a charged Leyden jar, in which there are parts capable of interacting kept asunder by a non-conductor. The question is whether change be induced by communication being set up between these distant parts by the interposition of an external conductor, or, in other words, the completion of a circuit; or whether it be the outcome of a disturbance similar to that which would have the effect in the case of a Leyden jar of smashing aside the dielectric at some point, and consequently of bringing into contact the two coatings previously kept apart. The manner in which the decomposition of potassium chlorate is promoted by the presence of various substances might be regarded as evidence in favour of the former view were it not that anything which would give rise to changes developing a back electromotive force would at once alter and of course increase the rate of change; and such actions are clearly not impossible in the case in question. It would be a matter of great interest to closely study the behaviour of some of the complex carb-oxylic acids which lose carbon dioxide when heated, or of the keto-acids from which carbon monoxide is evolved, with the object of ascertaining whether the rate of change is in any way dependent on the amount of impurity present—whether, in fact, such compounds would prove to be the more stable the greater the care taken in their purification, including dehydration under purification; but it is not to be expected that positive results will be attained in such cases until the approach to purity becomes very close. In the case of single substances undergoing rearrangement of parts, it is not unlikely that "residual affinity" may come into play as much as it does in the case of ordinary interactions, and therefore that such decompositions will equally depend on the realisation of particular conditions; in other words, that the stability of compounds ordinarily reckoned very unstable may be very considerable in the pure state.

The instability of liquid ozone, to which attention has been drawn by Dewar and Liveing's observations, for example, may not

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be an intrinsic property of ozone in the liquid state, but may be conditioned by the circumstance that, being liquid, it is more readily brought into circuit or coupled up with impurities which happen to be present, so that opportunity is given for change to set in. The decomposition of liquid ozone would seem, in fact, to be comparable with that of a liquid system of sulphur dioxide, oxygen and water, in which change occurs somewhat readily, although a gaseous mixture of the same substance is stable, according to H. B. Dixon.

Of the many directions in which the introduction of electrical conceptions into chemistry promises to be of service, the determination of the "electromotive efficiency" of chemical change appears to be one of the most important.

Braun in Germany, and in this country Alder Wright, whose loss we so much deplore, have devoted much attention to the determination of "chemical affinity" in terms of electromotive force, following the method first adopted by William Thompson (now Lord Kelvin), and successfully applied by him to the Daniell cell. Thomson's calculations involved the assumption that the energy of chemical change becomes wholly converted into electrical energy, but the comparisons which have been since made *seem* to show that in cells other than the Daniell this is rarely, if ever, the case. Helmholtz and others, in fact, have proposed to draw a distinction between free and bound energy, the latter being that portion of the total energy of the system which is not convertible into electrical energy, but becomes frittered down into heat in chemical changes. It has always seemed to me that most physicists who have discussed these matters have had far too little feeling as regards the nature of chemical changes, and that the conclusions have been too often based on *à priori* considerations. Obviously, it is necessary to know the precise character of the changes going on under particular conditions in any cell before the attempt can be made to ascertain whether the electromotive force developed is the precise equivalent of their "chemical energy." Our knowledge as to what goes on in solutions is so vague, however, that at present we can never assert that we know precisely what is happening in a particular system. As Herroun has pointed out in an important Paper on "The Divergence of Electromotive Forces from Thermochemical Data" (*Phil. Mag.*, March, 1889, 209), there is reason to believe that in the case of a number of metals, silver and mercury, for example, it is probably altogether wrong to base calculations on the assumption that the heat of formation of a hydrated salt, or of the salt in a solution of the concentration of that which is ultimately formed in the cell in which the metal is dissolved, is the heat of formation to be made use of in the calculation of electromotive force; we must, in many cases, rather assume that the anhydrous salt is alone formed in the circuit. In like manner, Robertson and I have contended (*Roy. Soc. Proc.*, 1891, 50, 108) that in the lead-sulphuric acid-lead peroxide cell the active acid is not that actually filled in, but a lower hydrate or the anhydrous acid; in this manner it is possible to account for the cooling observed during the discharge of an "accumulator," as the separation of molecules of the acid from a solution (by dissociation) would, of course, involve cooling.

If, as Faraday has said, the forces termed chemical affinity and electricity are one and the same, there does not seem to be any reason why there should not be an integral conversion of the energy of chemical change, nor any necessarily valid objection to the view than an explanation of the discrepancies which have been observed is to be sought for in phenomena that prevent an integral "conversion" from being realised. Meanwhile, the determination of electromotive force may be of great service as enabling us to discriminate between a number of conceivable modes in which change may occur in a given case. Thus it is clear, for example, that whereas a metal like zinc is dissolved by, say, sulphuric acid in a circuit of which the hydrated, not the anhydrous, acid forms a part, metals like silver, mercury, lead and even nickel (compare Herroun, *loc. cit.*, p. 226) require to be coupled with, it may be, the anhydrous acid, but in any case, with one which is less hydrated than that which is active in the case of zinc; the anhydrous salts formed in such cases apparently undergo hydration outside the circuit of electrolytic change, and their hydration only affects the temperature of the cell, so that the phenomena are comparable with those which attend local action in a cell in which ordinary or imperfectly amalgamated zinc is used.

In other words, it is not a mere question as to what is present in a solution; the *compatibility* of the various substances must also be considered, and of this we know very little at present. Incompatible molecules may get in the way and hinder change, but only compatible molecules can co-operate in changes, so that we cannot simply write $C=\frac{E}{R}$, and treat R as the resistance of the solution as a whole in which the change takesplace; it may of ten be the resistance of circuits within the solution, the precise nature of which it is difficult, if not impossible, to determine.

It is impossible to doubt that, as a means of determining the precise character of the changes which may be going on in a complex system, the determination of the electromotive efficiency of various combinations will prove to be of the utmost importance. As a further illustration of the manner in which we may derive assistance from the introduction of such physical considerations, attention may be directed to the complex changes attending the action of metals on nitric acid, a subject which has long troubled the minds of chemists, and which has always exercised a special fascination over me. There is little, probably no hope, that we shall ever arrive at a satisfactory solution of this complex problem, so long as we regard it from a purely chemical point of view.

The observations of fundamental importance which must be first taken into account in discussing such changes are those of Millon (1842), Russel (1874) and Veley (1891), showing that silver, copper, &c., are not soluble in nitric acid free from nitrous compounds. In my opinion, however, these observations cannot be regarded as proof that nitrous acid is the solvent of the metal; the conclusion to be derived from them, I think, is of a far more interesting character.

Silver has a negative heat of dissolution, the value calculated from the data given by Thomsen being (at 18deg.):—

$$2Ag+2HNO_3, Aq = -51{,}580 \text{ gram-deg. C. units.}$$

This value, however, is reduced to - 40,700 if the heat of dissolution of silver nitrate be deducted. As the reduction of nitric acid to nitric peroxide ($2HNO_3 - O = N_2O_4, H_2O$), according to Thomsen, involves an expenditure of but 10,010 units, the oxidation by *nitric acid* of the hydrogen displaced by silver dissolving in nitric acid would give $68{,}360 - 10{,}010 = 58{,}350$ units, which is considerably in excess of the value $-51{,}580$, and still more so if the lower value corresponding to the formation of the anhydrous salt be taken. Silver, therefore, should be easily soluble in nitric acid if this acid can act as a *depolariser*. A still stronger case may be made out by considering the values for mercury and copper, as the heats of dissolution of these metals, although negative, are considerably lower than that of silver. Such facts appear to leave little room for doubt, and to justify the important conclusion that the nitrous compound is the active depolariser.

To conclude that such metals as bismuth, copper, mercury and silver are dissolved by nitrous acid, not by nitric acid, is to attribute to nitric acid properties which would make it entirely peculiar among acids, for it appears to be a characteristic property of acids generally to dissolve metals generally whenever the conditions are such that exothermic change can occur.

It seems to me that such problems can only be treated from an electrolytic standpoint, and the fact that we do not always so treat them is evidence of a most extraordinary failure on the part of chemists to apply Faraday's teachings. Unfortunately the physicists have also neglected this subject, having apparently left it to the chemists to discuss the changes attending the interaction of metals and acids; the result is blank ignorance of all that is fundamental with regard to such matters on the part of both chemists and physicists.

Objection has been taken to the use of the hypothesis of nascent hydrogen in explaining the effects produced with nitric acid. No doubt the conception is much misunderstood and misused; but it is, after all, a conception which cannot be put aside. Hydrogen undoubtedly is often displaced and brought into action without ever escaping from the circuit in which, and along which, it is displaced; "nascent" hydrogen, in fact, is but hydrogen in circuit, the hydrogen which is active at the surface of the plates in a Grove's gas battery, or which effects reduction when condensed in charcoal, being as much "nascent" in this sense as that displaced from water, say, by sodium amalgam in presence of a reducible substance. Moreover, the "activity" of such hydrogen depends entirely on its origin. This cannot be denied in face of the fact that if in cells of the Daniell type, for example, cadmium be substituted for zinc, not only is the electromotive force developed lower, but lower to the extent to which the heat of dissolution of cadmium in the acid used is less than that of zinc.

In dissolving metals in nitric acid we are but dealing with "cells" of the Grove type. If nitrous acid be in any way directly active as solvent of the metal, in all probability it can but act along with the nitric acid, and not to its exclusion; but it is useless to discuss this question further until we are sure that nitrous acid actually exists, and there is much reason to doubt this. As copper is readily dissolved by diluted sulphuric acid in presence of oxygen, although insoluble in the acid alone, it is inconceivable that nitric acid should not be equally active in presence of a sufficiently active depolariser—when the conditions are such, in fact, as are secured by the presence of oxygen together with copper and sulphuric acid, and a system is formed within which exothermic change is possible.

In all cases of chemical change energy is ultimately degraded, but in most cases a switchback rather than a simple inclined plane is the graphic analogue of a circuit of chemical change. Or, still better, we may liken it to a system of pipes laid up and down hill through which water is supplied to a town, in which case the function of the depolariser is comparable with that of the stand-

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pipe or accumulator at the pumping station, up and through which the water is forced in order to secure the head which is necessary to overcome the friction in the pipes and to cause water to mount the hills in the district supplied, as well as to raise it to the tops of the houses and in the fire mains. Such hydraulic systems can only be constructed of pipes which can be fitted together, just as chemical changes can only be brought about between compatible substances. Lastly, those who enjoy a constant service have no right to assume that the supply of water is automatic; on the contrary, a complex organisation which may altogether escape notice is required to secure it. And so it may be in the case of electrolysis and chemical change.

(To be concluded).

HIGH-VACUA RESEARCH.*

During the 56 years which have passed since Faraday first offended physical mathematicians with his curved lines of force, many workers and many thinkers have helped to build up the nineteenth century school of *plenum;* one ether for light, heat, electricity, magnetism; and the German and English volumes containing Hertz's electrical Papers given to the world in the last decade of the century, will be a permanent monument of the splendid consummation now realised. But, splendid as this consummation is, we must not fold our hands and think or say there are no more worlds to conquer for electrical science. We do know something now of magnetic waves. We know that they exist in nature and that they are in perfect accord with Maxwell's beautiful theory. But this theory teaches us nothing of the actual motions of matter constituting a magnetic wave. Some definite motion of matter perpendicular to the lines of alternating magnetic force in the waves and to the direction of propagation of the action through space there must be; and it seems almost satisfactory as a hypothesis to suppose that it is chiefly a motion of ether with a comparatively small but not inconsiderable loading by fringes of ponderable molecules carried with it. This makes Maxwell's "electric displacement" simply a to-and-fro motion of ether across the line of propagation—that is to say, precisely the vibrations in the undulatory theory of light according to Fresnel. But we have as yet absolutely no guidance towards any understanding or imagining of the relation between this simple and definite alternating motion, or any other motion or displacement of the ether, and the earliest known phenomena of electricity and magnetism—the electrification of matter, and the attractions and repulsions of electrified bodies; the permanent magnetism of lodestone and steel, and the attractions and repulsions due to it; and certainly we are quite as far from the clue to explaining, by ether or otherwise, the enormously greater forces of attraction and repulsion now so well known after the modern discovery of electromagnetism.

Fifty years ago it became strongly impressed on my mind that the difference of quality between vitreous and resinous electricity, conventionally called positive and negative, essentially ignored as it is in the mathematical theories of electricity and magnetism with which I was then much occupied (and in the whole science of magnetic waves as we have it now), must be studied if we are to learn anything of the nature of electricity and its place among the properties of matter. This distinction, essential and fundamental as it is in frictional electricity, electro-chemistry, thermo-electricity, pyro-electricity of crystals, and piezo-electricity of crystals, has been long observed in the old known beautiful appearances of electric glow and brushes and sparks from points and corners on the conductors of ordinary electric machines and in exhausted receivers of air pumps with electricity passed through them. It was also known, probably as many as 50 years ago, in the vast difference of behaviour of the positive and negative electrodes of the electric arc lamp. Faraday gave attention to it[1] in experiments and observations regarding electric sparks, glows and brushes, and particularly in his "dark discharge" and "dark space" in the neighbourhood of the negative electrode in partial vacuum. In [1523] of his 12th Series he says: "The results connected with the different conditions of positive and negative discharge will have a far greater influence on the philosophy of electrical science than we at present imagine." His "dark discharge" ([1544—1554]) through space around or in front of the negative electrode was a first instalment of modern knowledge in that splendid field of experimental research which, 15 years later, and up to the present time, has been so fruitfully cultivated by many of the ablest scientific experimenters of all countries.

The Royal Society's *Transactions* and *Proceedings* of the last 40 years contain, in the communications of Gassiot,[2] Plücker,[3] Andrews and Tait,[4] Robinson,[5] Cromwell Varley,[6] De la Rue and Müller,[7] Spottiswoode,[8] Moulton,[9] Grove,[10] Crookes,[11] Schuster,[12] J. J. Thomson,[13] and Fleming,[14] almost a complete history of the new province of electrical science which has grown up, largely in virtue of the great modern improvements in practical methods for exhausting air from glass vessels, culminating in Sprengel's mercury-shower pump, by which we now have "vacuum tubes" and bulbs containing less than 1/190,000 of the air which would be left in them by all that could be done in the way of exhausting (supposed to be down to 1mm. of mercury) by the best air pump of 50 years ago. A large part of the fresh discoveries in this province has been made by the authors of these communications; and their references to the discoveries of other workers very nearly complete the history of all that has been done in the way of investigating the transmission of electricity through highly-rarefied air and gases since the time of Faraday.

Varley's short Paper of 1871, which, strange to say, has lain almost or quite unperceived in the *Proceedings* during the 22 years since its publication, contains an important first instalment of discovery in a new field—the molecular torrent from the "negative pole," the control of its course by a magnet, its pressure against either end of a pivoted vane of mica according as it is directed by a magnet to one end or the other, and the shadow produced by its interception by a mica screen. Quite independently of Varley, and not knowing what he had done, Crookes[15] was led to the same primary discovery, not by accident, and not merely by experimental skill and acuteness of observation. He was led to it by carefully-designed investigation, starting with an examination of the cause of irregularities which had troubled[16] him in his weighing of thallium; and, going on to trials for improving Cavendish's gravitational measurement, in the course of which he discovered that the seeming attraction by heat is only found in air of greater than 1/1,000[17] of ordinary density; and that there is repulsion increasing to a maximum when the density is decreased from 1/1,000 to 36/1,000,000, and thence diminishing towards zero as the rarefaction is farther extended to density 1/20,000,000. From this discovery Crookes came to his radiometer, first without and then with electrification; and, powerfully aided by Sir George Stokes,[18] he brought all his work more and more into touch with the kinetic theory of gases; so much so that when he discovered the molecular torrent he immediately gave it its true explanation—molecules of residual air, or gas, or vapour projected at great velocities[19] by electric repulsion from the negative electrode. This explanation has been repeatedly and strenuously attacked by many other able investigators, but Crookes has defended[20] it, and thoroughly established it by what I believe is irrefragable evidence of experiment. Skilful investigation perseveringly continued brought out more and more of wonderful and valuable results: the non-importance of the position of the positive electrode; the projection of the torrent *perpendicularly* from the surface of the negative electrode; its convergence to a focus and divergence thenceforward when the surface is slightly concave; the slight but perceptible repulsion between two parallel torrents due, according to Crookes, to negative electrifications of their constituent molecules; the

* Extract from Lord Kelvin's Presidential Address to the Royal Society in November, 1893.

[1] "Experimental Researches," Series 12 and 13, Jan,, and Feb., 1838.

[2] *Roy. Soc. Proc.*, Vol. X., 1860, pp. 36, 269, 274, 432.

[3] *Roy. Soc. Proc*, Vol. X., 1860, p. 256.

[4] *Roy. Soc. Proc.*, Vol. X., 1860, p. 274; *Phil. Trans.*, 1860, p. 118.

[5] *Roy. Soc. Proc.*, Vol. XII., 1862, p. 202.

[6] *Roy. Soc. Proc.*, Vol. XIX., 1871, p. 236.

[7] *Roy. Soc. Proc.*, Vol. XXIII., 1875, p. 356; Vol. XXVI., 1877, p. 519; Vol. XXVII., 1878, p. 374; Vol. XXVIX., 1879, p. 281; Vol. XXXV., 1883, p. 292; Vol. XXXVI., 1884, pp. 151, 206; *Phil. Trans.*, 1878, pp. 55, 155; 1880, p. 65; 1883, 477.

[8] *Roy. Soc. Proc.*, Vol. XXIII., 1875, pp 356, 455; Vol. XXV., 1875, pp. 73, 547; Vol. XXVI., 1877, pp. 90, 323; Vol. XXVII., 1878, p. 60; Vol. XXIX., 1879, p. 21; Vol. XXX., 1880, p. 302; Vol. XXXII., 1881, pp. 385, 388; Vol. XXXIII., 1882, p. 423; *Phil. Trans.*, 1878, pp. 163, 210; 1879, 165; 1880, p. 561.

[9] *Roy. Soc. Proc.*, Vol. XXIX., 1879, p. 21; Vol. XXX., 1880, p. 302; Vol. XXXII., 1881, pp. 385, 388; Vol. XXXIII., 1882, p. 453; *Phil. Trans.*, 1879, p. 165; 1880, p. 561.

[11] *Roy. Soc. Proc.*, Vol. XXVIII., 1878, p. 181.

[11] *Roy. Soc. Proc.*, Vol. XXVIII., 1879, pp 347, 477; *Phil Trans.*, 1879, p. 641; 1880, p. 135; 1881, 387.

[12] *Roy. Soc. Proc.*, Vol. XXXVII., 1884, pp. 78, 317; Vol. XLII., 1887, p. 371; Vol. XLVII., 1890, pp. 300, 506.

[13] *Roy. Soc. Proc.*, Vol. XLII., 1887, p. 343; Vol. XLIX., 1891, p. 84.

[14] *Roy. Soc. Proc.*, Vol. XLVII., 1890, p. 118.

[15] *Roy. Inst. Proc.*, Friday evening lecture, April 4, 1879, Vol IX., p. 138 *Roy. Soc. Trans.*, 1874, "On Attraction and Repulsion Resulting from Radiation." Part II., 1876; Parts III. and IV., 1876; Part V., 1878; Part VI., 1879.

[16] Tribulation, not undisturbed progress, gives life and soul, and leads to success when success can be reached, in the struggle for natural knowledge

[17] Crookes, "On the Viscosity of Gases at High Exhaustions," § 655, *Phil Trans.*, February 1881, p. 403.

[18] *Phil. Trans.*, Vol CLXXII. (1881), pp. 387, 435.

[19] Probably, I believe, not greater in any case than 2 or 3 kilometres per second.

[20] Presidential Address to the Institution of Electrical Engineers, 1891.

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change of direction of the molecular torrent by a neighbouring magnet; the tremendous heating effect of the torrent from a concave electrode when glass, metal, or any ponderable substance is placed in the focus; the phosphorescence produced on a plate coated with sensitive paint by a molecular torrent skirting along it; the brilliant colours—turquoise-blue, emerald, orange, ruby-red—with which grey colourless objects and clear colourless crystals glow on their struck faces when lying separately or piled up in a heap in the course of a molecular torrent; "electrical evaporation" of negatively electrified liquids and solids;[21] the seemingly red-hot glow, but with no heat conducted inwards from the surface, of cool solid silver kept negatively electrified in a vacuum of 1/1,000,000 of an atmosphere, and thereby caused to rapidly evaporate. This last-mentioned result is almost more surprising than the phosphorescent glow excited by molecular impacts in bodies not rendered perceptibly phosphorescent by light. Both phenomena will surely be found very telling in respect to the molecular constitution of matter and the origination of thermal radiation, whether visible as light or not. In the whole train of Crookes' investigations on the radiometer, the viscosity of gases at high exhaustions, and the electric phenomena of high vacuums, ether seems to have nothing to do except the humble function of showing to our eyes something of what the atoms and molecules are doing. The same confession of ignorance must be made with reference to the subject dealt with in the important researches of Schuster and J. J. Thomson on the passage of electricity through gases. Even in Thomson's beautiful experiments showing currents produced by circuital electromagnetic induction in complete poleless circuits, the presence of molecules of residual gas or vapour seems to be *the essential*. It seems certainly true that without the molecules there could be no current, and that without the molecules electricity has no meaning. But in obedience to logic I must withdraw one expression I have used. We must not imagine that "presence of molecules is *the* essential." It is certainly *an* essential. Ether also is certainly *an* essential, and certainly has more to do than merely to telegraph to our eyes to tell us of what the molecules and atoms are about. If a first step towards understanding the relations between ether and ponderable matter is to be made, it seems to me that the most hopeful foundation for it is knowledge derived from experiment on electricity in high vacuum; and if, as I believe is true, there is good reason for hoping to see this step made, we owe a debt of gratitude to the able and persevering workers of the last 40 years who have given us the knowledge we have; and we may hope for more and more from some of themselves and from others encouraged by the fruitfulness of their labours to persevere in the work.

NEW PROPERTIES OF CATHODE RAYS.*

BY JEAN PERRIN.

(I.) Two hypotheses have been brought forward to explain the properties of cathode rays. Some, like Goldstein, Hertz and Lenard, think that the phenomenon, like light, is due to etherial vibrations[1] and even that it is short-wave light. From this it would follow that these rays would have rectilinear propagation, would excite phosphorescence, and impress photographic plates. Others, like Crookes and J. J. Thomson, think the rays are due to negatively-charged matter moving at a high speed. From this their mechanical properties would follow, also the manner in which they are deflected in a magnetic field. This last hypothesis suggested certain experiments to me which I propose to briefly describe without troubling myself for the moment whether the hypothesis accounts for all the facts known up to the present or whether it alone can do so. The supporters of this hypothesis assume that the cathode rays are negatively charged. So far as I know, this electrification has not been ascertained. I, therefore, first tried to discover whether or no it existed.

(II.) To effect this I had recourse to the laws of influence, which enable us to ascertain the introduction of electric charges within a closed conducting envelop and to measure these charges. I therefore caused the cathode rays to penetrate into a Faraday cylinder. To this end I employed the vacuum tube represented in Fig. 1, in which A B C D is a metallic cylinder closed everywhere except at a little opening in the centre of the face B C. This played the part of the Faraday cylinder. A metal wire soldered at S to the wall of the tube placed the cylinder in communication with an electroscope. E F G H is a second metallic cylinder *in permanent communication with earth* and pierced only by two small openings at β and γ. It protects the Faraday cylinder against all external influence. Finally at about 0·1 metre in front of F G there is an electrode N, which served as the cathode, the anode being formed by the protecting cylinder E F G H.

When a cathode beam penetrated into the Faraday cylinder it invariably became charged with negative electricity. The exhausted tube could be placed between the poles of an electro-magnet. When this was excited the cathode rays, being deflected, no longer entered the Faraday cylinder and the cylinder was not charged; it became charged the moment the electro-magnet was no longer excited.[2] In short, the Faraday cylinder is negatively charged when the cathode rays penetrate it, and only when they do so: *cathode rays are therefore charged with negative electricity.*

It is possible to measure the quantity of electricity which these rays convey. I have not completed this investigation, but I may give an idea of the order of the amount of the charges obtained when I state that with one of my tubes at a pressure of 20 microns[3] of mercury, and for a single interruption of the primary coil, the Faraday cylinder received sufficient electricity to bring a capacity of 600 C.G.S. units to a potential of 300 volts[4].

(III.) Cathode rays being negatively charged, the principle of the conservation of energy induced me to search for the corresponding

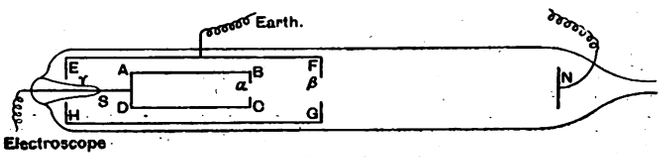

FIG. 1.

positive charges. I believe I have found them in the very region where the cathode rays are generated, and that they travel in the reverse direction and precipitate themselves on to the cathode.

To verify this hypothesis we have only to make use of a hollow cathode, pierced by a small aperture, through which the attracted positive Electricity may enter. This electricity can then act on a Faraday cylinder inside the cathode. The protecting cylinder E F G H, with its opening β, fulfilled these conditions. I therefore employed it this time as cathode, the electrode N being the anode. The Faraday cylinder was then invariably charged with *positive electricity* of the same order of quantity as the previously-obtained negative charge. Hence at the same time that the negative electricity is radiated from the cathode; positive electricity travels towards the cathode.

I experimented to discover whether this positive flux formed a second system of rays absolutely symmetrical with the first.

(IV.) For this purpose I constructed a tube (*see* Fig. 2) analogous to the first, with the exception that between the Faraday cylinder and the opening β there was a perforated metallic diaphragm, β', so that the positive electricity which had entered through β could only act on the Faraday cylinder by traversing also the diaphragm β'. I then repeated my former experiments.

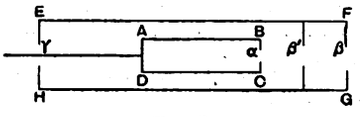

FIG. 2.

When N was the cathode the cathode rays emitted traversed the two apertures at β and β' without any difficulty, and caused the gold leaves of the electroscope to diverge widely. But when the protecting cylinder was the cathode, the positive flux, which, as was shown by a previous experiment, enters by the aperture β, did not succeed in separating the gold leaves, except at very low pressures. If we substitute an electrometer for the electroscope we shall see that the action of the positive flux is real, but that it is very small, and increases as the pressure decreases. In a series of experiments at a pressure of 20μ this action brought a capacity of 2,000 C.G.S. units to 10 volts, and at a pressure of 3μ, in the same time, to 60 volts.[5]

By means of a magnet the action could be completely suppressed.

(V.) These results, taken as a whole, do not appear to be easily reconcilable with the theory that cathode rays are ultra-violet light. On the contrary, they support the theory that attributes these rays to radiant matter, a theory which may at present, it seems to me, be enunciated as follows:—In the vicinity of the cathode the electric field is sufficiently strong to tear asunder *into ions* some of the molecules of the residual gas. The negative ions start off

Roy. Soc. Proc., June 11, 1891.

* *Comptes Rendus*, Vol. CXXI., No. 27, p. 1130.

[1] These vibrations might be something else than light. Quite recently Herr Jaumann, whose hypotheses have been criticised by M. H. Poincaré, suggested longitudinal vibrations.

[2] All these experiments succeeded equally well with an induction coil or with a Wimshurst machine.

[3] [1 micron = 10^{-6} mètre = $\frac{1}{1000}$th of a millimetre.—ED. *E.*]

[4] [300 volts = 1 C.G.S. electrostatic unit.—ED. *E.*]

[5] The rupture of the tube has temporarily prevented me from studying the phenomenon at lower pressures.

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towards the region where the potential increases, acquire a considerable velocity and form cathode rays; their electric charge, and consequently their mass (at the rate of one gramme-equivalent per 100,000 coulombs), is easily measured. The positive ions move in the reverse direction; they form a diffused tuft, susceptible to magnetism, but are not a regular radiation.[6]

ALL SORTS AND CONDITIONS OF RAYS.

The *Comptes Rendus* for January 27th and February 3rd contain numerous communications on X and other rays, of which communications we give a brief summary below :—

On. p. 188 of the *Comptes Rendus* for January 27th there is a Paper by M. Gustave Le Bon, entitled "Dark Light." M. Le Bon states that recent announcements on the subject of the photographic power of rays emanating from the cathode compels him to make public some researches, still incomplete, which he has been carrying out for the past two years on photography behind bodies opaque to ordinary light. M. Le Bon states that his experiments prove that ordinary light, or at least certain rays, traverse the most opaque bodies without difficulty. "Opacity is a phenomenon which only exists for an eye like ours; constructed a little differently, it could see through a brick wall."

The following is M. Le Bon's own description of what he has done :—"In an ordinary positive photographic frame introduce a sensitive plate, and above it a photographic *cliché*, then above the *cliché*, and in intimate contact with it a sheet of iron entirely covering the front face of the frame. Expose the plate thus masked by the metal sheet to the light of a petroleum lamp for about three hours. A strong and very prolonged development of the sensitive plate, pushed to complete blackening, will give a very pale but very clear image of the *cliché*. We need only slightly modify the previous experiment to obtain images almost as good as if no obstacle had been interposed between the source of light and the sensitive plate. Without altering the arrangement just described, place behind the sensitive plate a sheet of lead of any thickness and bend down its edges so that they just cover the sides of the iron plate. The sensitive plate and the *cliché* are thus imprisoned in a sort of metal box, the front of which is formed by the sheet of iron, and the back and sides by the sheet of lead. After three hours' exposure to the light of the petroleum lamp, as before, we shall obtain, after development, a good image. . . . Solar light yields the same results as a petroleum lamp, and does not appear to be very much more active. Cardboard and metals, especially iron and copper, are easily traversed by light. The passage of light through the most opaque bodies is only a question of time."

In the *Comptes Rendus* for February 3rd, p. 233, M. Le Bon describes the precautions who took to eliminate any possible effect due to light "stored up" by the *clichés* previous to the experiment. He only employed *clichés* which had been in contact with the sensitive plate in the dark for a whole day without producing any effect. As to heat being a possible cause of the phenomenon, M. Le Bon kept sensitive plates in contact with *clichés* for 12 hours at a temperature of 50°C. without getting a trace of an image. Photographic effects have been obtained by M. le Bon through aluminium, copper and iron sheets from 0·5mm. to 0·8mm. thick. Photographers' black paper, in spite of it being only about 0·02mm. thick, is only slightly transparent to these rays, whilst, as will be remembered, it is very transparent to cathode rays.

On p. 235 of the same number, MM. L. Benoist and D. Hurmuzescu present a Paper on "New Properties of the X-rays." These gentlemen experimented on the effects of X-rays on an electrically-protected electrified Hurmuzescu electroscope about 20cm. distant from the Crookes tube. Using various laminæ in the window of the metallic cover of the electroscope, they found that X-rays immediately and completely discharged the electroscope, though *more rapidly in the case of negative charges than in the case of positive.*

On p. 237 M. Albert Nodon states that he finds he cannot get any appreciable impression on a sensitive gelatino-bromide of silver plate exposed for 15min. behind several thicknesses of black paper to a 20-ampere arc at a distance of 40cm. Using orthodox Röntgen rays he finds that they are not differentially affected by differently coloured media—all colours appear to come alike to Röntgen rays.

On p. 237 M. V. Chabaud describes some experiments on the transparency of rectangular metallic laminæ, 0·2mm. thick, 35mm. long, 7mm. broad, arranged side by side on a piece of cardboard, and crossed by a transverse lamina of platinum $\frac{1}{10}$mm. thick. With a 45min. exposure and a 7cm. spark coil, he found that the platinum alone was quite opaque. He experimented with 0·2mm. strips of lead, zinc, copper, amalgamated zinc, tin, steel, gold, silver, aluminium and platinum. Mercury 0·1mm. thick was as opaque as the platinum.

On p. 238 M. G. Moreau has a communication on "The Photography of Metallic Objects through Opaque Substances by Means of the Brush Discharge of an Induction Coil without a Crookes Tube." The discharge was produced by a coil, worked by a 6-ampere current, between a positive point and a small plate or one or more negative points. The sensitive plate, with the object to be photographed (a one millimetre thick aluminium wheel), were placed inside a completely closed cardboard box. The box could be placed at right angles or parallel to the discharge, and could be separated from it by cardboard or a wooden screen 0 005 mètre thick. No result was obtained with the discharge at right angles to the box. Six photographs with the discharge parallel gave absolutely clear, strong negatives. Two photographs taken through wood showed the existence of decided absorption of the rays and of the appreciable refraction. Exposure varied from half an hour to one hour. Up to the present no results have been obtained with the discharge from an electrostatic machine.

[6] This research was carried out in the laboratory of the École Normale, and in M. Pellat's laboratory at the Sorbonne.

In this connection the following letter appearing in the current issue of *Nature* is of great interest :—

"A brief account of some experiments which I have been making in my laboratory at Blythswood, in connection with the new photographic rays, may, I hope, be of interest to the readers of *Nature*.

"Three or four years ago I constructed a very powerful Wimshurst electrical machine It has 128 plates, three feet in diameter, and is driven by an electric motor of about 1½ horse-power. With this machine, which was specially built for quantity, I can obtain a torrent of sparks a foot and half or two feet long; and it occurred to me to try to obtain photographs, after the manner of Röntgen, but without the intervention of a vacuum tube."

"A thick sheet of lead was placed upright between the poles of the electric machine, as a screen, and was connected to the ground, the two poles being insulated. A sensitive dry plate was put into the camera dark slide, with a metallic object to be photographed (a steel washer with holes in it), and this was connected, by a wire which passed out of the dark slide to the ground. The whole was wrapped up in four folds of a black velvet focussing cloth, and was put in some cases between the negative pole and the lead screen and in other cases between the positive pole and the lead screen, the plane of the slide being perpendicular to the line of discharge. In all cases good strong negatives were obtained with exposures of about twenty minutes. The machine was arranged to give a silent brush discharge during the experiments.

"I next tried similar experiments with the dark slide containing the sensitive plate quite out of the line of discharge, and with the plane of the plate parallel to the line of discharge, and obtained equally good results. It seems, therefore, that the vacuum tube is not essential to the production of the Röntgen rays. With reference to this, however, I am not so sure, as I think I may have been deceived by using isochromatic plates—at all events I am engaged in further experiments either to confirm or the contrary. Blythswood.

"Blythswood, Renfrew, February 10th."

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

New York, *February 1, 1896.*

Acetylene Gas.—The only enlivening feature at present relating to electrical affairs is furnished by discussions concerning acetylene gas. The promoters of the Willson patent are apparently making desperate efforts to dispose of stock, going so far as to fill entire pages in the daily press with "reading articles" setting forth the revolution which the new gas will cause in illuminating methods. In the West central station owners are being urged by agents to purchase the local right of manufacturing the gas, the argument being that their present electrical plant can be utilised in the manufacture of calcic carbide instead of, as otherwise would be the case, becoming a total loss in a few months from the competition of acetylene gas. The official estimates place the cost of manufacturing one ton of calcic carbide at $20·72, based upon a cost of $10 for a yearly 24-hour horse-power delivered. At the works now being built at Niagara the Acetylene Company will have to pay $20 per annual horse-power, and since the illuminating value of acetylene, as determined by disinterested experimenters, has been found to be only eight times greater than that of ordinary coal gas, it follows that, on the basis of the Company's own estimate, the equivalent cost of manufacture of the new gas will thus be over 40 cents per thousand. In the States, the *cost* of coal gas delivered into gasometers is as low as 17 cents per thousand, or less than half that claimed for the new

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competitor by its promotors. In order, apparently, to avoid application of figures showing the large cost of distribution under present methods, it is proposed to furnish the gas in cylinders, much stress being laid upon the advantages of this method. The programme includes even the displacement of petroleum, as it is stated that small cylinders for use with portable lamps will be furnished.

LEGAL INTELLIGENCE.

Gaskell and Another v. Gosling.

This case came before the Court of Appeal (consisting of the Master of the Rolls and Lords Justice Lopes and Rigby) on Wednesday, and was an appeal by the defendants in the action Gaskell and Grocott v. Francis and Cunliffe Gosling (reported in *The Electrician* of December 6th last) from a judgment of the Lord Chief Justice. The plaintiffs are makers of porcelain parts of electrical apparatus, and carry on business at Longport, Staffs., and brought their action to recover from the defendants, who are members of the banking firm of Gosling and Sharpe, £488. 9s. 3d., under the circumstances reported in our Dec. 6th issue. The action raised the all-important question as to whether trustees for debenture-holders who appointed a receiver to carry on the business of a company which was in liquidation were themselves liable to pay for goods sent into the receiver. The goods in question were so supplied, and when payment was asked for it was said that the goods were supplied to the Company, and that the Company must be looked to for payment. Down to 1892 Messrs. Poole and White (Limited) carried on business in Bread-street, and they also had a factory in Kentish Town. It appeared that they had become indebted to Messrs. Gosling and Sharpe to the amount of about £3,000, which was secured by a trust deed executed in favour of the defendants—two members of the firm, one of whom had died since the commencement of the action. On July 22, 1892, the trustees certified that the debenture holders' security was in peril, and thereupon the debenture holders appointed a man named Kelly as Receiver. On September 1st a petition was presented by a creditor to wind up the Company, under which, on September 14th, a compulsory order was made. After the winding up order the business was carried on by Kelly. In 1893 the plaintiffs called at the office and saw Kelly, and ascertained that the business was being carried on for the benefit of the debenture holders, and from time to time they took orders and supplied goods to Kelly in his capacity, as they alleged, of receiver. Three sets of debentures, amounting to £11,000, had been issued, the first being for £7,000, the second for £3,000 (those held by the defendants), and the third for £1,000. But Kelly being appointed, as above stated, on behalf of the second set of debenture holders, it was not until February, 1895, that the first debenture holders came in and turned him out. While Kelly was carrying on the business over £700 worth of goods were delivered to him by the plaintiffs; but by means of small credits that sum had been reduced to the amount claimed. The Lord Chief Justice in giving judgment, said that it was necessary for Kelly to obtain money or credit to carry on the business, and that when he was appointed Receiver he disclosed the fact that he was Receiver, and he held that the defendants were undisclosed principals, and he gave judgment for the plaintiffs for the amount claimed with costs.

Mr. JELF, Q.C., who appeared with Mr. Hamilton for the appellants (the defendants), contended that by the terms of the trust deed under or by virtue of which Kelly was appointed Receiver he was distinctly made the agent of the Company, and that even after the Company had gone into liquidation he was as personally liable as if he had had no principal behind him—as a Receiver appointed by the Court.

The MASTER of the ROLLS: He was appointed with authority to carry on the business.

Mr. JELF: Yes, but in doing so the defendants were simply exercising the power given them by the deed for the protection of their security, and by the terms of which deed the Receiver was made expressly the agent—as would be expected—of the Company. He had no business to pledge anybody's credit.

The MASTER of the ROLLS said that Kelly in point of law was the manager for the defendants.

Mr. JELF replied that the very object of the appointment was not to cast any present or future liabilities on the debenture holders, but to give them greater security.

The MASTER of the ROLLS: Could Kelly have disobeyed any orders given him by the trustees?

Mr. JELF: Yes, certainly; he was under no orders from the trustees.

The MASTER of the ROLLS: Could they have dismissed him at any moment?

Mr. JELF replied that the trustees had that power, as they could not be bound for ever to a man who turned out to be an unsatisfactory man.

The MASTER: If they directed him to give a certain order, and he disobeyed it, could they have dismissed him?

Mr. JELF: If they were not satisfied with the way he was going on, they had power to put somebody else in his place.

Mr. REED for the respondents argued that the decision to which the Lord Chief Justice had come was the right one, and ought to be upheld. He submitted that it was very difficult to see how a receiver, as such, could do what Kelly was authorised to do and did. A Receiver, as such, he contended, would only be Receiver of the mortgaged premises. The defendants had used the original term in the deed and called Kelly a Receiver, and proceeded to give him powers which no Receiver ever could have. The powers which Kelly had were incident to an agent for debenture holders—incident to a manager of a business, but not incident to a Receiver.

The MASTER of the ROLLS: The whole question seems to me to be whether the Trustees appointed Kelly as the Company's manager or whether they appointed him as their own.

The contentions of the parties having been further discussed,

LORD JUSTICE LOPES said there was evidence to show that Kelly was carrying on the business as receiver for somebody, because the form in which the goods were ordered where, so and so, "Kelly, Receiver," upon which Lord Justice Rigby remarked that he was carrying it on for the benefit of all whom it might concern, and not only for the trustees.

After counsel on both sides had briefly replied, their Lordships intimated that they would give judgment this (Friday) morning.

Clarke v. Julius Sax & Co., Limited.

In the Chancery Division, on Friday last, a motion was made on behalf of Messrs. Julius Sax & Co. to rectify the register of designs by striking off the registered design No. 206,807, registered by John C. Clarke, on the ground that it was not novel and that similar designs had been used before. The design consisted of a lamp used for an electric lamp to light shop windows, and was practically identical or similar to lamps used for this purpose before.

The motion was opposed on the ground that the design was novel, inasmuch as it had been adapted and applied to electric lights.

For the motion it was urged that the design of a lamp had been used for gas, and the fact that it was now used for electricity did not make it a novel lamp. Many similar lamps had been used for gas before, and it was impossible for the plaintiff to get protection because he had adapted the lamp to electricity, any more than if he removed the electricity and put in gas.

Mr. S. EADY, Q.C., for the plaintiff, said he had cross motion against the defendants for infringement.

It was arranged to treat both motions as one.

Mr. V. SMITH, Q.C., for Messrs. Sax, said that if his Lordship was against him on the motion to rectify, he should submit that his lamp was not an infringement, and that, looking at the lamps that were in the market at the time, it was not a fraudulent design or an imitation of the plaintiff's lamp.

Mr. EADY said that the plaintiff and the defendants were not strangers, as the latter had entered into an agreement with the plaintiff for the supply of certain lamps, and there was an action now pending in the Queen's Bench Division because the defendants had obtained lamps from somebody else in direct breach of the agreement.

Mr. Justice NORTH, in giving judgment, said that in his opinion both the motions failed. He could not say the plaintiff's design was so entirely without novelty that it ought not to be registered, and in his opinion the defendants were not infringing the plaintiff's rights in what they had done. The result was he must dismiss both motions, and there would be a set-off as to costs.—Judgment accordingly.

South v. Dadge and Co.

In the Westminster County Court, on Tuesday, an application was made to commit the defendants to Holloway for non-payment of a judgment debt. The principal point to be decided was who were the partners in the firm of Dadge and Co., electrical engineers, against whom judgment had been obtained. One of the defendants, Mr. Nelson Dadge, stated that at the time the goods were delivered the sole proprietor was his father (Mr. Charles Dadge) who was a retired farmer and knew nothing whatever about electrical work; he was the electrician, but at this time he was an infant. In May last his father sold the business to himself and Mr. W. A Fraser, but as witness was unable to find the necessary capital the partnership was dissolved. The business was now being carried on by Fraser, under the style of Dadge and Fraser. His Honour (Judge Lumley Smith) decided that the firm of Dadge and Co., was Charles Dadge, and pointed out that, even if Nelson Dadge was liable, he was an infant at the time the debt was contracted. He had no doubt the affair was a juggle, and plaintiff had been cheated out of his money. No order was made on the present application, but leave was given to amend the summons so as to be against Charles Dadge, trading as Dadge and Co.

South Staffordshire Tramways Company v. Ebbsmith & Wain.

An action was heard before the Lord Chief Justice on Wednesday, which was brought to recover damages from Mr. Joseph Ebbsmith and Mr. W. J. Carruthers Wain for alleged fraudulent conspiracy by which, while occupying a fiduciary position, they had induced the plaintiff Company to purchase from them certain unnecessary land and worthless patents; and also to recover secret profits and monies of the Company alleged to have been employed by the defendants in packing meetings of shareholders; and for the recission of the contracts for the purchase of the said land and patents. The defendants denied the allegations. An imposing array of counsel were engaged in the case, which occupied the whole of Wednesday, and was continued yesterday (Thursday). Much conflicting evidence was adduced.

Lazare Weiller and Co. v. Bolton and Sons.

The hearing of this action was resumed in the Queen's Bench Division on Friday last. Full particulars were given in our last issue, and Mr. Justice Mathew, in giving judgment, said he had come to the conclusion that there was no ground whatever for imputing to M. Weiller that he had made any misrepresentation to the defendants, and that the defendants were bound by the contract. As to the letter written by M. Weiller, that was a contract binding on the plaintiffs, and the defendants were entitled to counter claim in respect of it. The question of damages would stand over for further argument. He hoped the parties would come to some arrangement.

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d., abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations issued February 6th.

NEW BOOKS AND EDITIONS.

The following New Books and Editions of "THE ELECTRICIAN" SERIES *can be obtained of the Booksellers or direct from the Publishing Offices :—*

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many origina illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.), Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

TENDERS INVITED.—The Vestry of the parish of St. Mary, Islington, invite tenders for the supply of electrical and engineering stores, manhole and other covers, castings, and other iron-work, &c. Tenders must be sent to Mr. Wm. F. Dewey, Vestry Clerk, Vestry Hall, Upper-street, N., by 12 o'clock on the 23rd inst.

——— The Corporation of Sunderland invite tenders for steam engines, continuous-current dynamos, water-tube boilers, fuel economiser, water-softening plant, and cast-iron tank. Specifications, &c., can be obtained at the office of the Borough Electrical Engineer, the Electric Supply Station, Sunderland, and tenders must be sent to Mr. Fras. M. Bowey, Town Clerk, not later than 5 p.m. on Friday, the 13th March. Further particulars are given in our advertisement columns.

——— The French Authorities require tenders for the supply of 125 tons of bronze or copper wire. Tenders to the Direction Générale des Postes et des Telegraphes, 103, Rue de Grenelle, Paris, by the 27th inst.

——— The Bridlington District Council require tenders for the lighting of the public streets for one year from March 31, 1896. Tenders to the clerk, Mr. C. Gray, Bridlington, by the 17th inst.

——— Tenders are being invited by the Cuckfield (Sussex) Board of Guardians for a telephonic installation at the workhouse premises.

TENDERS ACCEPTED.—The Corporation of Birkenhead have accepted the tender of Messrs. Drake and Gorham for wiring the Town Hall for the electric light. The amount of the tender was £215.

——— The Electric Lighting and Tramways Committee of the Blackpool Town Council have accepted the tender of the Lancaster Carriage and Railway Company for two new tramcars, and the tender of Messrs. Crompton and Co. for motors, exciters and fittings.

TENDERS ACCEPTED.—The Portsea Guardians received nine tenders for installing the electric light in the Hospital and Imbecile block. The tenders ranged from £174 to £305. It was decided to accept the lowest tender, that of Mr. T. H. Sotheby.

——— The Bradford Town Council have accepted the tender of Messrs. Siemens Bros. and Co. for the supply of two dynamos for the proposed new electricity works in Valley-road for £2,650, and the tender of Messrs. Willans and Robinson for the supply of two 600 I.H.P. steam engines for £4,400.

——— The Harrogate Town Council have accepted tenders for building work in connection with the erection of their electric lighting station. The whole of the accepted tenders amount to about £3,100.

TENDERS RECEIVED.—The St. Pancras Vestry received twenty-five tenders for wiring and fitting up the Vestry Hall and offices for the electric light, but at the last meeting of the Vestry it was stated that no authority had been given for the issuing of advertisements inviting these tenders, and therefore the question of the acceptance of a tender was deferred for the present, and the whole matter referred back to committee for reconsideration. The tenders received varied in amount from £304. 6s. 6d. (Messrs. Laing, Wharton and Down) to £553. 11s. 3d. (Maple and Co., Limited).

PARTNERSHIP.—Messrs. Fred. A. Donnison and Fred. Berlyn inform us that they have started business as electrical engineers, and will trade under the style of "Fred. A. Donnison, Berlyn and Co.," at 8, Great Portland-street, W.

BUSINESS CHANGE.—The business of patent agents and consulting engineers, which has hitherto been carried on the titles of Fell and Wilding and Fell and James respectively, will in future be carried on under the sole title of Fell and James.

MAN WANTED.—The authorities of the Hospital for Consumption, Brompton, require an experienced man to take charge of their electric lighting plant.

LIQUIDATION.—At a meeting of the proprietors of the Electric Novelty Syndicate (Limited), on January 13th, it was resolved to wind up the Company voluntarily. This resolution was confirmed at a meeting on January 27th, when Mr. G. F. Haskins, 18, Walbrook, E.C., was appointed liquidator.

BANKRUPTCIES.—The public examination of George Isaac Reekes, lately carrying on business as an electrical engineer at Shrewsbury, took place at the County Court, Shrewsbury, on Tuesday last. The bankrupt's liabilities amounted to £906. 11s. 11d., and the assets to £137. 0s. 4d. The debtor stated that in 1893 he was manager to the Worcester Electric Light Company, and in July of that year started in business on his own account. He had little or no capital of his own, but he had borrowed £380, and in addition he had received money from relatives who did not now claim from the estate. Altogether he had lost £1,026 in two and a-half years, and he attributed his losses to want of sufficient capital at starting and to loss upon some of his contracts. The examination was adjourned in order that the debtor might produce further accounts.

——— Notice is given that all claims against the estate of Philip C. Pope, late electrical engineer, 6, Castle-street, Hapton, near Burnley, must be sent in to the trustee, Mr. T. Edelston (Official Receiver), Preston, by the 20th inst.

——— At the Halifax Bankruptcy Court, on Tuesday, a Receiving Order was made against Charles Frederick Fox, electrical engineer and contractor, of 1, Bond-street, Leeds. The liabilities are estimated to amount to £460.

PRITCHETT ACCUMULATORS.—Mr. J. A. Newton, of Cromwell-buildings, Melbourne, has been appointed by Messrs. Pritchetts and Gold as sole agent for their accumulators for Australia.

THE "JOURNAL."—Part 119 is now ready of the *Journal* of the Institution of Electrical Engineers, containing Papers on "The Electric Wiring Question," by F. Bathurst, and "Concentric Wiring," by Sam Mavor, price 2s. 6d.

THE TELEGRAPH WIRE EXPORT TRADE.—The value of the exports of telegraph wire and apparatus from this country during the last month amounted to £57,224, as compared with £296,145 in December. The respective totals for January, 1895 and 1894, were £35,193 and £18,738.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The fourteenth annual issue of this publication is now ready. The new volume is very up-to-date, and even contains the revised Board of Trade Regulations issued last week. The Directorial Section of the work is equally forward, and will be found to contain corrections and new names and addresses complete up to the 5th of the current month.

CATALOGUE.—Messrs. H. M. Salmony and Co., of Charing Cross-road, W.C., forward us a copy of their 1896 catalogue. Particulars

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and prices of a great variety of electric light fittings and apparatus are given, including switches, cut-outs and ceiling roses, cables and wires, wiremen's tools, jointing materials and accessories, the "H.M.S." measuring instruments, incandescent and arc lamps, lamp holders, sockets, dynamos and motors, electric bells and indicators, telephones, Leclanché cells, storage batteries, &c. Various tables are given, and the catalogue also includes a suitable index. Messrs. Salmony notify us that in consequence of the great demand for their instruments and accessories, they have been compelled to transfer the manufacture of accessories to separate works at Cheapside, Birmingham, where they have laid down extensive plant, which will enable them to execute orders with dispatch.

CATALOGUE.—We have received from Messrs. P. R. Jackson and Co., of the Salford Rolling Mills, Manchester, a copy of Section A catalogue and price list. This is well illustrated, and the views of the works, shops, yards and foundries which introduce the book show that Messrs. Jackson and Co. are in a position to execute orders for electrical and general engineering plant of any magnitude. The catalogue before us deals chiefly with machine-moulded tooth, spur and bevel wheels, steel roll pinions, fly-wheels, castings, pulleys, and a large assortment of patterns for steel boiler blocks. Messrs. Jackson and Co. claim to have made ten times as many machine-moulded tooth wheels as any other makers, and an important testimony to the care which is used in their manufacture is shown in a letter from the Engine, Boiler and Employer's Liability Assurance Company, Limited, in the annual report of which Company some time back reference was made to the number of breakdowns in tooth-gearing for main-driving. Messrs. Jackson and Co. received at the time the satisfactory assurance that none of the breakdowns referred to occurred to wheels made by their firm. The groups of steel castings which are given in the photographic illustrations accompanying the catalogue show in a very clear manner the great variety of articles of this class which are turned out by Messrs. Jackson and Co., and certainly justify the claim of the firm of occupying a foremost position in this branch of trade. A very useful set of tables of wheel patterns is given. The catalogue is most complete and handily arranged, and should be of special use to electric traction engineers and other users of geared electric motors. Messrs. Jackson and Co. have been particularly successful in their electrical department, and have large orders on hand, including eight dynamo machines of 270 kilowatts each.

ABERDEEN.—The Docks and Pilotage Sub-Committee, which was recently appointed to consider the question of the electric lighting of the harbour, before coming to a final decision in the matter have decided to obtain information from other ports where electric light has been introduced.

AMBLESIDE.—At the last meeting of the District Council the Electric Lighting Committee recommended the Council to oppose the application of the Windermere and District Electric Supply Company for a Provisional Order, and that the Council themselves apply for an order to supply electric current. The recommendations were agreed to.

BEDFORD.—At the last meeting of the Urban Sanitary Authority the Electric Light Committee reported that the work in connection with the public electric lighting was proceeding satisfactorily, and that they proposed to remove the gas standards in the area in which the electric lamps had been erected, and they therefore recommended that the arrangements in connection with the removal be left in their hands. Mr. Miller, in criticising this report, started by stating that he was not going to speak of his connection with the gas company, but he thought the order for the removal of the gas lamps should come from the Authority and not the Committee, and he complained that "since he had been shunted off the Committee he had not been able to get any information." Mr. Taylor said that the gas company had duly received six months' notice that they would not want the lamps after a certain date. Mr. Miller then argued that this notice only referred to the supply of gas light, and that it had no reference to the removal of the standards. After considerable discussion the report was approved. A letter was then read from Messrs. Sharman and Trethewy, on behalf of the gas company, complaining of the manner in which the electric light cables were being laid, and of their proximity to the gas mains. It was decided to ask the gas company to allow the Committee to take a tracing of their maps, showing the positions of the existing gas mains and other underground works, and to ask the Company to give three days' notice when the Company intended to dig up the ground on the electric light mains. The Committee further recommended that the Authority borrow £12,500 on account of the loan of £27,000 already sanctioned, for carrying out the following work:—For public lighting only, St. Mary's, St. John's and all the streets east of the Hitchen railway (£1,000) for private lighting only, Bromham-road, Union-street, Ashburnham-road (northern half), Goldington-road (to Bower-street), Rothsay-road and Gardens, De Parys-avenue (northern part), Park-avenue, Embankment (Newham-road to Bushmead-avenue), Kimbolton-road (to St. Agustine's-road) (£8,750); machinery at central station (£2,500), and contingencies (£250). Alderman Richards, in moving the adoption of the report, said that the private lighting in the first section had been provided for, and when all the plant was put in the lighting of that part of the town would be complete. With regard to the second section, the Committee thought that, as a matter of finance and expediency, there would be an advantage in preparing for the private lighting before that of the streets.

BLACKBURN.—At the last meeting of the Town Council the Gas Committee reported that they had considered the report of the Town Clerk upon the application of the Blackburn Corporation Tramways Company for sanction to work two sections of their lines by electricity instead of by horses and steam. It was resolved, on the recommendation of the Committee, to sanction the application of the Company subject to certain terms, and the Chairman of the Committee and Town Clerk were appointed to negotiate with the Company as to these terms.

BLYTH.—The following striking description of the position of electric lighting matters in Blyth is taken from the *Newcastle Leader*:—

"Those monuments to the stupidity of the Cowpen Local Board, the standards and overhead network of electric wires, still ornament the streets of Blyth. The usual order of things has been reversed by gas superseding electricity, and there are a number of complaints from those ratepayers who were previously accustomed to peruse penny novelettes at their bedroom windows by the aid of the electricity which was generated in Cowpen. Now, alack! the upper storeys and the tiles are plunged in a perpetual darkness, and the only reminder of the past magnificence of the lighting system is the unsightly entanglement of wires which stretches over the town in a manner indicative of the remains of a huge cobweb. The result is not picturesque, and, moreover, it is painfully suggestive of the folly of an Authority which imagined that, by placing the lights at a great altitude above the buildings, two streets might be sufficiently illuminated by one lamp. The idea was almost as brilliant as the light, but it didn't answer, and the councillors are objecting now to these unsightly pillars remaining to perpetuate the memory of their original lighting scheme. The contractor has, in consequence, been ordered to remove his plant."

BRADFORD.—At the meeting of the Town Council on Tuesday, the minutes of the Gas and Electricity Supply Committee, recommending the Council to make applications to the Local Government Board for power to borrow £40,000 for the extension of the electricity works, were agreed to.

BURTON.—At the last meeting of the Town Council Alderman Coxon, in moving the adoption of the minutes of the Farm Committee, said that they had instructed the surveyor to prepare plans for installing the electric light at the pumping station. The Committee were using a good deal of gas at the station, and, as they were anxious to be as economical as possible, they thought the electric light would prove to be cheaper.

CAMBERWELL (LONDON).—The Clerk reported at the last meeting of the Camberwell Guardians that during the past year 6,918,500 cubic ft. of gas had been consumed. This cost of this amounted to £766. 14s., and as this sum appears to the House Committee to be excessive, it was resolved to recommend that Messrs. W. H. Allen, Son and Co. be asked to report as to the probable cost of installing the electric light throughout the entire building, and as to the utilisation of the existing engine and boilers for supplying the necessary power. The matter was, however, referred back for further consideration.

CLACTON.—At the last meeting of the District Council a long debate took place on the lighting question. Dr. Murray proposed that advertisements be issued inviting proposals and estimates for lighting the streets electrically. At the present time he said they were paying 5s. per 1,000 for gas of an inferior quality, and the cost of the electric light would not in any event be more than this, and, in addition, they would have the advantage of a far superior light. After considerable discussion, the matter was referred to the Lighting Committee for consideration and report.

CORK.—A scheme for the construction of a system of electric tramways in the city and suburbs of Cork has just been brought forward, and plans of the suggested lines have already been lodged with the Clerk of the Union and the other public officers. The promoters intend to construct a series of lines to Blackpool, the Lower-road, St. Luke's, Western-road, and Douglas Village. It is also contemplated to make connections with the termini of the Great Southern and Western, the Cork and Bandon, the Cork and Macroom and the Cork and Passage Railway Companies. The plans have been prepared by Mr. Walsh, C.E., and Mr. Maurice Healy, M.P., is the solicitor to the promoters.

CHURCH LIGHTING.—Certain improvements are at present being effected at the Halifax Parish Church, and it is also contemplated to introduce the electric light.——The Wesley Chapel at Stow-Hall, Newport, was lighted electrically for the first time on Saturday last. About 150 incandescents are used, and the light has given the greatest satisfaction. Messrs. R. Alger and Sons were the contractors.

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DOUGLAS (ISLE OF MAN).—Mr G. Gillmore writes, in reference to a Trade Note in our last issue, that we have scarcely done him justice in his opposition to the introduction of the electric light into Douglas; but Mr. Gillmore will see, on again reading the paragraph, that we expressly stated that his opposition was only as to its inopportuneness. Mr. Gillmore explains that the ratepayers are discussing the expenditure of considerable sums of money on urgent town improvements, and this, he considers, justifies opposition to the immediate introduction of the electric light; but, as we read Mr. Berry's contention, it is that the electric light is one of the urgent necessities of the town, in order that its popularity with visitors may continue. We took exception to Mr. Gillmore's contention that the cost of electricity is three times that of gas, and our reference to Mr. Trotter's report was in this connection. How far the opponents of the electric light can go is shown by the figures given at the end of last week's paragraph.

DUNGANNON (IRELAND).—At the last meeting of the Town Commissioners a letter was read from Mr. C. M. Wilson, intimating his intention of applying to the Board of Trade for authority to establish electricity works in the town, and asking for the consent of the Commissioners to his application. After some discussion it was decided to offer no objection to Mr. Wilson's proposals, and to give him every assistance and encouragement in his endeavour to introduce the electric light into the town, as the Commissioners think the scheme will lead to considerable reduction in taxation for lighting purposes, and will be a great advantage to private persons using artificial light and also in the better protection of employés in factories, workshops and shops.

FAREHAM.—At the last meeting of the District Council a letter was read from the Local Government Board with reference to the purchase by the Council of the undertaking of the Fareham Electric Lighting Company. The Board stated that they would be prepared to sanction a loan of £6,681 for a period of 20 years for the purchase, but would not entertain an application to borrow money for the purchase of additional land, for larger cables for underground lines, or for the payment of interest on the purchase money. The Board further stated that they would have to be satisfied that the Board of Trade approved of the purchase. The Chairman (Mr. T. Pankhurst) thought the communication a very satisfactory one, and that after a little further explanation the Local Government Board would sanction the borrowing of the additional £320. He therefore suggested that they should pay the £4,886 to the Company, obtain the new engine and anything else that might be required for putting the works in proper order, and engage a consulting engineer to advise and assist them in putting the affair on a sound footing. Resolutions to this effect were passed, and another inviting Mr. E. Manville to act as consulting engineer was approved. It is satisfactory that there is now a fair prospect of this very tedious dispute coming to an amicable termination.

GLASGOW.—The sub-committee recently appointed to visit Edinburgh and report on the electric lighting of that city has just issued its report. The sub-committee favourably compare the system of lighting in Edinburgh with that employed in Glasgow, and the report concludes with the statement that the sub-committee found that the street lighting of Edinburgh was much better than that of Glasgow, that that result had been obtained by a more judicious employment of the light, and recommend that the matter be remitted back to them to consider and report as to what measures are necessary to improve the present electric lighting system, with power to confer with the Electric Lighting Committee. They also strongly recommend that the Electric Lighting Committee of the Corporation appoint some of their members to co-operate with this Sub-Committee in further investigation.——At the last meeting of the City Council Mr. Primrose moved the adoption of the minutes of the Watching and Lighting Committee, which recommended the Council to adopt the report of the Sub-Committee. He said it seemed strange that, while every important city in the Kingdom was rapidly extending their electric lighting works, they in Glasgow should have been at an absolute stand-still for two or three years. This condition of affairs he attributed to the fact that the Lighting Committee had been endeavouring to avail themselves of the incandescent gas light, which was certainly an improvement on the ordinary gas light, and might serve in some streets for a time, but it was insignificant as compared with the electric light. It was not creditable to them that in a city like Edinburgh, with only about one-third of the population of Glasgow, 440 electric lamps should have been erected for street lighting, while at Glasgow they stood where they had been two years ago—viz., 120. The lamps in Prince's-street, Edinburgh, were run at 15 amperes, and the remainder were run some at 12½ and some at 10 amperes. At Edinburgh the cost was £20 per annum per lamp, and it was hoped that within a few months this charge would be reduced to £18 per lamp; in addition, the Glasgow Lighting Committee had to incur an initial capital expenditure of about £20 for their posts and lanterns, while these were provided free of cost at Edinburgh. Mr. Primrose further attributed the success of Edinburgh to the low charge at which the Council started to supply current, and to the fact that current for motor purposes was supplied at 3½d. per unit. Many printers had discarded their gas engines, and were working their presses by means of electric motors. Butchers, also, were utilising electricity for driving their chopping machines. Further, in order to give a fair and impartial trial to the merits of the electric light, the Edinburgh Council appointed a separate committee, which was free and uncontrolled by the Gas Committee; they had permission to enter into the heartiest rivalry with gas, and their aim was to cheapen what would unquestionably be the light of the future, and to make its use more general throughout the city. After a long discussion, in which Messrs. R. M. Mitchell, Dr. Colquhoun and Mr. Walter Paton took part, the recommendations of the Committee were adopted.

HALIFAX.—The Town Council have decided to oppose the Bill which is being promoted for the construction of a system of electric tramways in the town.

HAMMERSMITH (LONDON).—At the last meeting of the Vestry the Electric Lighting Committee reported that they had instructed the surveyor to invite tenders for the excavation, &c., work necessary in connection with the erection of the electricity generating station in the Fulham Palace-road, and they had accepted the tender of Mr. Greenham for carrying out this work. The Committee now recommend that the surveyor be instructed to prepare the necessary plans for the buildings, and this recommendation was, after some discussion, agreed to.

HORFIELD.—At the last meeting of the District Council, Mr. A. G. Stennard moved a resolution in favour of the appointment of a Committee to take into consideration the best means of lighting the district electrically. After a short discussion the resolution was agreed to.

HUDDERSFIELD.—The Local Government Board have sanctioned the borrowing of a further sum of £50,000 by the Town Council for the purpose of extending the electric lighting works. The loan is for a period of 25 years. The Council have already borrowed £50,000 for electric lighting purposes; £38,000 of this sum is to be repaid in 15 years and the balance in 30 years.

HULL.—Dr. Holder has just decided to resign his position as chairman of the Electric Lighting Committee. It is at least satisfactory to note that he has decided to take this step when the electric light undertaking of the Corporation is in a thoroughly sound financial condition, and no small share of the credit for the present highly satisfactory condition of the department is due to Dr. Holder.

KEIGHLEY.—At the last meeting of the Keighley and Bingley Joint Hospital Board the Buildings Committee reported that they had had the question of the electric lighting of the hospital premises under consideration. They had received various voluntary estimates for the work, and these ranged from £493 to £538. The Committee, however, recommended that no action be taken in the matter at present, and this recommendation was agreed to. It was decided to advertise for tenders for fitting up a system of telephones throughout the buildings.

LAMBETH (LONDON).—The electric lighting question was once more discussed at the last meeting of the Vestry. Letters were recently received from Mr. G. W. Sax and the County of London and Brush Provincial Company on the subject of the transfer of the Vestry's Provisional Electric Lighting Order. Mr. Martin, in opening the discussion, said he thought that the letters contained much more matter than the whole Vestry could go into, and he, therefore, moved that a special committee be appointed to consider the letters. This resolution was duly seconded, but Mr. King moved an amendment that the letters be referred to the Lighting Committee, and that two members be also appointed by each of the standing committees. This proposition was finally carried by 25 votes to 15.

LEEDS.—At the meeting of the Highways Committee on Wednesday, it was decided to recommend the Council to adopt the suggestion of the Tramways Committee to introduce the overhead system of electric traction throughout their entire tramway system. The Committee are to visit Bristol on Monday next in order to inspect the system in operation there.

LONDON COUNTY COUNCIL.—On the recommendation of the Building Act Committee, the London County Council have approved of the plans submitted with the application of Mr. W. B. Pinhey, on behalf of the Charing Cross and Strand Electricity Supply Corporation, for the construction of a generating station, coal bunkers, and furnace chimney shaft at 85, Commercial-road, Lambeth, and have authorised the erection of the station, bunkers and shaft.

MORECAMBE.—The District Council have at last come to terms with the Morecambe Electric Light and Power Company for the sale of the Company's business and plant. The Council have decided to pay the Company the sum of £3,897 for the undertaking.

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OFFICE LIGHTING.—Mr. F. H. Taylor has just completed the work of wiring and fitting up for the electric light to the new premises of the Salvation Army Bank and General Insurance Office.

PRESTWICH.—At the meeting of the District Council, on Wednesday, the General Purposes Committee presented a report on the electric lighting question. The Committee state that the initial expenditure of an installation would amount to about £15,000, and, provided they had applications for about 6,000 lights, they thought there was every prospect of making a profit on the undertaking. They recommended the Council to make inquiries as to the number of lights that would be required before proceeding further in the matter. The report was adopted.

STAFFORD.—At the last meeting of the Town Council, the Chairman of the Gas and Electricity Committee, Alderman Peach, submitted the quarterly accounts for the Electricity Department. He stated that up to the present the customers had expressed themselves highly satisfied with the light and with the charges made. The engineer (Mr. J. F. Bell) estimated the revenue from the supply of current for the ensuing 12 months at £1,000, and then he believed they would make both ends meet and be able to pay their way without any charge on the rates.

ST. PANCRAS (LONDON).—The Vestry have decided to issue regulations for the information and guidance of electrical engineers and contractors carrying out work in the Vestry's area. At the last meeting of the Vestry the draft of these regulations was finally approved.

ST. SAVIOUR'S (LONDON).—At the last meeting of the Vestry the Works Committee reported that they had considered the letter from the County of London and Brush Provincial Company asking for the consent of the Board to their application for a Provisional Order. The Committee had informed the Company that they were opposed to the project, as two companies were already authorised to supply electric current in the district, and some inconvenience and great annoyance would be caused if a third company had power to break up the roads and pavements in Borough High-street. In consequence of these representations, the Company have agreed not to include the Borough High-street in their Order, and to limit the area of supply to the small portion of the district lying to the east of Bowling Green-lane, in Newcomen-street, the principal object of the Company being to connect the two districts of St. Olave's and St. George-the-Martyr, for which the Company had already obtained powers. Under these circumstances the Committee recommended that the formal sanction of the Board be given to the application, and this was agreed to.

SUNDERLAND.—At the last meeting of the Highways' Committee the Electric Lighting Sub-Committee presented their accounts for the half-year ending September 30th next. The Committee anticipate that the expenditure for the period will amount to £1,541. 2s. 9d., and the receipts to £960. 15s., leaving a deficiency of £580. 7s. 9d. The estimate was approved. The Committee also decided to join with the other Corporations in opposing an application by the owners of the patents of the three-wire system for an extension of time. Under this patent the Council at present pay a royalty of £50 a year.

SWANSEA.—At the meeting of the Electricity Committee on Monday last the Council's Bill for the purchase of the local tramways was considered. The Chairman pointed out that the Company were endeavouring to depart from the terms originally proposed by the Corporation and accepted by them. The amount to be paid to the Company (£32,000) was to be applied by them as follows: £10,400 in paying off the existing mortgage debt on the lines, and the balance in the purchase of motor cars for the working of the tramway system. The Company now, however, asked for the payment of this sum without any restrictions. In addition to certain other modifications, the Corporation agree to purchase the plant at the end of the term (21 years) at a valuation on condition that the plant is kept in proper repair to the satisfaction of the Borough Surveyor. The Town Clerk was directed to convey these terms to the Company, and in the event of their non-acceptance he was directed to withdraw the Bill. A special meeting of the Council has been convened for to-day (Friday) to confirm the action of the Committee.

TELEPHONE SUBSCRIBERS' LIST.—The National Telephone Company announce that a subscribers' list is in preparation which will contain the names, trades and addresses of all subscribers to the National Telephone Company's system throughout the country. It is calculated that this list will contain about 75,000 names, and that it will be ready for delivery to subscribers at the end of June next.

THE THREE-WIRE PATENT.—A conference of delegates from the Corporation of Glasgow, Edinburgh, Aberdeen, Belfast, Brighton, Bradford and Lancaster was held at the offices of Messrs. Martin and Leslie, of Abingdon-street, Westminster, on Monday, to determine what steps should be taken with reference to the royalty claimed by the Westinghouse Electric Company, who are the owners of the Hopkinson three-wire patent. It was unanimously decided to oppose the application for extension, and it was decided on counsel's advice that the Corporations of Aberdeen, Belfast and Edinburgh, who had not yet paid a royalty under the patent, should offer independent opposition to the application.

TORQUAY.—At their meeting to-day the Town Council will discuss Mr. W. H. Trentham's amended report on the electric lighting question. The Electric Lighting Committee recommend the Council to proceed with the scheme, and to erect the generating station at the Beacon Quay cellars. The estimated cost of the entire scheme is put at £22,300.

VIENNA.—The lighting contract of the Imperial Continental Gas Association expires in 1899, and the *Daily Chronicle* states that Dr. Friebeiss, the Imperial Commissioner who is conducting the affairs of the Municipality while the City Council remains dissolved, has been requested by the committee associated with him in the management to apply to the Diet for permission to raise a loan of 30,000,000 florins for the purpose of purchasing the works of the Association and erecting new gas and electric lighting works in the city.

WAKEFIELD.—The new County Council Offices at Wakefield are to be fitted up for the electric light. Current is to be supplied by the Wakefield Corporation.

WALSALL.—It has been decided to wire the new baths for the electric light at a cost of £120.

WANDSWORTH (LONDON).—At a meeting of the District Board of Works last week attention was called to the fact that a local tradesman had opened the streets, laid an electric cable, and supplied current to private consumers without having received the sanction of the Board. A letter had been received from the County of London and Brush Provincial Company calling attention to this matter, and pointing out that they were the only persons having Parliamentary powers for opening the streets to lay electric mains, and that should any accident occur with the installation put down by Mr. Singer, they would probably be blamed. A discussion arose, and many of the speakers showed an inclination to support the application of Mr. Singer that the cable he had laid down should remain, and that he should have permission to put down a second cable. An amendment, however, that the matter should be referred back to the General Purposes Committee was finally adopted.

WATERLOO-WITH-SEAFORTH.—The District Council have decided to offer no objection to the application of the Liverpool District Lighting Company to the Board of Trade for a Provisional Order for the district.

WIMBLEDON.—The electric lighting licence of the District Council expires in July next, and recently application was made to the Board of Trade for an extension of time in order to enable the Council to apply for a Provisional Order. This extension has just been granted by the Board of Trade.

WORCESTER.—At the last meeting of the City Council, on the motion of Alderman Williamson, the Chairman of the Electricity Committee, the Council decided to borrow a further sum of £5,000 for electric lighting purposes

YORK.—At the general meeting of the shareholders of the York United Gas Light Company (Limited), last week, the Chairman (Mr. J. F. Taylor), in alluding to the subject of the electric light, said he had not usually alluded in his speeches to what some odd members of the public were apt to magnify as the light of the future—viz., the electric light. On the present occasion he would, however, do so. He then went on to quote some remarks of Prof. V. B. Lewes about the incandescent gas light. Mr. Taylor then told his hearers that, by using the best form of incandescent burner, light for light, the York gas might safely be said to be from 12 to 15 times cheaper than the electric light at its prevailing cost. The price of gas at York is from 2s. to 2s. 2d. per thousand, and it would be very interesting to know how Mr. Taylor arrives at his figures. It may be safely assumed that the speaker has not heard of Mr. A. P. Trotter's report on the comparative price of the electric light and gas recently prepared for the Hastings and St. Leonards-on-Sea Electric Light Company, or he would have been more guarded in his assertions. Mr. Taylor's previous forbearance towards the electric light may be accounted for by the fact that, though the York City Council have been for some time past talking of introducing the electric light, up till quite recently no very serious steps have been taken in the matter. Prof. A. B. W. Kennedy has now, however, been appointed consulting engineer to the Council, and doubtless Mr. Taylor has been reading the results of the Professor's connection with the Councils of Edinburgh and other cities, where very successful electric lighting works have been erected. Our readers will remember that at the last meeting of the Edinburgh Gas Company, the Chairman admitted that the electric light competition affected them in a very marked degree, and he issued an *ad misericordiam* appeal to the residents of Leith to come to the Gas Company's rescue. Mr. Taylor is perhaps fearsome of a similar result at York.

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PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

January 23, 1896.

1,611. W. McGEOCH, JUN. Glasgow. Improvements in and relating to holders for incandescent lamps.*

1,669. W. TURNER. London. Improvements in or relating to electric batteries.

1,678. W. DIGBY. London. Improvements in electrodes for electrolytical purposes. (A. E. Woolf, United States.)

January 24, 1896.

1,685. T. COOPER. Walsall. Method of utilising primary induced currents of dynamo-electric machinery.

1,687. H. RUDOLF. London. Isolator for fastening electric conducting wires.*

1,695. T. MEACOCK. Birmingham. Improvements in connection with electric tramways.

1,744. D. KORDA. London. Improvements in electric traction.*

1,775. A. I. GRAVIER. London. Improvements in dynamo machines.

January 25, 1896.

1,793. J. M. INGLIS. Edinburgh. The Inglis electrical photographic lamp for studio purposes.

1,796. W. G. MULLINER and W. H. STURGE. Birmingham. Improvements in means for or connected with the charging of portable electric secondary batteries or accumulators.

1,838. H. W. C. COX and G. BOWMAN. London. Improvements in electrically-driven wool shearing or hair-clipping machines.

1,842. T. R. D. KENNY. London. Improvements in holders for electric glow lamps and analogous electrical contact devices.

1,843. D. URQUHART and F. WYNNE. London. Improvements in the means and apparatus for connecting electrically-propelled vehicles on tram and railways to fixed conductors.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1895.

684. CANNON. Incandescent electric lamps.

687. CHEFFEY, JAMES and WARD. Generating or transforming electric currents.

2,277. HIRCHMANN. Electric accumulators.

4,466. PATERSON and HILL. Search-light projectors.

5,956. PEARSON. Thermometric circuit closers.

15,787. BRAHAM. Electroliers, electric light standards, &c.

22,985. BREMER. Transmitting electric currents.

COMPANIES' MEETINGS AND REPORTS.

Cuba Submarine Telegraph Company (Limited).

The forty-ninth ordinary general meeting of this Company was held on Wednesday at the offices of the Company, 58, Old Broad-street, Mr. Charles W. Parish (Chairman) presiding.

The SECRETARY (Mr. James Scott) read the notice calling the meeting.

The CHAIRMAN: Gentlemen, I presume you will wish to consider the report as read. If you will allow me I will follow our usual custom and point out to you any important variations there may be in the accounts for the past six months as compared with the same period of 1894. As far as expenses are concerned we have an amount of £6,084 in the half-year now under review, as against £5,633 in 1894, an apparent increase of £451; but an item of £545 spent upon a new harbour length at Cienfuegos and other repairs more than accounts for this amount. The salaries and wages paid at the stations have risen from £2,018 to £2,165 on account of overtime necessary to meet the increased business. There is also an addition of £72 for travelling expenses; but, *per contra*, there is a reduction from £829 for maintenance of land lines to £532; so the total expenses of the stations come out at £3,000, as against £3,064 last year. The traffic receipts have increased from £19,088 to £23,934, which is a very large proportion, but you will please understand that it is due to the disturbed state of the island owing to the revolution, which still continues. After paying dividends at the rate of 8 per cent. per annum on our Ordinary shares and 10 per cent. on the Preference, you will notice we are able to place £10,000 to the reserve fund and carry forward £3,539 to the new account. This substantial increase to our reserve fund is most necessary, for we have to meet a heavy expense in connection with the new cable referred to in paragraph 6 of the report. To more clearly explain the position I would draw your attention to the chart hanging before you; you will notice the town of Manzanillo, and you will understand that the suggestion which the Spanish Government made to us was to connect this town by a cable to one of our existing lines running from Santiago to Cienfuegos; but these cables have been laid for so many years that we could not take the risk of disturbing them. Then followed long and difficult negotiations carried on partly with the authorities in Cuba, and then at Madrid, where Mr. Keith and Mr. Scott went to be in actual touch with the Government. These negotiations finally led to the Spanish Government granting us a subsidy of £2,000 per annum to lay and work a cable between Cienfuegos, Casilda, Tunas, Jucaro, Santa Cruz, and Manzanillo. This cable was successfully laid and duly received from the contractors by Mr. Keith, acting on behalf of the Company, and we have since received the thanks of the Spanish Government for having carried out the work so promptly. This cable has entailed our opening five new stations, which will increase our expenses accordingly; but, on the other hand, we hope a satisfactory traffic will gradually develop over and beyond the Government business. You will notice that it can be continued from Manzanillo to Santiago, if necessary, as mentioned in the report. Before I close my remarks I would like to mention the very valuable services the Company has received from Mr. Keith; he has just returned from Cuba, and reports that our cables and property are in satisfactory order. His special acquaintance with the local circumstances has been of great advantage to us. I would also like to bear witness to the excellent manner in which our Secretary has met the increase of work which has lately fallen upon him. Gentlemen, our next meeting will be our fiftieth, and I hope we may then meet you with the same satisfaction as we do to-day. I will now formally move—

"*That the report and accounts for the half-year ended December 31st last, now submitted, be received and adopted.*"

Mr. GEORGE KEITH seconded the resolution.

Questions relating to the new cable, as to the increased traffic likely to result therefrom, and especially as to the subsidy from the Spanish authorities, were put by several speakers, and Mr. DEARBERG called attention to the large amount placed to the credit of the reserve fund.

The CHAIRMAN, in reply, said: I have much pleasure in answering the various questions put to me. The matter of the new cable was to a great degree one of expediency. In the first place, the Spanish Government were determined to have a cable, and if we had not laid it they would have laid it themselves. In the second place, they give us a subsidy and pay half-rates for their messages. It was part of the original concession that they should do so, and I need only indicate to you the large increase in the receipts you have seen for the last two half-years to show how much that amounts to. Then, as to the amount we place to the reserve fund, I would have you remember that some of our cables have been down for a long time, and we should be to blame if we did not greatly increase our reserve fund to meet any casualties that may occur.

Mr. DEARBERG, intervening, observed that he did not complain of building up a reserve. What he complained of was that they put more to reserve than they paid in dividends.

The CHAIRMAN: I understand that, and on the whole I think it is rather pleasant for Directors to be scolded for not paying out more in dividends, because we are shareholders, and we should like to have large dividends as well as anybody else. It is because we know the details of the business that we feel we should not be justified in paying larger dividends. I warned you at the last meeting that it was probable we might have to reduce our rates, and we felt the large increase of business we had had was not due to any general expansion of business on the island of Cuba, but to quite exceptional causes, which might come to an end at any time. With regard to our deposit at the New English Bank of the River Plate, we have made a careful calculation, and we believe that the £8,000 in reserve will more than cover any loss that may accrue.

The resolution was then carried unanimously.

The CHAIRMAN then moved the following resolution:

"*That the following dividends for the half-year be now declared upon the shares of the Company, viz., at the rate of 10 per cent. per annum, subject to income tax, on the Preference shares, and 8 per cent. per annum, free of income tax, on the Ordinary shares, payable on and after to-morrow.*"

Mr. R. KAYE GRAY seconded the resolution, which was agreed to unanimously.

A cordial vote of thanks to the Directors concluded the proceedings.

Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of this Company was held on Friday at Winchester House, the Marquis of Tweeddale (Chairman) presiding.

The notice calling the meeting having been read,

The CHAIRMAN said: Gentlemen, the report now before you is the best we have been able to present to you since 1892. In the half-year ended December 31, 1892, we paid you a dividend of £1. 10s. per cent., in 1893 it fell to £1. 6s. per cent., in 1894 to £1. 3s. per cent., while for the past half-year we are able to recommend you a dividend at the rate of £1. 8s. per cent., of which 10s. has been paid already, leaving a balance to be paid of 18s. The increased dividend is due, first, to improved traffic; secondly, to an increase in our receipts from the steamship "Minia," and, thirdly, to a considerable reduction in expenses. The increase in traffic amounted to £15,764, the result, of course, of the great improvement which has taken place in commerce and business, an improvement which I hope is destined to continue. The "Minia" has earned for us £1,350 more than last year, and we are able to report a decrease in the expenses of £1,056. This decrease in expenses is satisfactory, inasmuch as it compares with a half-year in which the decrease was no less than £3,399. I have before me a comparative statement of working expenses from the half-year ending December, 1891, and it shows a steady decrease from year to year to the present time, aggregating as much as £8,712. Our renewal fund now stands at the respectable figure of £624,265, and the value of the securities at the close of the half-year exhibited an increase of £74,000. In connection with the renewal fund, I may mention that owing to the lease of our offices in Throgmorton-street coming to a termination, we have

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purchased the lease of very suitable offices in Old Broad-street. The cost of this new lease, which is for 13 years, is £28,541. The offices are very superior to those we had before, and I am glad to say that with the receipts obtained from letting off a certain portion of the building the cost to us is within a pound or two of what the offices were which we have relinquished. The condition of our cables is very satisfactory. It is true that during the half-year we have not been altogether free from interruption, but with the exception of the 1873 cable, which was interrupted in the preceding half-year, and repaired on July 16th, the interruptions have been confined to our short cables west of Newfoundland and to the cable in the shallow sea. The repairs to these cables have been executed with skill and promptitude always exhibited by our officials both on the ship "Minia," commanded by Capt. Trott, and by our local officials at St. Pierre, who, in face of great difficulty from the weather and otherwise, repaired one of our most important short cables with perfect success. The report refers to the French case, and that, I am sorry to say, is not any nearer, or very little nearer, settlement than it was when I last addressed you. I need hardly say that it is not from any want of energy on our part, but the French lawyers, not unlike our own, were not disposed to be in too great a hurry in the settlement of such matters. The present position is this: the French counsel have had the matter in hand for many months, and it is understood that the Company's case is in draft, but not settled. When it is settled it will be proceeded with before the proper Court, and I hope that when we next meet I shall be able to report some settlement. I am glad to be able to inform you that the new half-year has commenced in a manner which augurs very well for our meeting six months hence. With these observations I beg to move that the report and accounts be adopted, and the dividends set out therein be approved.

Mr. FRANCIS A. BEVAN (Deputy-Chairman) seconded the resolution.

Mr. GARNER asked if the Board could say when the renewal fund would have reached a sum which might be considered sufficient. In his opinion they did not require the £1,000,000 that was at one time suggested necessary.

The short discussion which arose referred almost entirely to the delay in the settlement of the French action, and questions as to the amount of costs already incurred by the Anglo Company in the matter, were put by several shareholders.

The CHAIRMAN, in reply, said: I have been asked, with regard to the renewal fund, when we are going to stop adding to it. It is far too early in the day to give any definite answer to that question. Our renewal fund is now worth about £670,000, but our cables are getting older every day, and when they were much younger we considered £1,000,000 would be barely sufficient to make us feel quite confident of being able to keep our four cables in proper condition. Then Mr. Wood asked if our cables were in working order. Well, of course, the French cable is not, but all the others are in good condition. We have no present intention of repairing the French cable. Mr. Griffith, as I understood him, complained of the delay that had taken place in the settlement of the French case. Well, there is an old saying that "you may lead a horse to the water, but you cannot make him drink." In the same way you may do what you can—our legal advisers here and on the other side do what they can—but we cannot force this case on the Court of Appeal any quicker than they are willing to take it. There is no delay on our part. I must say distinctly that we on this side of the table do not anticipate any very large result from this case. The French Cable Company is not in a very good condition, and I do not believe they would be able to pay any large damages; but in any case we do not expect to get any very substantial sum. If we do, we shall be only too pleased, but our present opinion is that it would not do to rely on any large sum being awarded for damages.

Mr. FRY asked when the Board formed the opinion that the amount the Company were likely to receive would be a small one. If he referred back to the old reports he found the prospect of the damages running into thousands and tens of thousands of pounds was held out to them.

The CHAIRMAN: When I spoke of the possibility of our receiving considerable damages the decision from which we are now appealing had not been given.

Mr. C. BURT hoped the shareholders would not press the discussion further. Every word spoken here against their interests would be carried to the other side and made use of against them. There was no doubt but that the first decision was greatly in their favour, and if it could have been carried out the Company would have received a very large sum. But from that decision appeals were carried from court to court, until now they were at the last appeal on a question of law. Surely, having gone so far, and paid, as he believed, almost every item of costs they had to pay to the present time, it was not worth their while to make this fuss and say they would not have the case finished. He felt sure that after waiting for so many years to get justice done them they would go on until they obtained a final decision.

After further discussion the resolution was agreed to unanimously.

The retiring Directors (Mr. Francis A. Bevan and Mr. W. S. Cunard) were re-elected.

Mr. GRIFFITH moved the re-appointment of the auditors, Mr. Joshua Dean and Mr. John Gane, F.C.A.

Mr. GARNER seconded, and the motion was agreed to.

The proceedings terminated with a vote of thanks to the Chairman.

Liverpool Overhead Railway Company.

The half-yearly meeting of the shareholders of this Company was held on Tuesday last at the Law Association Rooms, Liverpool, Sir W. B. Forwood presiding.

The CHAIRMAN, in moving the adoption of the report and accounts, said that the passenger traffic had increased during the past half-year by 140,000. There was, however, a decrease in workmen's special tickets of 90,000, which was accounted for by the fact that at the end of 1894 they gave up the 2d. return workmen's tickets. At first this step led to a large decrease in the number of workmen who used the early morning trains, but they were gradually coming back to the railway. The total number of passengers carried during the half-year was 3,780,000, the total for the year being 7¼ millions. Their gross revenue had been £31,590, showing an increase over the corresponding half-year of £5,916. They had therefore earned 1·97d. per passenger as against 1·67d. Their working expenses amounted to £18,893, an increase of £1,731, and the trains had travelled 7,000 more miles. Their working expenses as compared with revenue had been 60 per cent., against 67 per cent. in the same period of last year. After paying £2,500 interest on debentures, they had a balance of £10,196, which, with the balance brought forward of £1,302, left £11,499 available for dividend. The usual dividend of 5 per cent. on the Preference shares would require £2,600, and the Directors recommend the appropriation of £6,825 to the payment of a dividend of 3½ per cent. on the Ordinary shares, as against 2 per cent. for the same period last year. This would enable them to carry forward £2,074, as compared with £1,087. The chairman stated that considerably more money had been spent upon maintenance of way works, repairs, &c. That had been done in order to keep the railway in the best possible condition. The amount they had set aside for the renewal of boilers and machinery (£1,200) was rather more than in previous half-years, and they had started a contingent fund towards which they had carried £100. The Chairman then referred to the progress being made with the southern extension, and they hoped that part of the line would be opened in the month of August. They proposed to transfer the station from the extreme end of the Herculaneum Dock to the bottom of the footbridge over the Cheshire Lines Railway. That would be much more convenient to the artisans using the docks, and would be more accessible to the large population residing in that portion of Toxteth-park. The new station would be at the Dingle, in close proximity to the ancient chapel of Toxteth Park, and he thought that that part of the line would prove a valuable feeder to their general system. The line had been maintained in a thoroughly efficient condition during the past year. No less than 98·40 per cent. of their trains had been on time, and that showed not only that they had worked their system with great punctuality, but that there had been no breakdowns. A great deal of their success was due to their manager, Mr. S. B. Cottrell, and the members of his staff, who had given them the most loyal service, and showed great industry and watchfulness in looking after the concern. He was glad to say that they received no complaints from the public, a circumstance which proved that they were not only a great public convenience, but were doing their work well.—The motion was duly seconded and carried.—The retiring Director (Mr. H. Brocklebank) and the auditors were re-elected, and the usual vote of thanks brought the proceedings to a close.

Newcastle and District Electric Lighting Company (Limited).

The ninth ordinary general meeting of this Company was held on Tuesday at the Station Hotel, Newcastle-on-Tyne. The Chairman (Mr. John D. Milburn), moved the adoption of the following report:—"The supply of current continues to give satisfaction to the Company's consumers. The installations to the Company's mains during the year are equal to 3,200 10 c.p. lamps, bringing the total up to about 24,700; 471,662 units of electrical energy have been supplied, against 431,239 in 1894. 1,650 yards of main and branch piping have been added, together with 3,781 yards of main and branch cable. The condensing plant continues to work satisfactorily, and the Directors anticipate making other improvements with the object of still further reducing the cost of production. The gross earnings during the year amount to £4,302. 9s. 11d., and after paying interest, making provision for depreciation, and writing off the balance of formation expenses (£563) a dividend is recommended at the rate of 4 per cent. for the half-year ended December 31st (less income tax), making 6½ per cent. for the year." He said it was gratifying to be able to state that their output was still on the increase. They had issued no new shares because they had required no extra money. They were keeping up a depreciation fund; they were fully alive to its value, and intended to continue it. A dividend at the rate of 4 per cent. for the half-year ended December 31st, making 6½ per cent. for the year, was then declared. The retiring directors, Sir B. C. Browne and Col. H. S. Dyer, were re-elected, as were the auditors, Messrs. Strachan and Co.

Cambridge Electric Light Company (Limited).

The annual meeting of the shareholders of this Company was held on Friday last at the offices, Thompson's-lane, Cambridge. The CHAIRMAN (Mr. D. Munsey) in moving the adoption of the report and accounts, said that although they had made an extra profit and had generated more units than in 1894, their consumption of coal was about the same. This had been mainly brought about by the new sub-stations which had been constructed. The motion was seconded and duly passed.

The CHAIRMAN then referred to the fact that the Company had debentures to the amount of £3,000 or £4,000, and after they had paid their debts they would owe the bank £5,000 or £6,000. If the Directors issued any new shares the present shareholders would have the opportunity of taking them up *pro rata*, according to their holding.—A discussion also arose on the public lighting question. It was stated that the contract with the gas company would shortly expire, and a shareholder expressed the opinion that the Company ought to make an effort to secure the contract.—The Chairman, in reply, stated that the Corporation had already authorised them to erect four arc lamps on the Market Hill as an experiment.—The retiring Directors, Mr. W. C. Hall and J. B. Simpson, were re-elected, as was also the auditor, Mr. A. Rutter,

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City of London Electric Lighting Company (Limited).

The report of the Directors of this Company, to be presented to the shareholders at the meeting to be held at Winchester House, London, E,C., on Friday next at 2:30 p.m. is as follows:—

Capital.—The expenditure on capital account during the year ended December 31st last amounted to £138,456. 2s. 6d. The balance of £100,000 of the present authorised amount of £400,000 Five per Cent. Debenture Stock has been issued, and an official quotation granted by the Committee of the Stock Exchange.

Revenue.—The total revenue for the year was £109,766. 19s. 10d., from which £50,666. 13s. 11d. has to be deducted, leaving a net revenue of £59,100. 5s. 11d., which, with £752. 13s. 11d. brought forward, makes a total available sum of £59,852. 19s. 10d., of which £12,076. 16s. has been distributed in interest on Debenture stock for the year, and £12,000 in interim dividend on £400,000 Six per Cent. Preference shares for the half-year to June 30th last, leaving for further distribution £35,766. 3s. 10d.

The Directors recommend dividends of 6s. per share on the Preference shares for the second half-year, making a total distribution of 12s. per share or 6 per cent. for the year, and 10s. per share on the Ordinary shares, being at the rate of 5 per cent. per annum. This will absorb £32,000, leaving a balance of £3,776. 3s. 10d. to carry forward. The necessary provision for depreciation in accordance with the City of London Electric Lighting Act, 1893, has been made.

The generation and distribution expenses for the year, including repairs and renewals, were 36·87 per cent. of the earnings, as compared with 46 for 1894 and 54·2 for 1893. The Company continues to make satisfactory progress, as will be seen by the following comparative statements, showing the position of the Company with regard to its earning powers as it was in 1892 and at subsequent periods:—

Number of Customers and Lamps Connected.

	Dec. 31, 1892.	Dec. 31, 1893.	Dec. 31, 1894.	Dec. 31. 1895.
Number of customers being supplied	242 ...	1,080 ...	2,740 ...	4,230
Number (equivalent) of 8 c.p. lamps connected	20,241 ...	65,341 ...	135,460 ...	195,317

On February 5, 1896, there were 201,126 8 c.p. lamps (equivalent) connected, and in addition 8,759 awaiting connection. In September last Mr. Joseph Bevan Braithwaite, Jun., resigned his seat on the Board, and two of the Directors (Lord Suffolk and Mr. F. W. Reynolds) now retire and offer themselves for re-election, as do the auditors (Messrs. W. H. Pannell and Co.).

National Telephone Company (Limited).

The report of the Directors of this Company for the half-year ended December 31st last, to be presented to the shareholders at the meeting to be held at the Cannon-street Hotel, London, on Thursday next at 1 o'clock, states that the income amounts to £422,649. 6s. 9d., compared with £378,789. 4s. for the corresponding period of 1894, an increase of £43,860. 2s. 9d. The working expenses amount to £216,537. 0s. 5d., compared with £205,192. 12s. 10d. for 1894, an increase of £11,344. 7s. 7d. The net result for the half-year's working (after deducting Post Office royalties amounting to £38,238 12s. 1d.) is a profit balance of £167,873 14s. 3d., against £138,642. 14s. 6d. for 1894, or an increase of £29,230. 19s. 9d. Out of the available balance of £138,217. 3s. 11d. the Board recommend a dividend at the rate of 6 per cent. per annum, less income tax, on the first and second Preference shares, 5 per cent. per annum, less income tax, on the third Preference shares, and 6 per cent. per annum, free of income tax, on the Ordinary shares, to transfer £35,000 to the reserve fund, and to carry forward the balance of £6,623. 7s. 11d.

The report for the half-year ended June 30, 1895, contained the following paragraph:—

"The draft of the formal agreement with the Post Office, for the acquisition by the Department of the Company's trunk lines, having been laid upon the table of the House of Commons in accordance with the promise of the Postmaster-General, the preliminary agreement requisite to give effect to the arrangements was duly executed and completed on March 15th last. The difficult and somewhat complicated details connected with the transfer of the Company's trunk lines are approaching completion, and payment of the purchase money, now in process of being ascertained, may be expected shortly."

In respect to the reference made in the report of the Directors for the period to June 30th last as to the Company's trunk lines being taken over by the Post Office, the many difficult questions involved in the settlement have led to some further delay. The amount due to the Company is now practically agreed, and there is reason to believe it will very soon be paid. In the meantime the Board are loyally co-operating with the Post Office in preparing for that transition in the conduct of the trunk business of the country which will follow the assumption of the trunk lines by the State.

Kensington and Knightsbridge Electric Lighting Company (Limited).

The report of the Directors of this Company for the year 1895, to be presented at the ninth ordinary general meeting, to be held at 1, Great George-street, Westminster, on Thursday next, at 5 p.m., states that the mains, which extended to a length of 18¾ miles on December 31, 1894, have been increased during the year 1895 to 20 miles, and that during the year the number of houses and shops connected with the system has increased from 908 to 1,109, while the number of lamps calculated on the usual basis of 8 c.p. has increased from 80,678 to 94,780.

The Debenture debt of the Company has been converted from Four and a-Half per Cent. First Mortgage Debentures to Four per Cent. Debenture Stock. The debentures were paid off at £105 by new stock issued to the holders. Further issues of Debenture Stock have since been made, £6,800 at £103, and £15,755 at £105 per cent., of which amount £11,780. 15s. 0d. was paid by December 31st. The Directors have thought it advisable to appropriate the balance of premiums thus obtained, after deducting the expenses of creation and issue of this stock, to the reduction of the cost of conversion, and have written £1,000 off the goodwill account and strengthened the renewal account by transferring to it £4,270. 2s. 11d., making the total amount placed to that account £9,990. 13s. 8d. After providing for the above amounts, and paying the dividends on the Six per Cent. First Preference shares to June 30, 1895, on the Five per Cent. Second Preference shares to September 30, 1895, and an interim dividend at the rate of 5 per cent. per annum on the Ordinary shares for the first half of the year, the balance standing to the credit of the nett revenue account for the past year is £5,227. 7s. 6d. Of this sum £1,450 has been appropriated to the payment of the First Preference dividend to the end of the year, and £150 has to be set aside to meet the portion of the dividend on the Second Preference shares accrued to the same date, leaving £3,627. 7s. 6d., out of which it is proposed to pay a further dividend on the Ordinary shares at the rate of 7 per cent. per annum for the past half-year, making, with the interim dividend paid to June 30th, 6 per cent. for the year. This will leave a balance of £1,089. 17s. 6d. No provision has been made in the accounts for Directors' remuneration.

Mr. Granville R. Ryder and Mr. Alfred Sohier Bolton offer themselves for re-election as Directors, as do the auditors, Messrs. Lovelock, H. W. S. Whiffin and Dickinson.

Bristol Tramways and Carriage Company (Limited).

The report of the Directors of this Company states that the gross receipts for the half-year amounted to £51,664. 17s. 9d., and the working and general expenses and renewals to £40,210. 9s. 11d., leaving a balance of £11,454. 7s. 10d., which it is proposed to appropriate as follows:—Interest on Four per Cent. Mortgage Debenture Stock, £1,378. 13s. 6d.; dividend at the rate of 6 per cent. per annum (to be paid on the 28th inst.) for the half-year ended December 31st, £7,350. A balance of £2,725. 14s. 4d. (including £200 for leased premises redemption, £1,000 for permanent way renewals, and £525. 14s. 4d. for electrical renewals) has been carried to reserve and renewal funds. The receipts from the tramways department show an increase of £4,271. The total number of passengers carried during the past six months on the Company's cars and omnibuses was 7,798,952. The Company's City and Kingswood Electric Tramway was formally opened on October 14th last, under favourable auspices, the public ceremony being attended by many distinguished scientific men, as well as the members of the Corporation and other local authorities. The Directors state that the working of the City and Kingswood electric tramway since the opening in October last has been most satisfactory, and the public greatly appreciate the immense advantage of a service so superior to that of the horse cars. For the four months during which the line has been opened the number of passengers carried has exceeded 1,000,000. Pursuant to an agreement with the Corporation the Company have applied to the Board of Trade for a Provisional Order to confirm the construction of the new lines in the vicinity of the tramways centre and St. Augustine's Bridge, and the Directors have included in the Order clauses enabling the Corporation and local authorities to approve of the use of electricity on other portions of the Company's existing system.

The retiring Director (Mr. Joseph Wethered) and the auditor (Mr. Solomon Hare) offer themselves for re election.

India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The Directors' report and statement of accounts for the year ended December 31st last (to be presented at the thirty-second general meeting, to be held at Cannon-street Hotel, London, on Thursday next, at 12 o'clock) are to hand, and appended to the accounts is the auditor's certificate, which is one to which shareholders may well pay more than usual attention. It is as follows:—

"I have examined the above balance-sheet with the head-office books and vouchers and the returns from Silvertown, Persan and the agencies; and, although not exactly in accordance with the form prescribed by the Articles of Association, it is, in my opinion, a fair and true balance-sheet, properly drawn up so as to exhibit a correct view of the Company's affairs, as shown by the books and returns of the Company, subject to the correctness of the value placed on the 'Debentures and Shares in other Companies,' and certain debts included in the item of 'Debts owing to the Company,' as to which I am unable to certify. Any possible contingencies with respect to these, however, are amply provided for by the reserve fund. The subsidiary books have, as usual, been examined in totals. I have had produced to me the inventories of stock of Silvertown, certified by the works manager. "J. F. Clarke, Auditor."

The accounts show that, after provision for doubtful debts, a net profit has been made of £49,325. 12s. Adding £20,913. 17s. 4d. brought forward, and deducting £12,500 interim dividend paid in July, there remains a disposable balance of £57,739. 9s. 4d. The Directors recommend the distribution of a dividend of 15s. per share, free of income tax amounting to £37,500, making, with the interim dividend, a total pay-

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ment of 10 per cent. for the year, and carrying forward £20,239. 9s. 4d. The report states that the year's general business has been satisfactory; that the cable department and steamships have been moderately employed, and that the Silvertown and Persan factories are in good order.

It is satisfactory to find the announcement that before the next accounts are presented the Directors will propose alterations "in the Company's Articles of Association" as to the form of balance-sheet and profit and loss account "to meet the suggestion of the auditor" in the certificate to which we have referred above. It will be seen, on reference to the document itself, that for meagreness of detail and for "lumpings" this balance-sheet and profit and loss account are bad to beat. We especially commend to the notice of shareholders in the Company the items—

Reserve fund	£450,000	0	0
Debts and loans owing by the Company	150,446	19	4
Debts owing to the Company	275,376	7	3
Stock in trade (including 150 miles of cable laid)	264,217	3	6
Debentures and shares in other companies	210,589	8	0
Cash, stock, &c., after deducting liabilities	135,056	9	7
Gross profit	134,930	0	2

No details whatever are given as to the investments on reserve fund account, nor as to the nature of the "debts and loans owing by the Company." Truly there is room for extended information. At December 31st, 1891, the item "Debentures and shares in other companies" stood at about £25,000, and "debts owing by Company" at about £82,000. The "gross profit" item is more meagre of detail than usual; in the 1894 accounts this was stated as "Gross profit, including interest on securities, and *after charging commission*" (the italics are ours). The interesting and curiosity-invoking term "commission" does not figure anywhere in the present accounts.

The Company's Four and a-Half per Cent. Debentures are repayable next month, and it is intended to issue new Debentures at 4 per cent.

NEW COMPANIES, STATUTORY RETURNS, &c.

CORK ELECTRIC TRAMWAYS COMPANY (LIMITED).—This Company was registered in Dublin on February 3rd, with a nominal capital of £1,000, in £10 shares, to obtain the necessary authority to construct and maintain tramways in the city and County Cork, and to supply the same with electric or other motive power. The first subscribers, with one share each, are: M. Murphy, W. Carter, J.P., James F. Lombard, J.P., J. J. O'Connor, J. F. Murphy, B.L., M. Lombard, and Sir Francis W. Brady, Bart.

FOWLER-WARING CABLES COMPANY (LIMITED).—This Company was registered on February 4th, with a nominal capital of £200,000, in shares of £5 each, to purchase or otherwise acquire and take over as a going concern the business carried on by the Fowler-Waring Cables Company (Limited), incorporated in 1889, together with all or any part of the property, assets and liabilities of the Company in connection therewith; to carry into effect an agreement with the said old Company; to acquire, hold, deal in and grant licences in respect of patents for or relating to electric wires and cables and methods or processes for insulating electric conducting wires and other appliances, and to manufacture, sell and deal in electric and other cables and wires, and all materials, machines and appliances capable of being used for the purposes of telegraphs, telephones, electric light, &c., tubes, pipes, conduits, cables, pulp, paper, rubber, gutta percha, waterproofing fabrics, varnishes, &c. The subscribers, with one share each, are: George Fleming, Alfred E. Mavor, electrical engineer, 32, Victoria-street, S.W.; Lord Medway, J.P.; Walter Chamberlain, manufacturer, Harborne Hall, Birmingham; George F. Smart, William Fowler, engineer, 6, Lombard-street, E.C.; and W. Macintosh. The first Directors are: William Fowler, Walter Chamberlain, George Fleming, Lord Medway, J.P., and George F. Smart. Registered office, 32, Victoria-street, Westminster, London, S.W.

GENERAL CONSTRUCTION AND TRAMROADS COMPANY (LIMITED.)—This Company was registered on January 31st, with a nominal capital of £11,000, in £100 shares, to further the construction, equipment, and development of tramways, tramroads and light railways, and to carry on business as promotors, concessionaires, and contractors for public and private works. Mr. Edward Mather, civil engineer, of Salford Iron Works, Manchester, is one of the signatories, and subscribes for 25 shares. The first Directors are: B. Sykes, G. Flett, Edward Hopkinson, D.Sc., T. S. Turnbull and A. Bruce.

MACMILLAN AND CO. (LIMITED), Publishers.—This Company was registered on January 31st, with a capital of £240,000, in 1,400 Six per Cent. Preference and 1,000 Ordinary shares of £100 each, to acquire as a going concern the business of publishers and booksellers carried on in London under the style of "Macmillan and Co." The first Directors are G. L. Craik, F. O. Macmillan, G. A. Macmillan and M. C. Macmillan.

GUILDFORD ELECTRICITY SUPPLY COMPANY (LIMITED).—The annual return to December 18th was recently filed. The nominal capital is £20,000, in 3,900 Ordinary shares of £5 each, and 500 Founders' shares of £1 each. 974 of the former and 482 of the latter have been subscribed for, and £2 per share has been called on the Ordinary, and the full amount on the Founders' shares.

W. AND J. ROBINSON AND CO. (LIMITED).—An agreement has been entered into by this Company with Messrs. W. H. and J. L. Robinson, electrical engineers, of Bootle, by which it is agreed that the balance of the purchase price of the business acquired by the Company (£7,100) shall be paid to Messrs. Robinson, as to £2,600 thereof in cash, £2,500 by the allotment of 100 fully-paid shares (Nos. 3,233 to 3,732), and the remaining £2,500 by the issue of debentures.

UNIVERSAL ELECTRIC CARRIAGE SYNDICATE (LIMITED).—An agreement has been made by this Company with Mr. Walter C. Bersey for the acquisition of Patent No. 7,240 (1894) for adaptation of electric motors and mechanism to ordinary existing horse vehicles, Patent No. 17,445 (1894) for an electric magnetic friction driving clutch, application for Patent No. 37,019 (1895) for improvements in connection with the driving gear for giving motion to vehicles propelled by electricity, and application No. 16,521 (1895) for improvements in connection with the overhead system of electric traction. The consideration is the allotment of £2,500 in fully-paid shares of the Company.

VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).—The annual return to January 14th has been filed. The whole nominal capital of £70,000, in £1 shares, has been taken up, and 56,506 shares have been issued as fully paid, while the full amount has been called and paid on the remainder,

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30⅞d. per oz. (Feb. 13th). Consols (2¾ per cent.) 108⅜–108½ for money, 108 7/16–108 9/16 for account; 2½ per cent. 105—105½ (Feb. 13th). Stock Exchange Settling Days: Consols, March 2nd; Stocks and Shares Continuation Day, Feb. 25th; Ticket Day, Feb. 26th; Pay Day, Feb. 27th; Mining Share Carry-over Day, Feb. 24th.

CASTNER-KELLNER ALKALI COMPANY (LIMITED).—The statutory meeting of this Company was held on the 6th inst. at the Cannon-street Hotel. The Chairman (Mr. W. Mather) stated that the Directors had secured a very convenient site for the erection of works at Weston Point. Building operations had already been commenced, and the work would be vigorously proceeded with during the next few months. The Chairman next referred to the fact that the Deutsche Solvay Werke Gesellschaft, who had been making investigations into the Castner-Kellner electrolytic processes, had been so satisfied with the results obtained that they had not only subscribed largely to the capital of the Castner-Kellner Company, but they had also decided to erect works in Germany simultaneously with the works which were being erected here. For the first few months the Directors intended to confine themselves to one-fourth of the plant they eventually contemplated putting down, and thus they would get such advantage as time and experience would give them.

CENTRAL LONDON RAILWAY COMPANY (LIMITED).—The half-yearly ordinary general meeting of this Company will be held on Wednesday, the 26th inst., at the Cannon-street Hotel, at three o'clock, to receive the Directors' report. An extraordinary general meeting will be afterwards held for the purpose of passing a resolution authorising the raising of £150,000 additional Ordinary capital by the issue of 15,000 new shares of £10 each. The transfer books of the Company will be closed from the 20th to the 26th inst. inclusive.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended February 9th were £972, against £1,022 in the corresponding week of 1895, a decrease of £50. The total receipts for the half-year amount to £5,997, against £6,041 for the corresponding period of 1895, a decrease of £44.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The Directors of this Company have decided to recommend to the shareholders at the forthcoming meeting the payment of the following dividends (subject to the completion of the audit): 6s. per share on the Preference shares for the second half-year, making, with the interim dividend already paid, a total distribution of 6 per cent. for the year 1895, and 10s. per share on the Ordinary shares for the year 1895, being at the rate of 5 per cent. per annum. Notice is given that the transfer books and registers of members of this Company are closed from the 7th to the 21st inst. inclusive.

GAS LIGHT AND COKE COMPANY.—At the half-yearly meeting of this Company last week the Chairman (Col. W. T. Makins), in moving the adoption of the report and accounts, congratulated the shareholders upon the fact that "in spite of the competition of the electric light," the use of gas for public lighting was still on the increase. Col. Makins, doubtless, meant to say this gratifying state of affairs was in consequence of, and not in spite of the competition of, the electric light. Citizens who have the advantage of the electric light in one quarter are no longer satisfied with dimly lit, but by no means religiously lit, streets elsewhere, and demand increased light, which, as often as not, is provided in minor thoroughfares by additions to or improvements in the gas burners. This naturally leads to increased consumption, but cannot be truly said to be brought about "in spite of the competition of the electric light."

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended the 9th inst. amounted to £1,090. The amount for the corresponding week last year was £859. Increase, £231.

STOCK EXCHANGE NOTICES.—The Stock Exchange Commiteee have appointed Monday, the 17th inst., a special settling day in 200,000 shares (Nos. 100,001 to 300,000) of the Castner-Kellner Alkali Company (Limited), and have ordered the same to be quoted in the official list.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LTD.).—The Directors of this Company propose to pay a balance dividend of 10 per cent. (£1. 4s. per share), making 15 per cent. for the year 1895.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended February 7th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,848.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Feb. 5.		Price Wednesday, Feb. 12.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Feb. 8.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS.								
£1,012,880	Stock	10/0	Anglo-American	47	49	47	49	4 11 10	Jan., Apr., July, Oct.	48½	..
£2,993,560	Stock	20 0	Do. Preferred	83	89	84½	89½	5 9 0	" " "	89¼	—
£2,993,560	Stock	5/0	Do. Deferred	7½	8	7½	8	..	.. ..	..	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	100	104	100	104	3 17 4	January and July ..	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	9½	10½	10	10½	..	.. ..	..	..
190,000	£10	9/0	Brazilian Submarine	13½	14	14	14½	4 15 8	Mar., June, Oct., Dec.	14	13⅞
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110	114	110	114	4 12 9	June and December	..	—
10,000,000	$100	$1½	Commercial Cable Capital Stock	160	170	160	170	4 2 10	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12½	12¾	13½	13¾	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20½	21¼	20½	21¼	4 13 0	" "	—	..
12,921	5	2/0	Direct Spanish (fully paid)	4	5	4	5	4 0 0	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10	10½	10	10½	4 15 3	" "	10⅝	—
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104½	107½	104½	107½	4 4 5	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	8¼	9½	9	9½	4 4 3	Jan., Apr., July, Oct.	9½	9⅜
400,000	10	2 6	Eastern	17	17½	17	17⅝	3 14 4	" "	17⅝	17
70,000	10	6%	Do. 6 per Cent. Preference	18	18½	18	18½	3 4 10	" "	18⅝	18
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	126	129	127	131	3 2 2	May and November	129½	127½
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1999 xd	105	108	105	108	4 12 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17½	18	17½	18	3 17 9	Jan., Apr., July, Oct.	17⅝	17⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock xd	127	130	126	129	3 2 0	February & August	126	—
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	100	104	100	104	4 16 7	January and July ..	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	100	104	100	104	4 16 7	.. ..	102	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1900 (regd.) xd	105	108	105	108	3 14 1	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112%	115%	113%	115%	3 10 2	May and November	112½	..
180,227	10	1 6	Globe Telegraph and Trust	10	10½	10	10½	3 18 6	Jan., Apr., July, Oct.	10½	10
190,042	10	6%	Do. 6 per Cent. Preference	16½	17	16½	17	3 10 7	" "	17	16⅝
150,000	10	5/0	Great Northern	22	23½	22½	23	3 14 7	Jan., April, and July	22½	22⅜
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1933 issue	104	107	104	107	4 15 6	March & September	..	..
17,000	25	12 6	Indo-European	46	49	46	49	5 2 0	May and November	47½	47⅛
37,513	10	..	London Platino-Brazilian	..	..	..	..	..	.. ..	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107	111	107	111	5 10 7	March & September	110	—
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1912	108	111	108	111	3 12 5	" "	—	—
11,839	8	4/0	Reuter's	4½	5½	4½	5½	..	April and October	..	..
3,881	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	127	132	127	132	4 10 11	" "	130	127
15,600	10	2/0	West African Telegraph	5½	6½	5½	6½	..	January and July ..	..	..
£233,300	100	5%	Do. 5 per Cent. Debentures (red.)	101	104	101	104	4 18 3	March & September	..	..
30,000	10	2/0	West Coast of America	1	2	1	2	..	January and July .	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	94	99	94	99	8 3 3	June and December	..	..
88,321	10	1/3	West India and Panama	1	1½	1	1½	..	.. ..	1½	1⅜
84,563	10	6%	Do. 6 per Cent. 1st Preference	10½	11½	10½	11	5 8 1	May and November	11	10⅞
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	.. ..	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108	111	108	111	4 19 8	June and December	..	..
64,248	15	3/0	Western and Brazilian	8½	9½	8½	9½	5 5 8	May and November	9½	..
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6½	6¾	6½	7	..	—	6¹¹⁄₁₆	..
33,129	7½	1/6	Do. Deferred Ordinary	3	3½	3	3½	..	.. ..	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910 xd	102	105	102	106	5 13 2	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910 xd	102	106	102	105	5 13 2	" "	—	—
£1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	113	118	113	118	6 0 8	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	102	105	102	105	5 16 10	March & September	..	—
			TELEPHONES.								
44,000	5	2/6	Chili Telephone (fully paid)	3½	3¾	3½	3¾	..	—	—	
224,850	10/0	1½1.	Consolidated Telephone Const. & Maintenance	⅛	¼	⅛	¼	..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	⅛	¼	⅛	¼	..	Yearly	..	..
484,597	5	2/6	National	6¾	6¾	6½	6¾	4 8 11	June and December	6¾	6⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16	18	16	18	3 6 8	" "	16½	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	16	17	16	17	3 10 7	" "	16½	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6½	6¾	6½	6¾	4 8 11	—	..	..
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	104	107	104	107	3 5 9	January and July ..	106½	105⅜
53,000	5	3/0	United River Plate	2½	3½	3	3½	..	" "	..	—
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	93	98	94	99	5 1 9	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	5/0	City of London Electric Lighting (fully paid)	14	15	14	15	1 13 4	—	14½	14½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	16	16½	16	17	3 10 7	—	16½	16⅜
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	134	138	134	138	3 12 10	June and December	137	135½
19,900	£5	..	Electricity Supply Co. for Spain	..	—	..	—	..	—	..	..
£80,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½	5¾	5½	5¾	..	—	5¾	5⅝
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	—	—	—	—	..	—	..	..
2,475	£8	..	County of London & Brush Prov. Ord. (fully paid)	8	9	8	9	..	—	..	..
10,000	£10	9½d.	Do. Pref. (£6 paid)	10½	11	10½	11	..	—	10¾	..
8,238	£5	..	House-to-House Electric	—	—	..	..	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	—	—	—	—	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	..	..	January and July ..	..	..
45,000	£5	8/0	Liverpool Electric Supply (fully paid)	7¾	8½	7¾	8½	3 13 10	—	..	..
111,000	5	..	London Electricity Supply	..	..	..	..	..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	11½	12½	12	12½	2 13 1	—	12½	12
150,000	Stock	4½%	* Do. 4½% Debs.	116	118	115	118	3 16 6	June and December	..	..
6,452	£10	2 0	Notting Hill Electric	8½	9	8½	9	..	—	..	..
..	..	..	Rand Electric	⅛	⅛ prem	¼	⅜ prem.	..	—	..	..
19,930	£5	2'0	St. James and Pall Mall	9	10	9½	10	..	—	9½	9½
20,000	£5	7%	Do. 7 per Cent. Preference	9	9½	9	9½	3 13 8	—	..	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	9	9½	8½	9½	3 11 10	—	9⅝	9½
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	3	1/8	Brush Electrical Engineering	1	1½	1	1½	12 1 0	—	1	1
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝	1¾	1½	1¾	6 17 2	—	1¾	1⅝
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	112	115	113	115	3 19 10	March & September	114½	114½
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2	2½	2½	2¾	..	January and July ..	2	2
89,281	5	1/6	Edison and Swan United	1½	1¾	1½	1	..	..	1⅛	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104	107	103	106	4 5 6	..	102½	..
£10,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	—	—	—	—	..	..	..	..
110,000	2	..	Electric Construction	⅜	½	⅜	½	..	..	..	..
12,845	2	2/9½	Do. 7 per Cent. Cumulative Pref.	2	2½	2	2½	5 13 0	..	—	..
91,195	2	10'0	Elmore's Patent Copper Depositing	⅜	1	⅜	½	..	..	1	1⅛
20,000	5	..	Fowler-Waring Cables (fully paid)	⅜	½	⅜	½	..	..	..	..
59,000	10	5/0	India Rubber, Gutta Percha, &c., Works	21½	22½	20½	21¼	3 9 9	February & August	21½	21½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 17 1	March & September	..	—
15,925	£10	..	International Okonite Ordinary	..	..	..	..	..	—	—	..
16,000	£10	..	Do. 8 per Cent. Preference	..	..	..	..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	⅜	½	⅜	½	..	.. ..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	44	46	33	41	5 17 0	March and July	46	45
£150,000	100	5%	* Do. 5 per Cent. Bonds	102	105	102	105	4 15 8	January and July .	..	—
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	..	..	..	..	..	—	..	—
41,093	£5	..	Do. Preference (fully paid)	..	..	..	..	..	—	..	—
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	13½	14½	13½	14½	4 2 9	—	14½	13⅞
£30,000	10	7/0	Do. 7 per Cent. Preference	15½	16½	16	17	4 2 4	—	16⅝	16½
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	108	111	108	111	4 2 9	—	..	..
			RAILWAYS AND TRAMWAYS.								
£350,000	Stock	1½%	City and South London Railway Con. Ordy. xd	40	43	40	42	2 16 6	May and November	4 ¼	40
7,650	10	5%	Do. 5% Perpetual Preference xd	14½	15	14½	15	3 6 8	.. ..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130	132	130	132	3 1 2	May and November	..	..
87,500	£10	2½%	Liverpool Overhead Railway	13⅜	13⅝	13½	13⅝	1 11 8	—	..	..
10,000	10	5%	Do. 5% Preference	16	16½	16	16½	3 1 6	—	..	..
125,000	Stock	4%	Do. 4% Debenture	113	114	113	114	3 10 2	January and July	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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NOTES.

An Association, with offices at 27, Chancery-lane, to be known as the United Kingdom Telephone Defence Association, has just been launched, with a strong Executive Council, an influential General Council and a whole series of extremely laudable objects. The motive force of the Association, the Executive Council, consists of Prof. Silvanus Thompson, Mr. R. E. Crompton, Major-Gen. Webber, Mr. A. R. Bennett, Prof. A. B. W. Kennedy, Mr. C. R. Haig, Mr. H. H. Bridgman, ex-chairman of the City Commissioners of Sewers, and Mr. James Swinburne—a veritable Ministry of All the Talents, scientific, technical and commercial.

The objects of this organisation, as set forth in the admirably lucid and highly persuasive circular which is being distributed broadcast amongst the National Telephone Company's *clientèle*, are in general to secure an improved service at a reduced rate, and in particular to place the telephone subscriber's case in an effectual manner before the Telephone Select Committee, should this Committee attempt to renew its Sisyphean labour of piling up mountains of official and interested evidence to be toppled over, as soon as raised, by arguments and evidence the Committee refuses to listen to. If the Association continue as it has begun it should prove a much-needed telephonic anti-soporific. The last paragraph of the "Objects of the Association" is a somewhat vague, self-denying ordinance. Unless the United Kingdom Telephone Defence Association is in every sense of the term "to be registered as an association without profit," as was to all practical intent the whilom Association for the Protection of Telephonic Subscribers, the members would do well to insist that everyone belonging to one or other of its two councils shall pledge himself not to go over to the enemy, either as a director or as an official, without the consent of a clear majority of the members of the Association. The National Telephone Company, it must not be forgotten, is an adept at amalgamation and absorption.

In another column will be found a copy of Major Cardew's Report on the recent fatality at Cheltenham. The circumstances under which the accident occurred are set forth with exemplary brevity and lucidity by the Board of Trade Inspector, and his recommendations and remarks are worthy of the careful attention of all central station engineers responsible for high-pressure systems, who will be well-advised to set their houses in order before the inevitable "accident" occurs. In the ordinary acceptation of the word, an accident is an occurrence which, humanly speaking, could not have been foreseen; we decline to admit that the term is applicable to a fatality which arose from sending an unfortunate carpenter into a more or less crowded transformer-chamber to drill holes at a distance of a few inches from a number of innocent-looking but deadly metal surfaces. Under the conditions which obtained, it surely required a minimum amount of prescience to foresee an "accident" and, with 2,000 volts pressure, a fatality. It is not a question of elaborate and expensive precautions in view of a remote contingency best guarded against by the exercise of individual care, but merely of employing a few cheap and obvious devices to ward off mishaps which must otherwise inevitably happen at short intervals. Electrical engineers may be assured that the moderate suggestions as to safety appliances made by the Board of Trade will be converted into orders, and stringent orders too, if by any chance a public outcry should be raised. The policy of shutting the stable door after the horse has got out is as inexpedient as it is expensive.

The decision of the London County Council, notwithstanding Earl Russell's weighty arguments, to again oppose the Bill of the London United Tramways Company, in which power is sought to make use of the overhead trolley, is a typical instance of the gratuitous obstacles that are in this enlightened country placed in the way of tramway improvements. Insecure tenure, lack of capital, and a stationary traffic are too often the lot of our English tramway concerns, and are in themselves almost sufficient to entirely arrest the introduction of improved methods of traction. The London County Council, however, with a grand display of fidgety anxiety about the beauty of London, preferred to make quite sure that a capitalist concern should in no way prosper, and summarily vetoed a system of traction which has found favour not merely in far away America but in Bristol and Coventry and in many Continental cities, where the beauty of the streets is generally considered to exceed even the elusive charm of the Uxbridge-road from Shepherd's Bush outwards. We yield to no one in a desire that engineering "improvements" should not be permitted to further disfigure the metropolis of the Empire; but high as is our opinion of

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the capabilities of the modern engineer, we must confess we never thought him capable of disfiguring the many dreary roads that lead out of London. By all means insist, if need be, on a conduit system in the central portions of London; but why refuse the inhabitants of Shepherd's Bush the boon of getting away from their hideous surroundings as fast as the electric car can take them; they are the persons most concerned, and by all accounts do not object to the proposed innovation. The overhead trolley, whatever its demerits—mechanical, electrical or æsthetic—and they are many, will always be the cheapest to erect, and, therefore, so long as our tramways are in the hands of companies liable to be bought out on onerous terms by the local authorities, this single advantage will rightly carry great weight, and should in all fairness and in all good sense be allowed to do so. When tramways are laid down by philanthropists, it will be time enough to expect a lavish capital outlay without thought of return.

Mr. H. F. Parshall's lecture at the Society of Arts on Tuesday evening last was essentially American, and came as a relief to the heavy Papers to which we are accustomed. It consisted of ten minutes' pleasant talk and of a forty-minute long procession of lantern slides illustrating some of the most recent and important improvements in electric traction. The lecturer did not trouble his audience with much description, but contented himself with pointing out a few of the most interesting details, and left the rest to the imagination. Indeed, Mr. Parshall's splendid series of photographs spoke more eloquently for the possibilities of electric traction than any words could. It was specially interesting to notice the huge steam dynamo units used for power stations; machines of from 1,000 to 1,500 kilowatts being by no means uncommon. The change of American practice from high-speed dynamos, driven by belting from a countershaft, to slow-speed direct-driven units, is a curious one and shows how transatlantic engineers have profited by European experience. High-speed engines of the Willans type have not found favour, possibly because the type is not thought suitable for the horse-powers common in the United States. The fly-wheel armature type of machine which was originated on the Continent seems to be preferred. American shafts, armature-plates, commutators, &c., are such large scale productions as to make it somewhat difficult for stay-at-home English electrical engineers to form an adequate conception of them. For example, a commutator weighing rather over two tons, with nearly 700 segments, requires time as well as imagination to mentally digest. The series-parallel starting device, which has been invented over and over again, and has been the subject of much investigation both in Europe and America, has been finally adopted as the method of starting and controlling tramcars. Indeed, it was always felt to be the proper method, and was not adopted sooner simply from mechanical difficulties in dealing with the changes of connections. The chief obstacle lay in the opening of the circuit before changing the motors into parallel. This has been overcome by short-circuiting one of the motors before placing it in parallel with the other. The American device of blowing out arcs at the switch contacts is of special importance and is little known in this country.

Two very valuable items of information were given to the meeting by Capt. Griffiths of the General Electric Company. The first was that the substitution of the series-parallel control for the rheostatic control on the lines at Boston had enabled the West End Company to double the number cars running without adding to its power plant. The second item of news was to the effect that experience with the two slotted-conduit lines now in operation in New York and Washington respectively showed that although the first cost of the system was high (£17,000 per mile of single track), the working cost was less than with the trolley. It is interesting to note the conversion of the General Electric Company. Only a year or so ago that powerful concern was engaged in the evidently congenial task of belittling any and every system of electric traction other than the one the patents of which it controlled.

The Belt-line tunnel locomotives were referred to by the lecturer, and some details of their performance will, no doubt, cause astonishment among those still sceptical about the tractive effort of electric motors. These "locos." weigh 96 tons, and have eight wheels coupled to four independent axles, each of which carries a gearless motor rated at about 100 B.H.P. The weight per wheel is thus 12 tons, or 5 tons in excess of ordinary steam locomotive practice. The brasses, Mr. Parshall explained, were designed for the full load according to usual practice, and no difficulty had been experienced since last August. The even torque caused no pounding and it was quite possible to load the wheels to a greater extent than in steam practice without damaging the brasses or the permanent way. The electric locomotives were designed to haul freight trains weighing, with their locomotives, roughly 400 tons each, through a tunnel with an up gradient of 0·8 per cent. They not only do this work quite easily, but one of them, on one occasion, hauled three trains, weighing together nearly 1,900 tons. The train was stopped in the middle of the incline and was started again without a hitch.

If writers of scientific Papers are going to follow the example set by the author of an American Paper, entitled "The Gross Untrustworthiness of Fuse Metals and Appliances as a Means of Protection for Electric Circuits," we may expect to find more vigour than elegance in the files of the future proceedings of scientific societies. Such a title as "The Atrocious Drop in Copper Feeders," or "The Preposterously Large Waste of Energy in Boosters," would, no doubt, have some advantage over a milder title, in giving prior notice of the author's opinions, and might even induce some people to "come up for the discussion" whom a colourless title would fail to draw from their fireside. The discussion, however, would probably be as unparliamentary in its brusqueness as the title itself, or even more so; and things might go from bad to worse when once the expletive ball had been set a-rolling. Taking one consideration with another, therefore, a return to the use of tame titles is to be recommended.

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But the matter of this Paper on fuses is more to be commended than its title. It takes the form of a report to the Philadelphia Board of Fire Underwriters, and, after an exhaustive discussion of all the vices which metal safety fuses are prone to develop, recommends that in all important places they should be replaced by automatic magnetic cut-outs. These, it is further recommended, should not contain springs, which would be likely to be let down in temper by the heat generated by the current. The maximum limit of current for which metal fuses might be used is placed at 10 amperes; but we should prefer that the limit should be determined not only by the current, but also by the power to be carried by the circuit controlled. A short circuit on 10 amperes with 100 volts would not be the same phenomenon that it would be on a 10-ampere 10,000-volt circuit. The practical hindrance to the general use of electromagnetic cut-outs has been their large cost relative to fuses, and it is to be feared that this will continue to militate against their extensive use in house installations. Up to the present time magnetic cut-outs have not, perhaps, been used in electric supply stations to the extent their merits warrant; but they are to be found on the switchboards of nearly all, if not all, electric traction stations in this country. One advantage which the electromagnetic cut-out possesses over the fuse should not be forgotten, viz., that it can be constructed to open both positive and negative leads in the event of either going wrong, whereas with a double-pole fuse it does not necessarily happen that both fuses will blow.

Time cannot wither, nor custom stale, the infinite variety of the Röntgen ray. To-day we print in our correspondence columns letters from Lord Blythswood, Mr. C. E. S. Phillips. and Mr. C. J. P. Cave, and a translation of a Paper just communicated to the Royal Academy of Bologna by Prof. Righi, Mr. Phillips finds flames are transparent, and Mr. Cave gives some interesting particulars with regard to the great increase in what may be termed the "sparking capacity" of a pair of terminals which is caused by the incidence of Röntgen rays. Prof. Righi, like Profs. J. J. Thomson and Borgmann, finds that both negatively and positively-charged bodies are diselectrified by Röntgen rays. Prof. Righi has also observed their electrifying power, but unlike Prof. Borgmann, he finds the electrification *positive*. In view of these and other contradictory results, it may be permissible to suggest that Röntgen-ray experimenters would be well advised in stopping further experiments for a while and in assembling together in Congress for the purpose of standardising experimental conditions.

Perhaps the most interesting addition to our knowledge is that made at the Royal Society last week by Prof. Dewar, who from a large number of experiments argues that opacity increases with atomic weight, not with the density merely, as stated by Röntgen. As was recorded on p. 524 of our last issue, M. V. Chabaud found mercury more opaque than platinum; now the atomic weights of mercury and platinum are respectively 200 and 194, whilst their densities are 13·6 and 21·5. An interesting case in point.

Cable Interruptions and Repairs :—

	Date of Interruption.
Puerto Plata—Martinique	December 19, 1895
Perim—Obock	January 2, 1896
Odessa—Constantinople	January 17, 1896

Expiring Patents.—On Thursday next, the 28th inst., will expire Patent No. 941, granted to J. Richardson, of the firm of Robey and Co., for "An Improved Arrangement of Appliances for Electrically Controlling and Regulating the Speed of Engines Employed for Driving Dynamo-electric Machines." The specification describes an arrangement of solenoids, by means of which the engine valves are controlled by the dynamo.

The Municipalisation of Telephones.—A town's meeting, presided over by the Lord Mayor, was held at Manchester on Tuesday last to consider the question of the Corporation undertaking to provide telephonic communication throughout the district. The attendance, which was very large, included the leading merchants and manufacturers of the city. A resolution in favour of applying to the Post Office for the necessary powers to carry out the project was submitted, but was rejected by a large majority.

The 1900 Paris Exhibition.—The Committee of the Paris International Exhibition of 1900 has rejected the Government proposal to incorporate the Champs Elysées, or any portion thereof, in the exhibition grounds. The Palais de l'Industrie will remain intact, and the Exhibition grounds will be exclusively on the left bank of the Seine. However, the verdict of the Committee will not annul the Government scheme, and there is some prospect of the original scheme being carried out in its entirety.

Röntgen Ray Photography.—In the *Comptes Rendus* for February 10th, M. Charles Henry gives a recipe for increasing the photographic action of Röntgen rays. M. Henry smears some of his phosphorescent sulphide of zinc to a depth of about ·5 mm. or 1 mm. on the *back* of a gelatino-bromide plate, and finds that a notable increase in the photographic action is the result. He further finds that a layer of the same substance on the face of a coin or similar object renders it decidedly more transparent to Röntgen rays.

The London-Paris Telephone Line.—The indefatigable Mr. Henniker Heaton, after rebuffs from three successive English Governments, has succeeded in obtaining from the more polite authorities across the Channel statistics with regard to the telephonic communications exchanged between London and Paris. These amounted in 1894 to 45,115, which, at the rate of 8s. for each conversation, represents a total income of £18,046. The number of conversations originating in Paris was less than that of the conversations started from London. The former only reached the number of 18,930, while the latter amounted to 26,185.

Accident at the Southport Central Station.—A few minutes before three o'clock on Wednesday morning, last week, information was received by telephone at the Central Police Office that a man had been injured at the electric light works at Blowick. It was found that an engine-man employed at the works was suffering from an electric shock, together with severe injuries to the right hand and right leg. He was conveyed to the infirmary. It is stated that the man received his injuries owing to the fact that he was not wearing india-rubber gloves, which it is customary at Southport to use when any work is being done in connection with the machinery. Had not a fellow-workman been at hand to render assistance the result would probably have been more serious.

International Horse and Horseless Carriage and Roads Locomotion Exhibition.—Our readers will probably be pleased to hear that at the forthcoming exhibition to be held at the Crystal Palace of all things appertaining to carriages and automotor vehicles, the interest of electrical engineering will be carefully watched over. We understand that Mr. A. R. Sennett, A.M.I.C.E., M.I.E.E., has accepted the position of Honorary Executive Commissioner. In addition to the class of electrically-propelled vehicles, there will be others for electric motors, special gears, accumulators, primary batteries, &c., as well as accessories such as electric lamps for the lighting of vehicles,

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tricycles, &c. The classification is not yet quite complete, and the Executive Commissioner would be glad of any proposals readers may care to send to him addressed to the Crystal Palace. Mr. Sennett is anxious to see electric vehicular propulsion take its fair position, and he will be glad to receive as soon as possible particulars from such of our readers who may be proposing to exhibit electrical vehicles in action, as to their requirements in regard to the recharging of accumulators in order that proper provision may be made.

The Measurement of High Potential Difference.—In a Paper recently read before the Royal Society, Messrs. H. C. Leake, R. Leventhorpe and C. S. Whitehead described some methods of measuring high potential difference. The Paper is divided into two parts. In Part I. the question of the measurement of high potential difference in terms of the absolute electromagnetic unit is considered, more especially with reference to the calibration of electrostatic voltmeters. After describing Lord Kelvin's method of multiplying a comparatively small known potential difference by means of a series of condensers, a full account is given of the method adopted by Prof. Ayrton and Mr. T. Mather for the calibration of their electrostatic voltmeters. The apparatus is arranged for the determination of alternating potential differences up to several thousand volts, either by measurement of the current passing through a non-conductive manganin resistance of about 20,000 ohms, or by comparison with the steady potential difference of the Clark standard cell, in a way that does not involve any measurements of resistance. It is probable that the measurements made in this way of potential differences of about 2,000 volts are correct to about $\frac{1}{10}$ per cent. in absolute units. Part II. discusses the measurement of high potential difference in terms of the absolute electrostatic unit.

Trials of the Laval Steam Turbine.—At a recent meeting of the Société Internationale des Electriciens, M. L. Fayot gave some particulars of a number of trials of the Laval steam turbine. The first of these was made on a 50 H.P. turbine, coupled to a dynamo, on July 7, 1895. The electrical horse-power developed was 48·64, and the steam consumption during a trial of 3hr. 30min. duration was 3,960lb., or 23·2lb. per horse-power per hour. The second series of trials referred to by M. Fayot was the series conducted at the Bordeaux Exhibition, an account of which has already been given in *The Electrician*, December 27, 1895. On November 10, 1895, a trial of a 100H.P. turbine was conducted at Vienna, under the direction of M. Desjuzeur. The turbine was rope-geared to a dynamo and ran for 10 hours, the steam consumption being 25·41lb. per electrical horse-power at the terminals of the dynamo. This is estimated as being equivalent to 19·58lb. per brake horse-power at the turbine shaft. Prior to the above-mentioned trial the turbine had run for 3,300 hours, and having been stopped on Saturday night for making ready, it was placed on trial during Sunday. Next follows a trial of three turbines at the electric supply station of the Place Clichy, in Paris. The engines were each rated at 75 H.P., and the trial was conducted by M. Compère. A steam consumption of 23·9lb. per electrical horse-power per hour was realised, which was estimated to be equivalent to 20·3lb. per brake horse-power at the turbine shaft. Finally there is an account of a trial of a 200 H.P. turbine, arranged to run at half-load. The trial was conducted at Troyes, and was of a somewhat elaborate nature. Tests were made of the variation of steam consumption with the initial pressure, &c., and the results are recorded in the form of a series of curves. The utility of these curves is somewhat marred by the omission of some of the lettering referred to in the text.

Blast Furnaces Struck by Lightning.—The *Engineer* states that at some ironworks in an exposed situation near the banks of the Rhine the workmen had often reported that lightning seemed to strike the tops of the blast furnaces, and even enter them. instead of being attracted by the lightning conductor on the chimney, which is at a much greater elevation. Though little credence was given to these reports, the men were instructed to keep a strict watch upon such phenomena in future. During eight years they stated that the furnaces were struck three times, while out of ten lightning flashes only one was attracted by the lightning conductor, the others chiefly striking piles of puddle bars. On one occasion, however, Herr Franz Büttgenbach was showing some colleagues over the works, and was with them at one of the furnace tops, when a flash of lightning struck the furnace, which trembled and rattled. The visitors and two furnacemen were stunned, but on coming to themselves they all declared that they saw a pillar of fire entering the furnace mouth. At the top of the furnace, however, nothing unusual was noticed, except that the thick coating of dust which covered the plate-iron shield was driven off; but the men at the bottom reported that the slag, flowing from the furnace in a slow stream, had flowed more quickly for a little while, as when a furnace is tapped. They too considered that the lightning had entered the furnace because of its rumbling and trembling. The furnace was then carefully examined, but no damage was observed, nor any change in its working. The next cast of metal also appeared normal; and analysis of the pig revealed no change in composition. Herr Büttgenbach, who communicates his experience to *Glückauf* of Essen-an-der-Ruhr, observes that he could now believe the men's former declarations that such phenomena were repeated at two of the furnaces every year, but always without leaving any appreciable trace behind. He considers that the reason the lightning entered the furnace, instead of being attracted by the lightning conductor, was that a compact pillar of smoke, containing much water and dust, rose to a height of 40m. above each furnace mouth, forming a good conductor of electricity, which must have passed through the furnace charge, out at the pig bed, and into the earth without doing any damage; but he regrets that the pig of the cast immediately following the lightning discharge was not examined under a microscope, which might have revealed differences of structure as compared with normal pig iron.

Contemporary Electrical Science.—In *Wiedemann's Annalen*, No. 2, we find two important Papers on the measurement of "dielectric constants." W. Nernst describes his telephone method, consisting of a bridge with two equal resistances in two branches, a dielectric trough in the third, and a variable capacity and a variable resistance in parallel in the fourth branch. Two opposite terminals are connected with a high-frequency induction coil or alternator, and the other two with a telephone. The latter is reduced to silence as soon as the variable resistance and capacity are the same as those of the dielectric. This method is very convenient and perfect, and the author tried to compare it with an electrometer method. But the latter was found to be too uncertain, until his disciple, J. F. Smale, hit upon the expedient of suspending the electrometer needle, a pointed lamina of platinum, by a quartz fibre and immersing it bodily into the dielectric between terminals surrounding it in semi-elliptical arches. The deflection of the insulated needle, which is charged by induction from the terminals, is proportional to the dielectric constant, and the two methods give highly consistent results.—P. Drude contributes a suggestive little Paper on dielectric resistance, working out the analogy of the magnetic resistance which has been so useful in the study of magnetic fields. He arrives at propositions like the following: The number of lines of force contained in an infinitely thin tube of force is equal to the difference of potential between its terminal points divided by its dielectric resistance. Or: The capacity of a conductor equals the reciprocal of the total resistance of all its tubes of force ranged in parallel, and divided by 4π.—Max Wien describes a very promising-looking apparatus for producing any self-induction "from 5,000 to 10^{10}cm." It consists of a fixed circle of several coils for step-by-step changes, and a concentric coil movable about a diameter to fill up the intervals.—E. Taylor Jones writes on magnetic carrying power and electromagnetic tension, and claims to have driven B up to 74,200 units in his apparatus!—A. D. Cole makes a further contribution towards the justification of Maxwell's celebrated $n^2 = k$ law. For electric waves 3m. to 6m. long, water has a refractive index of 8·95, and alcohol of 5·20. When the wave lengths are shortened to 5cm. the refractive index of water becomes 8·8, but that of alcohol falls to 3·2. It appears that n always approaches a limiting value for infinitely long waves, and that this value satisfies Maxwell's equation.

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THE ELECTRIC ARC.

BY HERTHA AYRTON.

(*Concluded from page 228*).

THE RATIO OF THE POWER EXPENDED IN THE SILENT ARC TO THE POWER DEVELOPED BY THE GENERATOR.

In the last article it was shown that with silent arcs, when the length was fixed, the conditions that $\frac{V}{E}$ should have the greatest value were given by the three equations

$$(E-a-bl)^2=4r(c+dl), \quad . \quad . \quad . \quad (10)$$

$$E-a-bl=2Ar, \quad . \quad . \quad . \quad . \quad . \quad (11)$$

and

$$A=\frac{c+dl}{e+fl}. \quad . \quad . \quad . \quad . \quad . \quad (19)$$

It was also pointed out that if we were free to choose the conditions of the arc circuit without regard to anything but obtaining the largest possible value of the ratio of the power expended in the arc to the power developed by the generator —that is, $\frac{V}{E}$,—the ideal conditions were that l should be zero, and that the other three variables should be found from equations (10), (11) and (19) on this assumption. In this case we should have for my carbons

$$E=a+2e=41{\cdot}22 \text{ volts},$$

$$A=\frac{c}{e}=9{\cdot}96 \text{ amperes},$$

$$r=\frac{e^2}{e}=0{\cdot}1175 \text{ ohm},$$

$$\frac{V}{E}=\frac{a+e}{a+2e}=0{\cdot}9716.$$

We are not, however, free to choose our variables in this way. One or more of them is sure to be fixed by quite other considerations, such as the least length of arc that will emit the desired amount of light, the minimum resistance we are compelled to have in the leads, generator, &c.

Having, therefore, considered what happens when l is fixed, we will take each of the other three quantities, E, A and l, as being fixed in turn, and consider under what conditions $\frac{V}{E}$ will be the greatest in each case.

Since it will be found that the resistance external to the arc must in each case be the smallest with which the given conditions can be carried out, I will point out beforehand that in equation (9)

$$r=\frac{E-a-bl+\sqrt{(E-a-bl)^2-4r(c+dl)}}{2A},$$

which connects E, A, l and r, r will be least for *any* simultaneous values of A and l when

$$(E-a-bl)^2=4r(c+dl)$$

—that is, when equations (10) and (11) hold.

Now, first let E be fixed, then since

$$\frac{V}{E}=\frac{E-Ar}{E},$$

$$=1-\frac{Ar}{E},$$

$\frac{V}{E}$ will be greatest when Ar isleast. But from equation (9) we have $2Ar=E-a-bl+\sqrt{(E-a-bl)^2-4r(c+dl)}$, therefore, for a fixed value of E, Ar is least when bl has its largest value, and when also

$$\sqrt{(E-a-bl)^2-4r(c+dl)}$$

is nought. That is, Ar is least, and, therefore, $\frac{V}{E}$ is greatest, when we use the longest silent arc possible with the given E.M.F. and select the resistance external to the arc, so that

$$(E-a-bl)^2=4r(c+dl).$$

The last equation, which is (10), carries with it equation (11), and from the two we find that

$$A=\frac{2(c+dl)}{E-a-bl}.$$

From this last equation it follows that when E is fixed, and l is as great as possible, A is also as great as possible, or $\frac{V}{E}$ is greatest with a fixed E.M.F. when A is the largest silent current that can be maintained flowing through the arc of greatest length that a generator with the fixed E.M.F. can produce.

Now it was shown on p. 225 of the last article that equations (10) and (11) gave the conditions that the line representing the resistance r ohms should be a tangent to the curve connecting P.D. and current for the length of arc $l$mm. Thus it has been shown that when the E.M.F. of the generator is fixed, $\frac{V}{E}$ is the greatest possible when—

(1) The arc is the longest that can be maintained with the fixed E.M.F.;

(2) The line representing the resistance is a tangent to the curve connecting P.D. and current for this greatest length of arc, and represents, therefore, the smallest resistance that can be used with the fixed E.M.F.;

(3) The current is the largest silent current for this greatest length of arc.

But, as shown in the last article, equation (19) gives the connection between the largest silent current for any length of arc and the length of that arc. Therefore we may say that when E is fixed, equations (10), (11) and (19) give the relations between E, A, l and r that make $\frac{V}{E}$ the greatest.

Next let A be fixed, and first let us suppose that l is fixed also. Then from equation (17) (p. 227 of the last article) we see that for $\frac{V}{E}$ to be as large as possible Ar must be as small as possible. But from equation (9) we have that

$$2Ar=E-a-bl+\sqrt{(E-a-bl)^2-4r(c+dl)}.$$

Hence, whatever the length of the arc may be, if A is fixed Ar is least when E is least, and when also

$$(E-a-bl)^2=4r(c+dl).$$

That is, Ar is least—and therefore $\frac{V}{E}$ is greatest—when we use the smallest E.M.F. that will send the fixed current through the arc, and when we select r, so that equations (10) and (11) hold. But when equations (10) and (11) hold the line representing the resistance is a tangent to the curve connecting P.D. and current for the length of arc used. Hence, when A is fixed, $\frac{V}{E}$ is greatest whatever length the arc may have when we use the smallest E.M.F. that will send the fixed current through that length of arc, and when the line representing the resistance is a tangent to the curve connecting P.D. and current for that length of arc.

Next, while A still remains fixed, let l vary. Then, since it has been shown that $\frac{V}{E}$ is greatest, whenever $\frac{Ar}{E}$ is least and that when A is fixed, $\frac{V}{E}$ is greatest when E is least, we must now find what value of l makes $\frac{Ar}{E}$ least, when E is least, when A is fixed, and when equations (10) and (11) hold.

Since E is to be as small as possible, Ar also must evidently be as small as possible. But from equations (10) and (11) we have

$$A^2r=c+dl,$$

or

$$Ar=\frac{c+dl}{A},$$

which, since A is fixed, shows that $c+dl$ must be as small as possible for Ar to be as small as possible. That is, Ar is least, and therefore $\frac{V}{E}$ is greatest, when l is the shortest arc that can be used, with due consideration for the light to be emitted.

Thus, when A is fixed, we find that the conditions for $\frac{V}{E}$ to be as great as possible are—

(1) That the arc shall be the shortest that will emit the desired light;

(2) That the E.M.F. shall be the smallest that will send the fixed current through this arc;

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(3) That the external resistance shall be such that the line representing it will be a tangent to the curve for this arc at the point where the current is the fixed current, and consequently the resistance must be the smallest with which the fixed current will flow through the shortest length of arc.

Next let r be fixed, and first suppose l to be fixed also. Then, since $\frac{Ar}{E}$ must be as small as possible, we have from equation (9) that $1-\frac{a+bl}{E}+\frac{1}{E}\sqrt{(E-a-bl)^2-4r(c+dl)}$ must be as small as possible. Hence, since l is fixed, E must be as small as possible, and

$$\sqrt{(E-a-bl)^2-4r(c+dl)}$$

must be nought for $\frac{Ar}{E}$ to be least. Thus, whatever the length of the arc may be, if r is fixed, $\frac{Ar}{E}$ is least when E is least, and when

$$(E-a-bl)^2=4r(c+dl)$$

—that is, when E is least, and when equations (10) and (11) hold.

Therefore, whatever the length of the arc may be with which $\frac{V}{E}$ is greatest when r is fixed, the E.M.F. must be the smallest that will maintain that length of arc with the given resistance in circuit, and the line representing the resistance must be a tangent to the curve connecting P.D. and current for that length of arc.

Now let the length of the arc vary, the resistance still remaining fixed. Then, since equation (10) holds, whatever the length of the arc, we get from it

$$E=a+bl+2\sqrt{r(c+dl)},$$

the positive sign only being taken, because from equation (7) (p. 225, *The Electrician*, December 13, 1895) it may be seen that $E-a-bl$ could not be negative. Hence, since E is to be as small as possible for the fixed resistance, l must be as small as it can be consistently with its emitting the desired amount of light. Also, since $\frac{Ar}{E}$ has to be as small as possible, and since r is fixed and E as small as possible, A must also be as small as it can be with the given resistance in circuit.

Thus, when r is fixed, $\frac{V}{E}$ is the greatest possible when,

(1) The arc is the shortest that will give the desired amount of light;

(2) The current is the smallest that will flow through this length of arc with the given resistance in circuit;

(3) The E.M.F. of the generator is the smallest that will maintain that current flowing through that length of arc with the fixed resistance in circuit.

It may not be out of place to give a few examples of the use that may be made of the foregoing methods of securing the largest value of $\frac{V}{E}$ when one or more of the quantities with which we have to deal is fixed by circumstances.

To take first the case of a constant E.M.F., let us consider how to arrange two arcs in series with a dynamo giving a constant E.M.F. of 110 volts, so as to make the ratio of the power expended in the arc to the power developed by the dynamo—that is $\frac{V}{E}$—as large as possible.

There is a constant E.M.F. of 55 volts for each arc and half the resistance in circuit external to the arc, therefore we must make E equal to 55 in equations (10), (11) and (19), to find what current, length of arc and resistance external to the arc will make $\frac{V}{E}$ as large as possible.

In this way we find that roughly

$$A=19{\cdot}6,$$
$$l=4{\cdot}7,$$
$$r=0{\cdot}16,$$
$$\frac{V}{E}=\frac{E-Ar}{E}=0{\cdot}94.$$

These are, of course, the extreme conditions, and if these values were actually used the arc would be very unsteady, for not only would the line representing the resistance be a tangent to the curve connecting P.D. and current, in which case it has been shown that the arc would be unstable (p. 38, *The Electrician*, November 8, 1895), but the current would be the largest silent current for the length of arc, and therefore the arc would be on the point of hissing. But, although we cannot actually use the current, length of arc, and resistance found from equations (10), (11) and (19), yet these will *serve as guides* for the choice of the actual values to be employed, so that $\frac{V}{E}$ may be as large as it is possible to be when the arc is perfectly steady.

Let us then take an arc of 2·5mm. and a current of 14 amperes, so as to be sure of being well within the limits of steadiness. We have now to put E equal to 55, A equal to 14, and l equal to 2·5 in equation (7), which is the *general* equation connecting E, A, l and r. For, as we are not now using the largest current and longest arc that can be maintained with an E.M.F. of 55 volts, we cannot use equations (10), (11) and (19).

Putting the above values for E, A and l in equation (9), we find that roughly

$$r=0{\cdot}6,$$
$$\frac{V}{E}=0{\cdot}85.$$

Hence, with a constant E.M.F. of 55 volts, and with the *solid* carbons I employed, the largest value of $\frac{V}{E}$, when the arc was silent and perfectly steady, would be obtained by having a current of about 14 amperes, an arc of about 2·5mm., and a resistance of about 0·6 ohm in the circuit external to the arc.

With a dynamo having a constant E.M.F. of 110 volts, two such arcs could be maintained in series, and, as each arc would require a resistance of 0·6 ohm in the external circuit, the total resistance in the dynamo, leads and regulating coil would have to be 1·2 ohms, and the ratio of V to E would be the same as when one arc was maintained with a constant E.M.F. of 55 volts—viz., 0·85. Hence, with such an arrangement, 85 per cent. of the power developed by the dynamo would be expended in the arcs.

Next let the current be fixed. This will be the case when there are many arcs in series. We must consider one of these arcs with its proportion of the E.M.F. of the generator, and of the resistance of generator and leads.

Let us take a fixed current of 10 amperes, and let us suppose that the arcs are found to give the most light when they are 3mm. in length.

Then we must put A equal to 10 and l equal to 3 in equations (10) and (11) to find what E.M.F. and resistance to use, so that $\frac{V}{E}$ may be as large as possible. Doing this we find that roughly

$$E=54 \text{ volts},$$
$$r=0{\cdot}43 \text{ ohm},$$
$$\frac{V}{E}=0{\cdot}92.$$

With these values, however, as before, the arcs would be unsteady. We must use a greater E.M.F. and a higher resistance to maintain a steady arc of 3mm. with a current of 10 amperes. With an E.M.F. of 60 volts for each, the arcs would certainly be steady. If, then, we put E equal to 60, A equal to 10, and l equal to 3 in equation (7), we shall find what resistance must be used outside each arc, so that a steady arc may be maintained. In this way we find

$$r=1{\cdot}06,$$

and

$$\frac{V}{E}=0{\cdot}82.$$

Thus, if a constant current of 10 amperes were flowing, and if the arcs were kept exactly 3mm. in length, an E.M.F. of about 60 volts and a resistance external to the arc of about 1 ohm for each arc would, with solid carbons of the diameters I employed, make $\frac{V}{E}$ as large as it could be for the arcs to be in a perfectly stable condition. As, however, they would not remain exactly 3mm.

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in length, the E.M.F. would rise as the arc lengthened, until the regulator acted and brought the carbons together again. Thus the *average* E.M.F. of the generator should be 60 volts for each arc, and this would be sufficient to allow of the arcs being perfectly stable. In that case we have seen that about 82 per cent. of the power developed by the generator would be consumed in the arcs.

Next let the arc be at such a distance from the dynamo that the resistance of the leads, dynamo and regulating coil cannot be made less than 1 ohm, and let us suppose that under these circumstances an arc of 4mm. gives the best light with uncored carbons of the size and hardness employed in these experiments.

Then, putting r equal to 1 and l equal to 4 in equations (10) and (11), we find that

$$A = 7{\cdot}3 \text{ amperes},$$
$$E = 61{\cdot}8 \text{ volts},$$
$$\frac{V}{E} = 0{\cdot}88.$$

In this case the current must be increased to make the arc steady, for we must *raise* the resistance line (Fig. 46, p. 37, *The Electrician*, November 8, 1895) to make it *cut* the curve instead of *touching* it. Let us then use a current of 11 amperes. Then, putting A equal to 11, l equal to 4, and r equal to 1 in equation (7), we find that roughly

$$E = 63 \text{ volts}$$

and

$$\frac{V}{E} = 0{\cdot}82.$$

Hence, with a resistance of 1 ohm in the circuit external to the arc, an E.M.F. of 63 volts would maintain a steady arc of 4mm. with a current of 11 amperes flowing, and 82 per cent. of the power developed in the generator would be expended in the arc.

The Smallest Resistance that can be Placed Outside a Silent Arc with Given Carbons.

It has been shown that r is always the least resistance that can be placed outside the arc for any given current to flow through a given length of silent arc when equations (10) and (11) express the relations between the variables. From these equations we get $A^2 r = c + d l$, which shows that when l is fixed and r is the smallest resistance that can be placed outside a silent arc of $l$mm. When a current of A amperes is flowing r varies inversely as A^2.

Hence, when the arc is silent and its length is fixed, the smallest external resistance that can be used with any current varies inversely as the square of the current.

From this it follows that with a fixed length of arc the larger the silent current the smaller is the smallest resistance that must be inserted in the external circuit when that current is flowing. Consequently the smallest resistance that can be used in the external circuit at all, when the arc is silent and of the given length, is the smallest with which the largest silent current will flow. Thus the smallest resistance that can be used outside a silent arc of given length is that which is represented by the line which touches the curve connecting P.D. and current for that length of arc at the hissing point.

But the relation between the length of the arc and the current at the hissing point has been shown to be given by equation (19), and the fact that the resistance line is a tangent to the curve is expressed by equations (10) and (11). Therefore from those three equations we can find the smallest external resistance that can be used with *any* silent arc of fixed length.

Not only this, however, but we can also find from the same three equations the smallest external resistance with which a silent arc can be maintained at all. For, from equations (10), (11) and (19), we have

$$r = \frac{(e + f l)^2}{c + d l}, \quad \ldots\ldots \quad (20)$$

or

$$l = \frac{d r - 2 e f \pm \sqrt{(d r - 2 e f)^2 - 4 f^2 (e^2 - c r)}}{2 f^2}. \quad (21)$$

Since the quantity under the root cannot be negative if l is to have a real value,

$(d r - 2 e f)^2$ cannot be less than $4 f^2 (e^2 - c r)$,

or $d^2 r^2 - 4 d r e f + 4 e^2 f^2$ „ „ „ „ $4 e^2 f^2 - 4 c f^2 r$,

or $d^2 r - 4 d e f + 4 c f^2$ „ „ „ „ zero.

Hence

$$d^2 r - 4 d e f + 4 c f^2 = 0$$

gives the smallest value that r can have, and consequently

$$r = \frac{4 f}{d^2} (d e - c f)$$

gives the value of the smallest resistance that can be placed in the circuit outside the arc in order that a silent arc may be maintained at all.

Since this value of r depends only on the constants c, d, e and f, it is apparent that—

In order to maintain a silent arc at all the total resistance external to the arc cannot have less than a certain minimum value, which depends solely on the carbons employed.

By putting the numerical values for the constants in the last equation, it will be found that, with the carbons used in my experiments, if a silent arc is to be maintained at all, the smallest resistance that can be placed in the circuit outside the arc is one of 0·1117 ohms. Further, by substituting 0·1117 for r in equations (10), (11) and (19), it will be found that with that resistance in circuit the length of the arc must be 0·6mm., and the current, which will be the largest that will maintain a silent arc of that length, will be one of 12·7 amperes, while the value of $\frac{V}{E}$ will be 0·967.

Equation (21) gives two values of l that make $\frac{V}{E}$ a maximum for each value of r, but those obtained from the negative root are either negative or so small that practically very little light would escape if the arc were maintained at those lengths. Therefore in practice only the lengths given by the positive root would be used.

The Equation to the Hissing Curve.

I have called the curve $X_1 X_2 X_3$ (Fig. 46, p. 37, *The Electrician*, November 8, 1895) the hissing curve, for convenience sake. The equation

$$A = \frac{c + d l}{e + f l}$$

which I have used throughout this and the last article shows the relation between current and length of arc for all points on this curve. It was obtained in the following way: The P.D. of each point on the curve was plotted as ordinate, with its corresponding length of arc as abscissa, and the result was found to be a very fair straight line, the equation to which was

$$V = 40{\cdot}05 + 2{\cdot}49\, l. \quad \ldots\ldots \quad (22)$$

Equating this value of V to that given by equation (4) (p. 420, *The Electrician*, July 26, 1895), we get

$$40{\cdot}05 + 2{\cdot}49\, l = 38{\cdot}88 + 2{\cdot}074\, l + \frac{11{\cdot}66 + 10{\cdot}54\, l}{A},$$

or

$$A = \frac{11{\cdot}66 + 10{\cdot}54\, l}{1{\cdot}17 + 0{\cdot}416\, l}. \quad \ldots\ldots \quad (23)$$

This equation gives, with a very fair degree of accuracy, the current for each of the points on the curve $X_1 X_2 X_3$ for the different lengths of arc.

If we put equation (23) in the form

$$l = \frac{1{\cdot}17\, A - 11{\cdot}66}{10{\cdot}54 - 0{\cdot}416\, A},$$

it becomes obvious that when

$$10{\cdot}54 - 0{\cdot}416\, A = 0$$

—that is, when $A = 25{\cdot}3$ amperes, l is infinite, and hence, if this equation holds for all lengths of arc, and not only for arcs of from 1mm. to 7mm., *there is a maximum current with which a silent arc can be maintained, and any current greater than this will cause the arc to hiss, however long it may be.* With the carbons I used this maximum current is 25·3 amperes.

Equating the two values of l obtained from equations (22) and (23), we get

$$V - 40{\cdot}05 = 2{\cdot}49 \left(\frac{1{\cdot}17\, A - 11{\cdot}66}{10{\cdot}54 - 0{\cdot}416\, A} \right),$$

or

$$V = 40{\cdot}05 + \frac{2{\cdot}91\, A - 29{\cdot}02}{10{\cdot}54 - 0{\cdot}416\, A}. \quad \ldots\ldots \quad (24)$$

This is the equation to the curve $X_1 X_2 X_3$ when the same axes and units are used as for all the curves in Fig. 46 (p. 37, *The Electrician*, November 8, 1895). Hence equations connecting l and V, l and A, and V and A for all points on the curve

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$X_1 X_2 X_3$ have been found, and they show that the P.D.'s, currents and lengths of the arcs for the hissing points are connected by very definite laws.

It is pretty evident that laws just as definite connect the points on the curve $W_1 W_2 W_3$ in the same figure, for this curve is almost parallel to $X_1 X_2 X_3$.

On comparing the points for the largest silent current with those for the smallest hissing current for each length of arc, it will be found that the drop of P.D. between the two is between 9 and 11 volts in every case. The average drop is about 10 volts, and for each of three out of the seven lengths of arc it is exactly 10 volts. Turning to the curves obtained by Prof. Ayrton's students with *cored* positive and *solid* negative carbons (Fig. 6, p. 337, *The Electrician*, January 8, 1895), we find that the fall of P.D. between the largest silent and smallest hissing current for each length of arc is just as strikingly constant, but that the average drop in this case is somewhat less, being about 9 volts. Thus it seems that *whether the carbons be cored or uncored, the fall of P.D. that takes place when the arc changes from silent to hissing is constant for any given carbons—that is, it is independent of the length of the arc and of the current that causes hissing.*

The *rise* of P.D., when the arc suddenly becomes silent after hissing, is not quite as great as was the previous drop, the difference being from half a volt to a volt. But the drop when the arc hisses again is the same as it was before, so that the P.D. for both currents is from half a volt to a volt lower after the arc has once hissed than before. If, however, the current be kept at a little below its largest silent value for some time, the P.D. for the largest silent current will resume its normal value.

It may be observed that the P.D. is fairly constant for each silent length of arc when approaching the hissing point, and that the P.D. for all the hissing currents for each length of arc is also fairly constant. Therefore, without knowing the exact values of the currents that are the largest which will flow silently, and the smallest that will cause hissing, we can ascertain the exact value of the *drop* of P.D. that occurs in passing from a silent to a hissing arc of the same length.

The change of the *current* when the arc passes from silence to hissing is, on the other hand, considerably affected by this difficulty of determining the exact current that causes the arc to hiss, and consequently the law governing this change is much less clearly defined than that governing the change of P.D. Indeed, with my carbons the law connecting the length of arc with the change of current when the arc passes from silence to hissing appears to be a straight line law, whereas, with the carbons used by Prof. Ayrton's students alluded to above, this change appears to be constant for all lengths of arc.

Which of these two laws is correct—if either—or whether the first is true for solid carbons and the second when the positive carbon is cored, must be determined by further experiment. But in any case, it is abundantly evident that, in spite of the instability of the arc when it is at the hissing point, the laws connecting the length of the arc with both the change of P.D. and with the change of current, caused by the arc passing from the silent to the hissing state, are perfectly definite.

I have not, in the present series of articles, been able to touch upon the subject of the distribution of potential in the arc, or of the true shape and size of the arc as distinguished from the shape and size of the merely visible portion, but I hope shortly to publish the results of the many experiments I have made on these points.

In conclusion, Prof. Ayrton asks me to express his thanks for the assistance rendered by various groups of students of the Central Technical College, in the carrying out of the earlier of the experiments described in this series of articles; and in particular to one of his assistants, Mr. Brousson, who, with the aid of Messrs. Duthy, O'Gorman, and Cozens Hardy, enthusiastically continued the work during his absence in America, and supplied the latest results that formed part of the Chicago Paper of 1893. Lastly, he desires specially to testify to the independence of thought that was brought to bear by Messrs. Dick, Everett, and Finlay in interpreting the results they obtained, and to the value of their suggestions regarding the methods employed in the inves igation.

For my own part, I have to thank many students of the Central Technical College for kind assistance with my experiments. But, above all, my warmest thanks are due to Mr. Brousson, whose kindness and patience were unfailing, and whose skill and ingenuity helped me to overcome many difficulties in the construction and arrangement of my apparatus.

NOTES ON STEAM SUPERHEATING.*

BY WILLIAM H. PATCHELL.

Nature of Steam Superheating.—Superheated steam is steam of any pressure at a temperature higher than the temperature of its evaporation from water at that pressure. Saturated steam may be superheated by imparting additional heat to it at a constant pressure, during which process its volume increases. By permitting saturated steam of a given pressure to expand without doing work, superheated steam at a lower pressure may be formed. Steam cannot be superheated in the presence of the water from which it was evaporated, owing to the fact that the water takes up the heat and evaporates into further saturated steam. The corollary follows that water cannot exist in the presence of superheated steam; either the surplus heat in the steam will evaporate the water; or, if there be too little surplus heat to evaporate all the water, the steam will immediately become saturated by evaporating as much of the water as it can.

Messrs. Fairbairn and Tate, Hirn, and Siemens, all found that saturated steam was not a true gas, and that its expansion on the application of further heat was at first much greater than that of a perfect gas. When a temperature of about 20°F. above that of the saturated steam was reached, the volume increased at about the same rate as that of a perfect gas. No data appear to be yet available as to the expansion of steam with high degrees of superheat; but there is little doubt that it would be that of a perfect gas. A marked feature in the use of superheated steam is the rapid fall in the superheat from radiation, &c. The reason of this more rapid fall in temperature as compared with saturated steam seems to be that the latter owes its heat-retaining properties to the water spray carried in it. It is only after this water spray has been evaporated that the steam becomes a true gas.

Aim of Superheating.—The greatest advantage to be gained by the use of superheated steam is in engine cylinders, and is due to the immediate absorption of the film of water on the metal surfaces by the surplus heat, thereby counteracting cylinder condensation, which is the heaviest loss in the expansive working of steam. In this connection superheated steam would appear to have an advantage over steam jackets, inasmuch as the heat is applied exactly where it is wanted, and during the period that it is wanted—that is, up to the point of cut-off; whereas a steam jacket wastes a considerable part of its heat and time in warming up the exhaust.

Early Attempts at Superheating.—That economy attends the use of superheated steam in engine cylinders has been known at least since 1828, when Richard Trevithick reported on the engines at Binner Downs Mine in Cornwall.† The engineer of the mine, Capt. Gregor, wishing to rival the record of a neighbouring mine where the cylinders had been cleaded in sawdust, built in his cylinders and steam pipes with brickwork, making a fire-grate underneath them and flues around. The results were unexpected, and the duty of the engine was raised from forty-one to sixty-three million foot-pounds per bushel (84lb.) of coal. Trevithick tested the 70in. cylinder engine, which, when 5 bushels of coal was burned in 24 hours under the cylinder, took 67 bushels under the boiler; when no coal was burned under the cylinder, 108 bushels of coal was used under the boiler for the same work, showing a saving of one-third of the coal by superheating. The steam pressure was 45lb. per square inch, and the strokes eight per minute. With the cylinder fires on, 13 gallons of injection condensing water was used per stroke, and heated from 70deg. to 104deg.; without the cylinder fires, 15½ gallons of condensing water was used per stroke, and heated from 70deg. to 112deg. Trevithick followed this up by inventing in 1832 a tubular boiler, combined with a superheater between the boiler and the engine cylinder; he also jacketed the cylinder with the waste gases from the furnace. In Fig. 1 is shown the arrangement, copied from his patent No. 6,308 of 1832. The external series of vertical pipes, connected top and bottom to a hollow ring, constitute the boiler; the superheating pipes inside it are formed like inverted siphons, so as to avoid jointing at the lower end next the fire. Trevithick had been combating cylinder condensation for 30 years before this date, having in 1802, in conjunction with Vivian, constructed a non-condensing engine, the cylinder of which was placed inside the boiler—a plan followed for many years with much success in agricultural portable engines by Messrs. Hornsby of Grantham.

* Paper read before the Institution of Mechanical Engineers.

† "Life of Richard Trevithick," Vol. II., pp. 315 and 323-4.

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Owing, doubtless, to the difficulty in controlling the temperature imparted to the steam, superheating made but little headway till 1850, when it came to the front again. Many plans were then proposed for superheaters and steam driers in various forms, both attached to boiler flues and separately fired. Asbestos packings and brass bushes with plumbago plugs were then introduced to meet the demand for steam-tight glands under superheated steam.

More Recent Efforts.—Some results then obtained were reported to this Institution by Mr. John Penn in 1859 (*Proceedings*, p. 195), followed by Mr. John N. Ryder in 1860 (p. 22). Mr. Penn described the apparatus employed by him in the "Valetta" steamer of the Peninsular and Oriental Company, with engines of 260 nominal horse-power, where the saving in fuel due to superheating was 20 per cent. The superheater consisted of two horizontal faggots, each of 44 2in. tubes, placed in the smoke box. The tubes were fixed into three wrought-iron boxes, welded up at the corners and closed with a flanged joint. The steam from the boiler passed into the centre box, thence through the tubes into the end boxes on its way to the engines, taking up heat from the escaping gases, which have been otherwise wasted. The proportions of the apparatus are given by Mr. Penn as $2\frac{3}{4}$ sq. ft. of superheating surface per nominal horse-power; the boilers had a heating surface of 19 sq. ft. per nominal horse-power. The steam pressure was 20lb. per square inch, and the amount of superheat about 100°F.

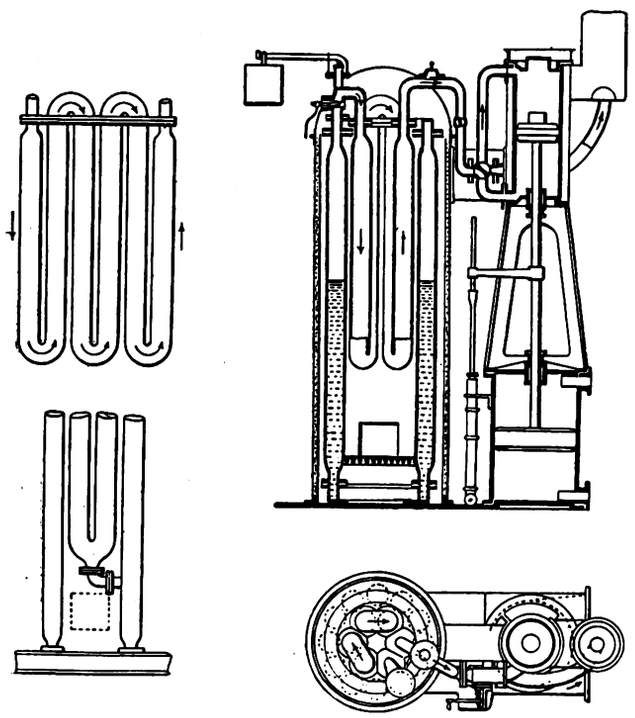

FIG. 1.—Trevithick Superheater.

Mr. John N. Ryder dealt with Messrs. Parson and Pilgrim's apparatus as fitted on marine boilers, and also Mr. David Patridge's superheater. The Parson and Pilgrim apparatus consisted of two horse-shoe pipes fixed over the fire-grate in the internal flue of the boiler. Tests on the steamers "Osprey" and "Swift" showed a saving over saturated steam of 30 to 40 per cent. in fuel; and on H.M. steam-tug "Bustler" a mean of 37 trials with a pressure of $8\frac{1}{2}$lb. and a temperature of 380deg. in the cylinders, which is 144deg. of superheat, gave 25 per cent. economy.

Mr. Patridge's apparatus was a cylinder filled with tubes, placed vertically in the uptake. The gases passed through the tubes and the steam around them; the working temperature was from 360deg. to 390deg. H.M. steamship "Dee" was fitted and tested for several months by the Admiralty, when an economy of fuel of from 20 to 25 per cent. was obtained. An aggregate of about 5,000 H.P. was stated to be then working with this apparatus.

Following closely on Mr. Ryder's Paper was one read by the Hon. John Wethered, of the United States, at the Institution of Civil Engineers (*Proceedings*, 1860, Vol. XIX., p. 462), wherein he animadverted on the futility of the common kinds of superheater, and strongly advised mixed or combined steam, which he claimed to have introduced from America four years previously.

Reasons for Former Abandonment.—If superheating was so common and of such manifest importance and efficiency in the saving of fuel some 40 years ago, the question arises, why was it given up? And what factors that led to its abandonment have been eliminated in modern practice?

Trouble was formerly experienced at the valve faces and in the cylinders from the decomposition and destruction, at the high temperatures of superheated steam, of the tallow and the low-class lubricants then in vogue. This trouble was two-fold: the cutting and excessive wear in the absence of lubrication, and the pitting caused by the fatty acids in the lubricant. On this score, however, no trouble need now be anticipated, at any degree of superheat likely to be attained, where good hydro-carbon oils are used. Gas engines run in regular working with a cylinder temperature in the neighbourhood of 2,000°F., lubricated with good oil; and with ordinary care and attention instances of cutting are not frequent. The common use of metallic packings for glands, and of piston valves in place of flat valves, has removed another serious obstacle. In this connection it will be well to note that pistons and valves which show little leakage when used with saturated steam may show considerable leakage with dry steam, probably owing to the film of water on the metal improving the fit when saturated steam is used.

Much of the trouble that has been attributed to the effects of superheat, in respect of cut cylinders and valve faces, has in the author's opinion been due in reality to the effect of alternate superheat and water in the steam, owing to want of proper control of the

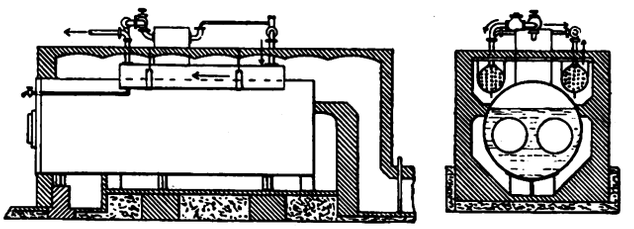

FIG. 2.—Gehre Superheater.

superheaters. A superheater may give a high degree of superheat when the fires are in good order, and at another time may even act as a condenser. The effect of this alternation demands much closer attention than it has at present received. A somewhat parallel case is the behaviour of a good hydro-carbon cylinder oil, which in one engine with normal dry steam leaves no deposit; whereas in a sister engine, at the same steam pressure, with wet steam a heavy deposit is formed from the same oil.

An instance of a cut cylinder which had to be re-bored has lately come under the author's notice, where it appears from the evidence that the trouble is not to be attributed either to the degree of superheat in itself, or to the lubricant, or to neglect on the part of the engineer in charge, but to the alternate effects of superheated and wet steam in the cylinder.

The majority of the old troubles were met with in the engines; but the superheaters themselves do not appear to have been always above reproach. When endeavouring to trace failures to faults in pipes or joints the author has sometimes found superheaters which were fixed with a by-pass for the steam, but none for the gases. The boilers were then worked occasionally with the steam shut off

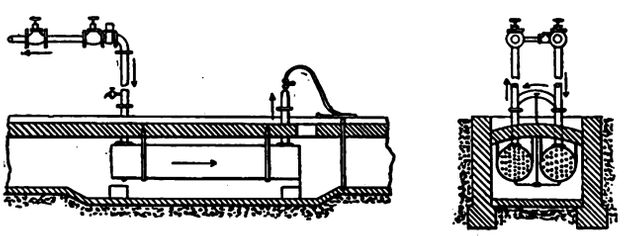

FIG. 3.—Gehre Superheater.

the superheater; and it is not surprising that the latter deteriorated rapidly, its position being eminently unsuitable for a combination of boxes, pipes and expanded tube joints.

Re-introduction of Superheating Apparatus.—Concurrently with the increased efficiencies gained in late years in both boilers and engines, competition has also increased, and with it has arisen the continual cry for cheaper power, cheaper transport, cheaper means of production. The result is that engineers cannot afford to dismiss without careful examination the claims of any plan the adoption of which may diminish their consumption of fuel. It is this fact which has again brought superheating to the front, and has made it the subject of close inquiry in many quarters. Several kinds of superheater are now in more or less extensive use, but only one of them is a radical departure from those of 40 years ago. Any change in the others is rather in manufacture than in design, and their parentage can be traced by their strong family likeness.

Gehre's Superheater.—This is in extensive use on the Continent, and has been introduced into this country by Messrs. B. Donkin and Co., of Bermondsey. It is shown in Figs. 2 and 3, and may be either fitted in the boiler flue or separately fired. Some of these superheaters have been fixed in England, but unfortunately they have not been tested. Mr. Bryan Donkin kindly gave the

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author a copy of a test made in Germany, of eight hours' duration, on a water-tube boiler with and without the superheater (Table I.). The heating surface of the boiler was 861 sq. ft., and of the superheater 646 sq. ft. The superheater was placed directly behind the boiler in a special flue.

Table I.—*Boiler Tests With and Without Gehre's Superheater.*

——	With.	Without.
Total coal used during trial.....lbs.	1,550	1,940
„ water „ „ „ .....lbs.	15,400	15,100
Temperature of feed-water .....Fahr.	205°	201°
Superheat in steam .....Fahr.	40°	...
Temperature of furnace gases before superheater Fahr.	600°	600°
„ „ „ „ after „ Fahr.	510°	..
Water evaporated per pound of coal .....lbs.	9·99	7·82
Water evaporated per square foot of heating surface per hour..... .....lbs.	2·23	2·20
Pressure of steam per square inch above atm.....lbs.	110-114	110-114
More steam used .....per cent.	...	5
Less coal used .....per cent.	34	...
Less work on engine .....per cent.	...	7

Hick, Hargreaves and Co.'s Superheater.—By the courtesy of the makers, the author has been favoured with the following particulars and tests, Table II., of their superheating apparatus in a mill at Bolton. As shown in Fig. 4, the apparatus consists of a nest of U tubes, bent to a large radius at the bottom, which are placed at the back of a Lancashire boiler where the hottest gases from the flues impinge upon them. The tubes are suspended from a tube-

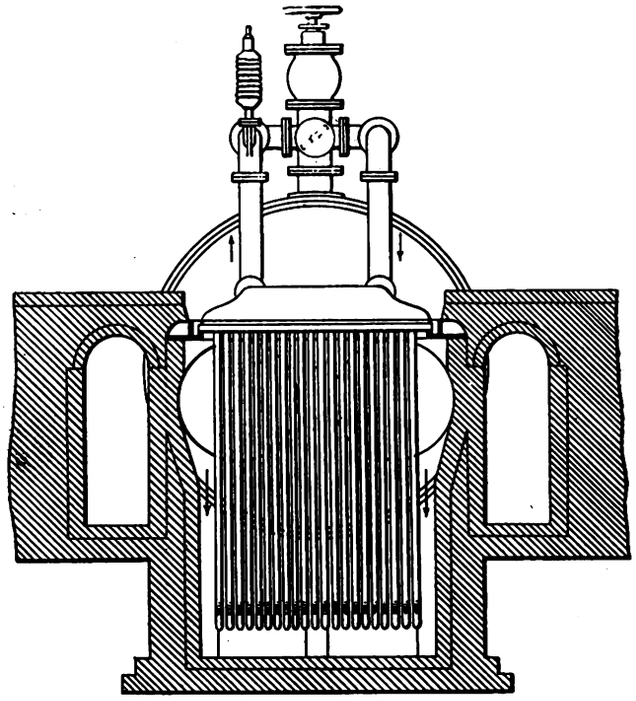

Fig. 4.—Hick, Hargreaves and Co. Superheater.

plate forming the bottom of a box, in which they are fixed by being expanded in the usual manner. The box is divided down the middle by a vertical diaphragm, so that the saturated steam entering at one side passes down and up through the tubes, and leaves superheated at the other side. A by-pass valve is arranged to regulate the flow of steam through the superheater, because only a portion of the steam from the boiler is intended to be superheated. Main valves are also provided, so that the superheater can be disconnected for examination, or even taken out entirely, without interrupting the working of the boiler. The Lancashire boiler to which the superheater is applied is 8½ft. diameter and 30ft. long, with two flues of 3¼ft. diameter, having nine circulating tubes in each. The grate surface is 39 sq. ft.; the heating surface in the boiler is 1,195 sq. ft., and in the superheater 120 sq. ft. The area of passage through the superheating pipes is 22 sq. in. The boiler pressure is 100lb. per square inch above atmosphere. In the tests a portion only of the steam was superheated. The steam pipes to and from the superheater are 3½in. diameter, and are provided with valves, which were kept full open. The main stop-valve on the boiler is 8in. diameter, and was kept only $\frac{5}{16}$ths inch open. The steam was taken to the superheater from underneath this valve, and the return pipe from the superheater was conducted direct to the main range of steam pipe supplying the engine. The temperature of the gases was not taken. The engine is a horizontal tandem compound, fitted with Corliss

Table II.—*Boiler Tests With and Without Hick, Hargreaves and Co.'s Superheater.*

Dates of Tests.	Number of tests with or without superheater.	Mean load.	Water evaporated per hour.	Coal burnt per hour.	Water evaporated per lb. of coal.	Water evaporated per I.H.P. per hour.	Coal burnt per I.H.P. per hour.	Degrees of superheat.
1895.	—	I.H.P.	Lb.	Lb.	Lb.	Lb.	Lb.	Fahr.
Feb. 19-20	2 Without	303·55	5,379·3	837·6	6·42	17·7	2·75	—
Mar. 1-2	2 With	290·5	4,706·3	667·2	7·06	16·2	2·29	42°
„ 5-6-7-8	4 With	298·06	4,778·5	676·5	7·06	16·0	2·28	42°
„ 20-21	2 With	311·2	5,141·1	734·7	7·00	15·5	2·35	55°
„ 26-27	2 Without	311·8	5,492·1	914·0	6·00	17·6	2·92	—
Means {	Without	307·67	5,435·7	875·8	6·21	17·6	2·84	—
	With	299·45	4,848·6	688·7	7·09	15·9	2·30	45·2°

Economy in Water per I.H.P. per hour 9·6 per cent. with superheating.
„ „ Coal „ „ „ „ 19 „ „ „ „

valve-gear; cylinders 18$\frac{1}{16}$in. and 36$\frac{1}{16}$in. diameter by 4ft. stroke. Each of the tests was of 7½ hours' duration.

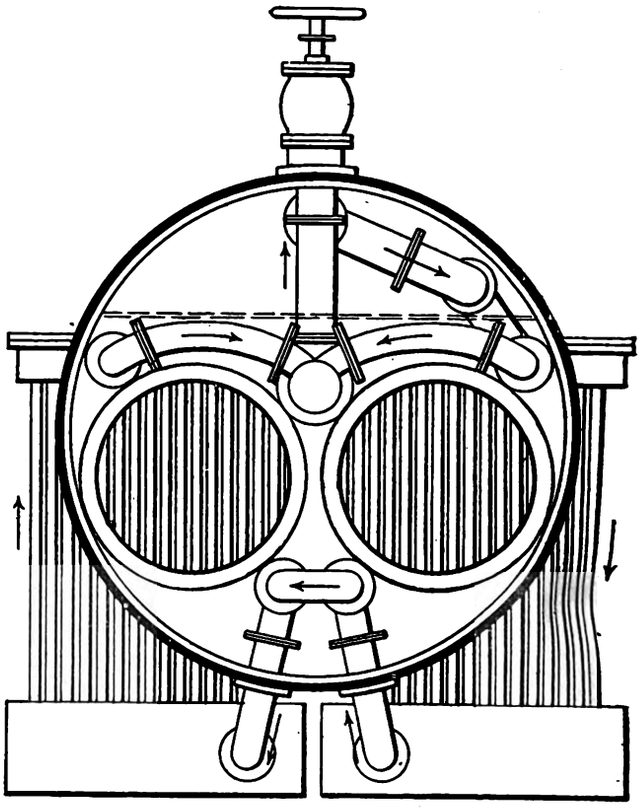

Fig. 5.—McPhail and Simpson Superheater.

The much easier working of the boiler for the same indicated horse-power at the engine is to be noted. During the tests of March 20th-21st and March 26th-27th the load was practically identical. In the former tests with superheating the rate of coal consumption was 18·81b. per square foot of grate per hour, whereas in the latter tests without superheating the combustion went up to 23·41b. of coal per square foot of grate per hour. Where there is a low and uncertain chimney draft, this slower combustion alone would tend to much steadier and more economical steaming, and would more than counterbalance any obstruction in the flues caused by the superheating pipes, which appears to be more imaginary than real.

McPhail and Simpson's Superheater.—This apparatus is the invention of Mr. Hugh McPhail, and is manufactured in Wakefield by McPhail and Simpson's Dry Steam Patents Company. It consists of two parts: the superheater proper; and the steam generator of radiating tubes, which distinguishes it from all other plans. As applied to a Lancashire boiler, Fig. 5, there are two nests of vertical steel tubes, expanded at top and bottom into cast-steel boxes, or "headers" as they are called in water tube boilers; these nests are placed preferably at the back end of the internal flues of the Lancashire boiler, in the down-take, where the furnace gases impinge on them and pass between them. One of the top boxes is connected to the usual anti-priming pipe in the boiler; and the corresponding bottom box is connected to a block, which

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passes into the bottom of the boiler, and from which a copper pipe runs along the bottom of the boiler under the internal flues to the front end, and thence back again to the rear, where it passes out of the boiler and into the other bottom box. The second top box is connected to another copper pipe, which runs along the boiler over the internal flues, just below the water line, and ends at the main steam stop-valve. The course of the steam is from the anti-priming pipe to the first top box, then down through the superheating tubes to the first bottom box, whence it enters the boiler, and passing through the lower copper pipe gives up part of its superheat to the surrounding water, before leaving the boiler and entering the second bottom box. It is then further superheated in passing up through the second nest of tubes; and thence passing through the second top box into the upper copper pipe in the boiler, it again parts with some of its superheat, before finally leaving the boiler at the steam stop valve.

The complete apparatus thus consists of two external superheaters and two internal radiators; and the final degree of superheat depends upon the proportion of the superheating tubes to the radiating pipes. The function of these radiating pipes is most important, as they give off to the water in the boiler the superheat which might be dangerous in the engines at times of heavy firing; and, when the fires are green after cleaning and the flue gases low in temperature, they prevent any possibility of the superheater becoming a condenser. They thus tend to keep regular the amount of superheat in the steam as it leaves the boiler. It will be evident therefore that this superheater may be arranged either for improving the evaporative efficiency of a boiler, and at the same time giving dry steam at the engine, or for the steam to leave the boiler highly superheated.

(To be concluded).

THE NATURE OF CHEMICAL CHANGE AND THE CONDITIONS WHICH DETERMINE IT.*

(Concluded from page 522.)

The discovery of the nature of the phenomena underlying electrolysis—and therefore those underlying chemical change—may not improbably be assisted by the study of substances other than conducting solutions; and for other reasons also the study of the electrical properties of such substances appears to be of the highest importance.

Thus it is well known that whereas metals generally are relatively good conductors, non-metals oppose a very great resistance to the passage of an electric current. A question of the utmost importance to consider is whether non-metals may not be capable of opposing an infinite resistance, and whether it may not be possible to base on electrical behaviour an absolute distinction between metals and non-metals, although hitherto we have been obliged, on general chemical grounds, to conclude that no line can be drawn, and that, in fact, the metals insensibly shade off into non-metals through the metalloids such as arsenic, tellurium, &c.

As long ago as 1887, in the course of the discussions which took place within the British Association Electrolysis Committee, I drew attention to the importance of making further observations on the specific resistances of the non-metals, pointing out that as these appeared all to behave as electrolytes of very high resistance, it became a question whether this might not arise from the fact that impure substances had been studied, and adding "if sulphur, &c., are found to behave as water—that is, to increase in resistance as they more nearly attain a pure state—then I think we may fairly divide elements into two distinct classes, and define a metal as an element which conducts, and a non-metal as an element which insulates."

The conductivity of what is so wrongly called carbon, in the form used for electric light purposes, is well known to be electrolytic in character, and is, therefore, most probably conditioned by the presence of salts, and not a specific property of the modification of the element present in such materials.

In the case of the metals also, on the other hand, many observations of great interest have been made, which are highly suggestive, and should serve to incite further inquiry.

The electrical conductivity and, at the same time, the mechanical properties of all the highly conducting metals which fall into positions in the periodic system not far removed from that of copper are affected in a most remarkable manner by the presence of minute amounts of impurity, especially by certain non-metallic and metalloïdal impurities. Owing to the very large use which is made of it in telegraphy, no metal has had more attention paid to it than copper, its manufacture having been greatly improved by the introduction of electrolytic methods in place of the old dry methods. Fitzpatrick, in a report of the specific resistance of this metal, published in the *Brit. Assoc. Report* for 1890, gives a value which is better than that found nearly 30 years before by Matthiessen for "pure" copper in the proportion of 100 : 102·6; but my colleague, Prof. Ayrton, tells me that copper of still higher quality, viz., above 103, is now made on a large scale. It is noteworthy that Swan and Rhodin, in a Paper communicated to the Royal Society in 1894 (56, 64), give a value which is not quite so low as that found by Fitzpatrick, viz., 1,563, Fitzpatrick's lowest value being 1,557. They speak of their copper as "pure," stating that it is probable that both of the specimens examined by them were "perfectly pure," and that, in fact, the limit of electrolytic purification has been reached, but this cannot have been the case. Moreover they, as well as Fitzpatrick and all other observers, obtained different values before and after annealing, the specific resistance of the soft wire being 1,563, whilst before annealing it was 1,603—a circumstance which in itself, I venture to think, affords strong presumptive evidence against the conclusion that we are yet come into possession of practically pure copper, and for the following reasons:—

E. van Aubel has observed in the case of bismuth (*Phil. Mag.*, 1889, 28, 332), that although annealing has a considerable effect when the metal is very impure, the effect becomes less and less marked as the impurities are removed, until finally the electrical resistance is scarcely altered by annealing; also there is a considerably greater difference apparent between the values given for hard and soft copper by Matthiessen than has been found by later workers, who, presumably, have dealt with a less impure metal. Therefore it appears not improbable that a pure material would suffer no change on annealing—that it would not require annealing, in fact.

Taking Spring's important investigation into the influence of extreme pressure into account, it appears likely that the change during wire drawing—hardening, to undo which resort is had to annealing—is in itself due to the occurrence of chemical change—that is, change in molecular composition. Barus, in particular, has advocated this view (compare *Nature*, 1890, 41, 369), and it has recently received confirmation from observations made by Unwin on the effect of repeated straining and annealing on the yield points of iron and steel (*Proc. Roy. Soc.*, 1894, 57, 178). But if change in molecular state in a metal be subject to the same laws as are interactions in other cases, a pure material should not undergo change under the influence either of pressure or of heat; and therefore from this point of view also the fact that all copper hitherto examined is softened by annealing may be regarded as evidence that it has contained impurity.

The nature of the "impurity," the character of the changes which take place in such cases, form subjects of inquiry not only interesting in themselves, but also of the highest technical importance. With regard to the former, attention may be called to a statement made by Hartley to the British Association Electrolysis Committee in 1887, pointing out that the preparation of pure copper is extremely difficult; and that such as he had had made for spectroscopic purposes, which was considered *pure*, had been found to contain as sole impurity about one hundred thousandth part of silver, while other samples contained tellurium and bismuth. The photographed spectra were the means of detecting these foreign constituents. I quote this by way of reminder that ordinary or even extraordinary chemical tests are of no use in such cases. It must also not be forgotten that gases may become "occluded" during annealing, and bearing in mind the extreme sensitiveness of copper—especially to oxygen—it would appear necessary in future inquiries to effect the annealing in a "vacuum" from which moisture, oxygen, &c., have been, as far as possible, removed.

As regards the character of the changes brought about in metals by admixture, we are, of course, but on the very fringe of the inquiry; it is certainly cause for congratulation that men like Roberts-Austen, Dewar (and Fleming), Heycock and Neville, and Alder Wright—all our own Fellows—have done so much during recent years to extend our knowledge of the behaviour of metals; and we may confidently expect that, now interest is so generally re-awakened in metals and alloys, we shall ere long be able to arrive at trustworthy conclusions.

Recent observations on the depression of the freezing points of metals seem to show that, in most cases, the liquid metal consists of monatomic molecules—in itself a very noteworthy conclusion, when it is remembered that the very opposite is true of liquefied non-metals. Whether, on solidification, and as cooling takes place, these fundamental molecules form complex groups, is a question which is now being warmly debated, but is a very difficult one to decide: the view advocated by Matthiessen—I am inclined to think with true prescience—that many metals are capable of existing in allotropic modifications—that is to say, in modern language, that they may exist of different degrees of molecular complexity, is at the present time but little approved of, there being a tendency to substitute for it more purely mechanical conceptions. Only in the case of iron is it fairly generally admitted that the facts are such as to make the acceptance of Matthiessen's view almost compulsory. Osmond—whose work is of extraordinary interest

* Abstract of an address delivered by Dr. H. E. Armstrong before the Chemical Society.

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and of the highest value—indeed has argued that this metal may exist in no fewer than three allotropic forms.

In the case of a pure metal consisting in the fused state of monatomic molecules, it is conceivable that when solidification takes place interatomic forces come into action in such a manner and so uniformly that the mass, as it were, forms one huge complex molecule. This could scarcely happen if impurities were present; but in that case similarly constituted smaller complexes—individual crystals—might form. The observations of Behrens on the microscopic structure of alloys of silver and copper are perhaps of significance from this point of view, showing as they do that, whilst the crystals are scarcely distinguishable in "pure" copper, in copper containing only a minute proportion of silver they become distinctly visible and are seen to be separated by a film of white alloy.

It is difficult to resist the conclusion that the properties even of congeries of such crystal molecules as are above referred to are not somewhat different from those of the simple fundamental molecules *en masse*. Silver, copper and gold, it is well known, are possessed of high electrical conductivity, especially silver and copper, which are all but alike in this respect; and yet, as Matthiessen has shown, when any two of them are mixed, the conductivity of the mixture is lower to an extraordinary extent than that of either alone. That such an effect should be produced is very remarkable, and it is difficult to understand how it can be brought about by the mere admixture of molecules which apparently are equally effective conductors; this behaviour would seem, indeed, to be an indication either that the molecular state of the metal is changed, and that, in fact, it is converted into a modification possessed of lower conductivity; or that a compound of the two metals of lower conductivity is formed and becomes interposed between the highly conducting crystals.*

The remarkable behaviour of silver towards oxygen also serves to suggest that the silver atoms combine on solidification. The fact that this metal is a solvent specifically of oxygen, and not of gases generally, is, in a measure, evidence that combination takes place between it and the gas; and on this assumption the well-known spitting may be explained as due to the occurrence of an interaction conditioned by the superior affinity of silver to silver outweighing that of silver to oxygen in the manner indicated by such an equation as $xAgO_2 = Agx + xO_2$. But this explanation does not necessitate the conclusion that the silver atoms combine otherwise than throughout the whole mass.

The evidence that one metal may combine with another is now so entirely beyond question that it is no longer open to doubt that like metallic atoms may combine. The eminently plastic character of some highly purified metals, *e.g.*, copper, gold, silver, iron, platinum—would, I imagine, lead us to prefer the view that they consist of relatively simple, if not of monatomic molecules. Whilst, on the other hand, the extraordinary brittleness produced on adding small proportions of certain elements to some of these metals is perhaps best explained by the assumption that such additions cause the formation of complex molecules having but little tendency to cohere. Such a conclusion is almost necessary in the case of iron, in which, as is well known, extraordinary alterations may be produced by altering the distribution of the impurities, without altering their amount—I allude to the passage of carbon from the combined into the free state during the rapid cooling of steel, and to the change in the opposite direction which takes place during slow cooling. Iron, indeed, is one of the most remarkable among metals, and there is no literature more deserving of the chemist's attention than that relating to the researches of Roberts-Austen, Barus, Hopkinson, Osmond, and others, who, during recent years, have contributed in a most important manner to our knowledge of the changes going on in iron and steel.

* In view of the possibility that impurities introduced during the preparation of such alloys may exercise an important influence, it is very desirable that Matthiessen's observations should be repeated and extended, using very carefully purified materials. No doubt the greatest care has been taken in purifying both gold and silver, as well as copper, but there is no reason to think, I imagine, that we have attained to finality in such matters. These three metals are so much alike in many of their properties that it is an interesting subject for inquiry whether they may not be still more closely allied, especially in electrical behaviour, than we now suppose them to be, and it is very desirable that they should all be worked at from this point of view. In future, however, it will be necessary to extend the examination so as to determine as many properties as possible, mechanical, physical and structural. If we knew, for example, the specific conductivities, as well as the tensile strength and extensibility, of the various gold alloys prepared by Roberts-Austen (*Phil. Trans.*, 1888, 179, 339), we should be better able to discuss his conclusion that the influence of various metals on the mechanical properties of gold may be co-ordinated with their atomic volumes—a conclusion which it is somewhat difficult to accept when lithium and potassium produce effects which place them at the very opposite ends of the scale. The improvement effected in metals and alloys by the addition of another—as that of aluminium to brass—may doubtless sometimes be traced to the fact that it brings about the removal of an objectionable impurity, and this may well be the effect on gold of some metals.

Osmond assumes that even "pure" iron alters in molecular composition as it cools, basing this conclusion on the observation that the electro-deposited metal exhibited the phenomenon of recalescence; but the conclusion that such iron is, to use Roberts-Austen's expression, "as pure as any iron can be" may fairly be called in question, especially as Osmond speaks of it as containing a little carbon (0·08 per cent., *Iron and Steel Institute*, 1890, i., 38), and it may be doubted whether any such change would take place in pure iron. In presence of carbon, it would seem that when the temperature has fallen sufficiently, molecules which are more complex than those existing at the higher temperature are formed, heat being liberated, thus giving rise to recalescence; the extent to which such complexes are formed largely depending on the amount and character of the impurity present. Perhaps it is from these complex molecules that the peculiar magnetic properties of steel are derived. The separation of carbon from iron may well take place at the moment when the complexes are formed, and the change which occurs at its separation may be of the character of that referred to above in connection with the spitting of silver. The carbide which is produced during slow cooling may conceivably be generated by the interaction of the complex molecular form of iron with the carbon. The explanation of the changes here discussed, advanced by Osmond, involving as it does the assumption that at high temperatures iron consists of the hard modification, which, unless prevented, passes into the soft modification on cooling, seems to me to be less natural and likely than the foregoing.

It is to be hoped that ere long methods will be devised of preparing considerable quantities of iron in a state closely approaching to that of purity, so that the individual influence of various foreign substances may be studied. At present we do not seem to be aware whether the presence of carbon especially is essential to hardening, and whether this element alone can condition the state which renders steel capable of becoming permanently magnetic. Sufficient will have been said, I trust, to emphasize the extraordinary importance of attention being paid to the behaviour of highly purified substances. Enough is known to warrant the assumption that in many cases such investigations will show that properties associated with individual substances are wrongly regarded as specific, and that in reality they are determined by an admixture. To give but one more illustration, if conduction in solids other than metals be always electrolytic conduction, conditioned by the presence of composite electrolytes, a condenser such as a Leyden jar may be regarded as a voltaic cell in which the electrolyte is a solid of high resistance, and its action as dependent on polarisation; the difference between such a cell and one containing a fluid electrolyte arising from the fact that in the latter polarisation cannot be maintained except at the electrodes, whilst in the former the polarisation extends throughout the electrolyte. On this assumption it should be impossible to form a condenser from a pure substance. I venture to point this out as *showing* the great importance of experiments being instituted with *very highly* purified dielectrics.

The more our attention is directed to the important part which impurities play in determining change, whether it be in metals, non-metals or compounds, the more necessary is it to inquire into the possible mechanism by which such change is brought about. So long as we are entirely unaware of the nature of chemical affinity and of the manner in which it is exerted, little progress can be made. There can scarcely be a doubt, however, that what has been termed residual affinity is largely operative, as, indeed, Faraday foresaw. The following remarkable passage in his fifth series of Researches (§ 523) is almost as clear a statement of this view as could be given at the present day:—

"The theory which I have ventured to put forth (almost) requires an admission that in a compound body capable of electro-chemical decomposition the elementary particles have a mutual relation to, and influence upon, each other, extending beyond those with which they are immediately combined. Thus, in water, a particle of hydrogen in combination with oxygen is considered as not altogether indifferent to other particles of oxygen, although they are combined with other particles of hydrogen, but to have an affinity of attraction towards them, which, though it does not at all approach in force, under ordinary circumstances, to that by which it is combined with its own particle, can, under the electric influence, exerted in a definite direction, be made even to surpass it. This general relation of particles already in combination to other particles with which they are not combined is sufficiently distinct in numerous results of a purely chemical character . . . and it probably has a direct relation to, and connection with, attraction of aggregation both in solids and fluids. It is a remarkable circumstance that in gases and vapours where the attraction of aggregation ceases, there likewise the decomposing powers of electricity apparently cease, and there also the chemical action of quantity is no longer evident. It seems not unlikely that the inability to suffer decomposition in these cases may be dependent upon the absence of that mutual attractive relation of the particles which is the cause of aggregation."

Hence, in studying the manner in which chemical change is brought about, we are necessarily obliged to consider valency, comprehending under this term both the quantity and the quality of

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the "affinity" possessed by atoms. But, again, progress is trammelled by tradition and fashion—the habit of teaching dogmatically has affected our whole attitude towards such questions, our theories being not only unsatisfactory, but eminently narrow in their disregard of facts, especially apparent in our neglect of molecular compounds. Helmholtz, in his Faraday lecture, after dwelling on the conclusion that definite atomic charges of electricity are associated with the atoms of matter, said that he did not suppose that the existence of other molecular forces, working directly from atom to atom, was to be excluded. But is this the case? I venture to think that, had Helmholtz been a chemist, he would have felt compelled to admit that whatever be the nature of chemical affinity, the same forces are active throughout—that what is termed residual affinity is of the nature of ordinary affinity, and that the difference is in quantity rather than quality. To repeat what I said in 1888 in a Note on valency especially as defined by Helmholtz (*Phil. Mag.*, 1888, [5], 25, 21), I do not hesitate to affirm that, from the chemical point of view, it is impossible to adopt the Helmholtz explanation of valency unless physicists are prepared to grant the possibility of the "division" of the unit charge. In the Paper in question, to explain my meaning, I developed what may be termed a skewer hypothesis of valency, desiring to give a graphic expression of chemical facts and thus help those who are not chemists to appreciate our position. Representing unit valency or charge by a single line, I postulated this line as capable of passing through the atom, and the atom as moving with more or less of freedom on the line. The union of two atoms was pictured as an overlapping of the unit lines. On this hypothesis, in cases in which the atoms do not move out to the end of their lines on combining, free ends would exist, by the overlapping of which combination between molecules could be brought about; and if it be supposed that hydrogen and the metals alone move freely on their lines, in order to give expression to the peculiar differences which apparently are manifest on contrasting the two classes of elements, the combination of a non-metal with a metal may be represented as involving the motion of the former alone out to the end of its line, leaving the line of the non-metal with a free end. In this manner expression may be given to what appears to be a fact—namely, that the non-metals condition the formation of molecular compounds.

What may be termed the *proper valency* of an atom—the number of atomic charges carried by, or of unit lines passing through, the atom—on this hypothesis is a function of the atom alone, whilst its *residual valency* in a compound is a complex function depending also on the atoms with which it is in association. This is well illustrated in the case of nitrogen by the behaviour of the amines—in all of which the nitrogen clearly functions as a triad—towards haloïds and acids, the extent to which basic characters are manifest depending in an extraordinary degree on the nature of the radicles associated with the nitrogen atom. Assuming that the proper valency of nitrogen is three, the formation of ammonium compounds from amines may be represented as due to the overlapping of the free end of the halogen line and that of one of the nitrogen lines: and if, in a case like that of the chloranilines, it be supposed that the effect of weighting the C_6H_5 radicle by introducing chlorine is to reduce the amount of free end of the nitrogen line to which it is attached, expression is given to the fact that the amine becomes less and less basic, and more particularly that the salt becomes less and less stable as each fresh atom of chlorine is introduced, length of overlap being regarded as the measure of affinity.

It may be asked why, on this hypothesis, if the nitrogen atom carries three atomic charges—is penetrated by three lines—it does not combine with three molecules of acid. Of course, at present no definite answer can be given, but, bearing in mind that the conviction is becoming more and more clearly established that affinity has direction and that geometrical considerations come into play, it is at least conceivable that the direction of two of the lines is such that their free ends perhaps meet, or that they are so directed towards each other that other lines are prevented from overlapping them. The introduction of some such conception would seem to be necessary to explain the remarkable behaviour of compounds such as nitrous oxide and diazoimide, N_3H, the inertness of which is most surprising, whatever view be taken of their constitution. Certainly, the difference between "unsaturated" nitrogen and "unsaturated" carbon which is manifest on contrasting these compounds with the olefines is most remarkable.

But it cannot be denied that, however possible it may be to "explain" the ammonium compounds on the assumption that nitrogen is but a triad, there are cases in which it is difficult to apply any such hypothesis as the above—one of the most striking being that afforded by the remarkable phenyliodonium compounds described by Hartmann and V. Meyer. It will scarcely be doubted by anyone, I imagine, that these and the equally remarkable iodoso-derivatives are not all to be regarded as proof that iodine is not merely a monad, but also a triad element—and yet it must not be forgotten that an iodine atom can combine with but a single hydrogen atom or methyl group, and that hydrogen and methyl are as yet the only trustworthy and, so to speak, legal standards by which the proper valency of an element can be measured. Even in such a case, therefore, a formula similar to that given to the ammonium compounds—viz., $C_6H_5{\cdot}I{\cdot}I{\cdot}C_6H_5$, cannot be put aside as absolutely out of the question; and if we bear in mind the peculiar character of the oxy-acids derived from the halogens, it is clear that much remains to be learnt of these elements. These acids are often quoted as arguments in favour of the view that the halogens are polyad elements, Mendeléeff having carried his poetic generalisations so far as to claim heptadicity for them; but even assuming that an oxide Cl_2O_7 exists, so long as we are unaware of its structure, we must remain unable to judge of the valency of its elements; we are certainly as little justified in assuming that it contains heptad chlorine as we should be in concluding from the existence of a compound of the formula C_6H_6 that carbon is a monad: valency is far too complex a function to be determined by a simple division method. It is not improbable that the oxy-acids in question are cycloïds.

The solubility of a substance such as triethylphenylammonium iodide in water, in which the amine and haloïd from which it is derived are so slightly soluble—and the fact that in the case of the ammonium salts of the chlorinated anilines above referred to hydrolysis of the salt takes place with increasing facility as the amine becomes less basic—may be referred to in further illustration of the difficulties to be overcome in formulating a consistent and sufficiently comprehensive theory of valency. On the hypothesis that such compounds are formed by the overlapping of the free ends of the lines of affinity, the compound should remain saturated or externally inactive so long as there was any overlap; on the other hand, if the somewhat more elastic atomic charge hypothesis be adopted, and it be supposed that any portion of the charge remaining unneutralised might be active, at least the case of the chloranilines would meet with an explanation.

But all these are matters of pure speculation, and I should not venture to allude to them, did I not feel that it is essential that now the amount of material at our disposal for discussion is so very large, it is time that some attempt were made to arrange it in such a form that the results won by chemists can be laid open to inspection by physicists and others capable of taking such transcendental questions into consideration. The theory of types and its logical outcome—the theory of bonds, have contributed in a remarkable manner to the progress of our science, and to these geometrical conceptions have now been added which are leading to further important developments; but it can only be supposed that such theories will all prove eventually to be of provisional value, and that far less mechanical conceptions must prevail.

Underlying all modern chemical inquiries there is an obvious desire to determine the structure of molecules generally, as well as to correlate structure with function; and most important advances in these directions have already been made. Whatever view we may hold, it is only too clear, however, that the conventional treatment of the subject involves the disregard of much that is of the highest importance; especially is it, perhaps, too commonly forgotten that whilst the determination of valency involves the knowledge of the structure of the compounds of elements whose valency is sought, the determination of structure is itself based on an assumed knowledge of valency. We are not only being led to frame the conception that affinity has direction, but also that its strength largely depends on the direction in which it is exercised (as shown by the very different behaviour and stability of cycloïds of different dimensions), and it is more than probable, therefore, that ere long we may formulate a theory in which the somewhat mechanical bonds to which we have become accustomed will give place to a more comprehensive hypothesis.

Faraday, in the paragraph previously quoted, regards both the hydrogen and oxygen in water as possessed of "residual affinity," and in his day, no doubt, there was no reason to draw any marked distinction between the two classes of elements—the metallic and non-metallic. But there is much in the behaviour of the latter which seems to me suggestive of the conclusion that they are the mainly active, attracting elements, and those, in fact, which condition chemical change; I venture to think that this will more generally be admitted to be the case than it is at present, when the facts are carefully considered. We have, it is true, long since abandoned the idea that only elements of opposite classes have considerable affinity for each other; but we are not yet advanced much beyond this, and have yet to recognise that the non-metals have very special mutual affinities.

It is in the play of these affinities more particularly that I am inclined to seek that conjoint influence to which I have frequently adverted by which electrolysis, and therefore change is, it seems to me, brought about. The force of the objection made to this explanation that there are no appreciable reverse electromotive forces within an electrolyte may easily be overestimated. Adverting to what was said above with reference to the phenomena involved in charging a condenser, if any similar effect were produced in a fluid electrolyte—if any internal polarisation were set up—it would at once be discharged; and such polarisation would

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be imperceptible, just as in the case of the determination of conductivity by an alternating current method. A considerable amount of work might, therefore, be done by the current unperceived, and the forces might well be enormous even within the liquid (compare Lodge, *Brit. Assoc. Report*, 1890, 330). I am loth to believe also that the low values found for "ionic velocities" are in truth the velocities of the ions, and would prefer to regard them as but differences between values of which at present we have no conception.

A similar argument will apply in the case of osmotic pressure phenomena, and therefore generally in explanation of the regularities observed in the case of dilute solutions. To say that the osmotic pressure is due to the dissolved substance alone, appears to me to be but a useful figure of speech—in reality, the phenomena must be due to both solvent and dissolved substance. Although one attracts the other, however, the unions are probably but temporary, and the opportunities given for exchanges to take place are so infinitely numerous that the dissolved substance behaves practically as an almost perfect gas. From this point of view it is also not remarkable even that the pressure should have the same value as it would have if the substance were gasified, for, inasmuch as the molecules of the dissolved substance are kept apart by those of the solvent, they are practically in the gaseous condition.

As regards the superior effects produced by electrolytes, I would repeat what I said at Leeds in 1890 (*Brit. Assoc. Report*, p. 326), that, having been able by observations of electrical conductivity, as well as by other methods, to classify electrolytes in the order of their activity, we are now in a position to apply the correction required to discount the superior effects produced by such compounds in comparison with dielectrics. Why they are specially active the future must decide. To me it seems that their activity is attributable to their special composition and structure—particularly to the presence in them of either oxygen or halogen in an eminently unsaturated condition, and possessed, therefore, of considerable residual affinity.

As regards semi-permeable membranes, as they have been called, I imagine we have yet much to learn in explanation of these. That the membranes through which liquid diffusion takes place cannot be mere sieves there is hardly a doubt, otherwise it would scarcely happen that gases only diffuse through septa consisting of materials in which they are soluble: as illustrated by the diffusion of oxygen through caoutchouc and silver, of carbonic oxide through iron, and of hydrogen through platinum and palladium.

In the case of colloïd membranes, through which so many crystalloïds pass, everything seems to depend on the peculiar relationship of water to such matters—a relationship which is so apparent in many physiological phenomena—and at the same time of water to crystalloïds.

The foregoing may be said to be an essay in advocacy of a theory of *association* in explanation of chemical change, as opposed to one of *dissociation*. The attempt has been made to show that such a theory is of universal application, whilst the dissociation hypothesis is apparently not only of limited application, but in some cases irreconcilable with the facts. It also involves assumptions which it is difficult for the chemist to grant: I allude particularly to the main article of faith in the dissociationists' creed that a certain very limited class of compounds—electrolytes—fall to pieces, as it were, more or less completely on entering into solution. As I have implied over and over again, such an assumption necessitates a profound distinction being made between electrolytes and other compound molecules generally which is not patent to the unprejudiced observer, and for which no motive or reason whatever can be assigned. It must not be forgotten that Clerk Maxwell was led by reasons of this very kind to remark that chemical combination is a process of a higher order of complexity than any purely electrical phenomenon.

I have sought also to make clear the great importance of the part played by "impurity" in Nature in conditioning chemical change—a part which seems to meet with an explanation from the association, but not from the opposite point of view. The influence of impurities on properties has also been specially noted.

Lastly, the insight which the study of the electrical behaviour of substances generally promises to throw on almost all of the chief problems of chemistry has been briefly touched on.

I am only too conscious that my discussion of all these questions is not only incomplete, but very general and even vague in many places, language being sometimes used—as in quoting from Faraday—in a sense which may somewhat offend the purist; probably, however, the object I have in view will be clear even in these cases.

BOOKS RECEIVED.

"Traité Théorique et Pratique des Courants Alternatifs Industriels." By F. Loppé and R. Bouquet. First and second volumes. (Paris: E. Bernard et Cie.)

"Die Galvanoplastik." By Julius Weisz. (Leipzig: N. Hartleben.)

THE CHELTENHAM ACCIDENT.

The following is Major Cardew's Report on the fatal accident which happened on December 16, 1895, to John Pugh, mechanic, employed in carrying out some alterations in one of the transforming chambers used by the Corporation for the purposes of electric light supply. The Inquiry was held on the 15th ult., and the following witnesses were examined:—

Leicester Richards Lee (Engineer), Richard Edwards (Jointer), M. H. Kilgour (Borough Electrical Engineer), and Richard Cresswell, D.Ph. (Surgeon).

Account of Accident.

The circumstances of the case, says the Inspector, were as follows:—

The Corporation of Cheltenham supply electric energy by means of a high-pressure alternating current, at a constant pressure of 2,000 volts, which is reduced by means of transformers placed partly in transforming stations below the level of the street and partly on consumers' premises, to a pressure of 100 volts, for purposes of supply to consumers. The transforming stations are larger than those usually constructed for the purpose, and are in all respects suitable in construction. The arrangements within them consist, in addition to the transformers, of high-pressure and low-pressure switchboards for regulating purposes. The particular station in question contains an extra number of high-pressure switches, as from it is controlled the supply to another transforming station.

The work upon which the party were engaged at the time of the accident was the erection of a low-pressure switchboard on the north wall, in a position closely adjacent to one of the high-pressure switchboards. The unfortunate man was at the time boring a hole in a wooden batten with a large gimlet at a distance of only about four inches from the high-pressure switchboard, on which were fixed several switches with exposed metal surfaces, charged to the full pressure of 2,000 volts.

The conditions, in fact, were such that, although it was possible to do the work without making contact with the charged metal, it required continual care and attention to avoid the fatal consequence of an unguarded movement. The danger was, I consider, almost equal to that of sending a man into a magazine full of loose powder with a lighted candle in his hand.

From the evidence of the foreman under whom Pugh was employed it appears that the latter was decidedly careless by nature, and that before the accident happened he had been cautioned several times. An india-rubber mat had been provided as a protection to be used when working at the high-pressure switchboards, but had been moved away, probably by the men at work, as not being required since they were not manipulating the electric circuits. India-rubber gloves were also provided, but the use of these would certainly have been inconvenient.

The accident appears to have been caused by Pugh, in a moment of forgetfulness, raising his left arm until it came, as it naturally would, into contact with the charged metal in two places, causing wounds as described by Dr. Cresswell, the current entering his body by this arm, and leaving it partly by his feet and partly by his right hand, assuming that he was grasping the gimlet at the time. The abrasions on the face were probably caused in his fall, either by a simple blow or a subsequent contact. Death appears to have been practically instantaneous.

Opinion and Recommendations.

In my opinion this accident is chiefly to be attributed to an error in judgment on the part of those responsible in allowing such work to be carried on in close proximity to highly-charged metal. It is too much to expect that any man, and especially an imperfectly educated man, should exercise such continual care over all the movements of his body as was necessary in this case when he is engaged upon work distracting his attention from the danger, and when the danger itself is not of a kind that appeals to the ordinary senses.

I understand that had the electric pressure been switched off from the sub-station to enable the work to be done with safety, the supply to a few customers would have been interfered with to some extent. I ascertained, however, that the Undertakers regularly stop supply altogether on Wednesdays for two hours in the middle of the day, and the work could have been carried out with absolute safety during this interval. The fact appears to be that the possibility of danger was unfortunately overlooked.

Under ordinary conditions no work other than attention to the electrical circuits should be carried on in any transforming station when any apparatus contained therein is charged to a high pressure.

In the second place, I consider that the switching arrangements on the high-pressure switchboards in use in this and other transforming stations are needlessly dangerous in that large surfaces of charged metal are exposed, which could easily be covered by solid insulating material, so as to render an accidental contact with them impossible.

I was pleased to find that on the main switchboard at the generating station, well-designed arrangements had been made for the guarding of all charged metal. Some similar arrangements should be carried out on the switchboards in the transforming stations. The necessity for some alteration in this respect is now fully recognised by the Borough Electrical Engineer, who had prepared for my inspection a model of an insulating cap to partially cover the charged metal. It appeared to me, however, that the protection could be made more complete, and my suggestions are now, I understand, under consideration.

Thirdly, I would suggest that in all the transforming stations a thoroughly insulated floor should be provided, as can easily be done at a small expense. The indiarubber mats at present used are probably effective, but they are

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easily displaced. They should be retained for use on the insulated floor as an additional precaution.

There should also be in every case where it can be arranged a stout wooden rail or other division to separate off the portion of the chamber in which high-pressure apparatus is fixed.

Finally, the Board of Trade should, I consider, request the immediate attention of the Corporation of Cheltenham to the remarks and suggestions contained in this report. Those who undertake the supply of electrical energy at a pressure which involves the danger of sudden death from a cause so unnatural and so remote from human experience as the mere contact with a piece of metal, and who in their operations necessarily employ men of imperfect education, untrained to grasp abstract ideas, have a heavy moral responsibility for the safety of their employés. I feel confident that the Corporation of Cheltenham and their electrical engineer fully realise their responsibilities in this matter, and that they will spare no expense or exertion to prevent for the future any accident to their employés.

THE LONDON COUNTY COUNCIL AND THE OVERHEAD TROLLEY SYSTEM.

At the weekly meeting of the London County Council, held at the County Hall, Spring Gardens, on Tuesday, the Parliamentary Committee reported having considered the London United Tramways Provisional Order. By the Order it was sought to exempt the Company from the provisions of the London Overhead Wires Act, 1891, and the bye-laws made under the Act, and to authorise the Company with the consent of the Council to place overhead wires for working the tramways by electrical or other mechanical power, including the overhead trolley system of electric traction or any other system. The Council twice last year refused its consent to the use by this Company of electric traction by means of overhead wires, and having been informed by the Highways Committee that in their opinion the granting of the Order should be opposed, they recommended "That the Council do refuse its consent to a Provisional Order being granted to the London United Tramway Company."

Earl RUSSELL said the Committee, in their preamble to the recommendation, said that the Council twice last year refused its consent to the use by the Company of electrical traction by overhead wires, and the Highways Committee's ground of refusal was that the Council had never consented to overhead wires. London was peculiar in not using the trolley system in traction. He thought they should be informed whether it would interfere with the traffic in the streets in which it was proposed to use it. The order as it stood was perhaps one they could not agree to because it gave power to the Company, with the consent of the London County Council, to maintain those overhead wires in any part of their system. The system as extended at present did not come nearer than Shepherd's Bush, and he thought it most probable that along the whole of its present length the system of overhead traction could be used without inconvenience. Of course, the Council could hardly consent to give them power to introduce over head traction into Oxford-street, and he did not propose that. All he asked the Council to do was to exercise its common sense in the matter. Those who had seen the thing at work or had seen illustrations must know that it caused no real eyesore in the streets. He would go further and say even if it did cause some slight æsthetic eyesore in the streets it was no reason why they should deny the benefits of easy transit to those who required it. People wished to get about their business rapidly and cheaply, and he ventured to say on behalf of the persons who used tramways that they did not care about a wire more or less in the streets. The Overhead Wire Act was never intended to apply to a tramway company. It was intended to preserve them from the existence in the streets of numerous unused wires, the supports of which were never examined and were consequently liable to fall at any moment. It was never intended to be a matter of general principle. He appealed to the Council to refer the matter back in order that it might be considered on its actual merits and to see whether they could not allow in particular instances overhead wires to be used.

Mr. THOMPSON seconded the amendment.

Mr. ROBERTS said it was a matter debated very much in the old Council, and they were almost unanimous in deciding that overhead wires were not desirable. He thought they ought to consider the matter not only with a view of cheapness, but with the view of those who really had some interest in the beauty of London. He even believed that in the view of economy it was not desirable to deface their thoroughfares in that way. The Company was only anxious to have overhead wires so that they could do the work cheaply—it was not so much a question of the convenience of the public as of dividend paying. The desire of the people who promoted those companies was of course to reduce the initial cost, and it was the duty of the County Council to stand out for the interests of the people as a whole. If they put those hindrances in the way of the Company they would get some more economical and perhaps better method of locomotion in London without defacing the streets. He asked the Council to make a bold stand at once and say they would have nothing to do with any such thing.

Mr. JOHN BURNS, M.P., said he had seen the overhead tramways in Leeds and in Boston and other cities, and he ventured to say, whatever the opinion of the Council might be with regard to the introduction of the overhead trolley system in London, the Houses of Parliament would not have it. If they allowed it to be introduced at Shepherd's Bush, they could not deny it to Kensington, and then they must at last allow it in the Mall and over their bridges. Did Earl Russell say that should be done? If Earl Russell would go down Brixton-road what would he see? He would see what he (Mr. Burns) considered one of the finest constructed tramways in the world. It was a cable tramway. He hoped that the proposal to introduce the American monstrosity of overhead wires would not be allowed.

Mr. J. WHITE said he was not an æsthetic, and he confessed that he had seen the tramways at work in Bristol and in Brussels, and saw nothing to offend the taste of average man. His friends Mr. Roberts and Mr. Burns were far above the average in æsthetic taste, and he asked the Council not to legislate for their high-toned notions, but to bring themselves down to the common sense standard which must govern the community. He could see no harm in the matter going back to be reconsidered by the Committee. The only reason at present given of refusal was that the Council had never done such a thing before, but if the Committee would give them some material reason why the thing should not be allowed, they (the Council) could be far better judges than they were now.

Mr. MCKINNON WOOD (Chairman of the Parliamentary Committee) said that the Committee simply moved on the recommendation of the Highways Committee, who were experts and were responsible. It was not, however, a mere question of the remote suburbs, but other roads might be disfigured by that particular form of electrical traction if the Order were approved, because the Company took powers to introduce the overhead wires in any part of their system, and that included the Uxbridge-road and the Hammersmith-road.

The amendment was then put and defeated in a somewhat small Council, and the recommendation was carried.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, February 21st.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting. Paper to be read: "Some Central Station Experience," by W. Fennell.

SATURDAY, February 22nd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Light," by the Right Hon. Lord Rayleigh.

MONDAY, February 24th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture II.: "The Chemistry of Certain Metals and their Compounds used in Building, and the Changes produced in them by Air, Moisture, and Noxious Gases, &c.," by Prof. J. M. Thomson.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

8 p.m. General Meeting at the Palatine Hotel, Hunt's Bank, Manchester. Paper to be read: "The Development of Electric Lighting Engines," by H. Lindley.

TUESDAY, February 25th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be discussed: "The Electric Street Railway System of Montreal, Canada," by G. C. Cuningham.

THURSDAY, February 27th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Conclusion of discussion on the following Papers: (1) "The Electric Wiring Question," by F. Bathurst. (2) "Concentric Wiring," by Sam Mavor. Paper to be read: "High-Voltage Lamps and their Influence on Central Station Practice," by G. L. Addenbrooke.

FRIDAY, February 28th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read: (1) "Experiments with Incandescent Lamps," by Sir D. Salomons. (2) "On the Alternating Current Arc," by Dr. Fleming and Mr. Petavel.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Concert (Ladies' Night) at the St. James's Hall Restaurant.

SATURDAY, February 29th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Light," by the Right Hon. Lord Rayleigh, F.R.S.

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THE RENAISSANCE OF SUPERHEATING.

The *renaissance* of superheating in steam practice, which has occurred within the last few years in this country and somewhat earlier on the Continent, promises to place the use of superheated steam upon a more firm and lasting footing than was the case when it was invented and first used in the time of TREVITHICK. For not only have thermodynamic theory and actual practical trial shown conclusively that this form of steam can produce more economical results in a steam engine than ordinary saturated steam can do, but the improvements in the manufacture of iron and steel and a better knowledge of boiler design enable superheaters to be built which do not possess the defects which rendered the pioneer superheaters such a failure. Among those whose interests are affected by any question, such as steam superheating, relating to steam engine economy, electrical engineers may claim one of the foremost places, at any rate as regards stationary engine practice. Indeed, the competition in which they have been placed with other modes of producing light and power, has compelled electrical engineers to turn their attention to every possible source of increased economy in their plant, and thus has forced them to take a lead in the modern improvement of the stationary steam engine. To them, therefore, the "Notes on Steam Superheating," recently read by Mr. W. H. PATCHELL before the Institution of Mechanical Engineers, will be of interest. We commence this week a reprint of this valuable and comprehensive Paper, in which the author has not only published his own personal and lengthy experience of the use of superheaters at the supply station of the Charing Cross and Strand Electricity Supply Corporation, but has drawn up what might be termed a critical history of superheaters and superheating, enriching it with details of numerous trials.

The practical advantages in the use of a superheater appear to arrange themselves under three heads—firstly, the steam is less damaged during its passage from the boiler to the engine; secondly, each pound of steam in the engine will do more work than if it had not been superheated; and thirdly, the boiler may, in certain cases, be made to generate a

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greater number of pounds of steam when steaming at its maximum rate. These three points are well brought out in Mr. PATCHELL's Paper. In order to understand the first of these three advantages it will be necessary to consider the second as a preliminary. Steam which leaves the boiler in a superheated condition, and passes through a system of pipes to an engine, will do more work in the engine than if it had not been superheated, *even when it does not reach the engine in a superheated state.* It is well attested by almost countless trials that this is the case, and the explanation is to be found in the fact that if steam has once been superheated it will reach the engine with a lower percentage of wetness than if it leaves the boiler merely as saturated steam. Now, wetness in steam seems to have the power, as it were, of feloniously inciting to further wetness immediately the steam enters the cylinder. If the steam is dry or only slightly wet the cylinder condensation will be small, but if there is a larger percentage of wetness the initial condensation will be altogether out of proportion to the additional wetness. A high degree of wetness, therefore, will develop a ruinously large amount of initial condensation, from 50 to 70 per cent. of the actual steam in the wet mixture being precipitated immediately upon its entry into the engine. It will be seen, then, that something by no means inconsiderable will have been done towards improving the economy, if the steam is brought to the engine, a little drier, even though it may not arrive there actually superheated. Of course, it will be better still if the steam is not only dry but possessed of actual superheat, for then it will carry with it right into the cylinder surplus heat which will arrest the cooling action of the walls. With these facts in mind, it will not be difficult to understand that the addition of a superheater to a boiler plant enables the steam pipes to convey the steam to the engine in a less damaged condition. We do not mean that there will be less radiation and conduction of heat; indeed, there will be more, for the steam will be hotter. What we do mean is, that this loss of heat will not injure the steam to the same extent that it would—or that even a lower loss would—if the steam were not previously forearmed against the generation of wetness. For, let it be remembered, not all of the water which arrives at the engine arises from priming in the boiler; most, sometimes all, of it is caused by cooling of the steam as it passes through the pipes. Superheating allows this cooling to occur without the formation of water.

With regard to the third advantage attending the use of a superheater there may be differences of opinion. Mr. PATCHELL has shown that in the case of one of the water-tube boilers at the supply station under his control the steaming capacity was raised from 3,457lb. per hour to 8,293lb. per hour, a matter of 140 per cent., by the aid of a superheater and extra draught; and at the end of the reading of his Paper he stated that a stoker under his charge had managed to get 10,125lb. per hour from this boiler, or nearly treble the normal maximum. In so far as this improvement was due to the superheater, it only shows that without the superheater there would have been wet steam, due to priming. If a superheater is supplied with dry steam it cannot possibly increase the gross output of steam from the boiler; and that it does so in any case is a proof that the boiler to which it has been fitted is liable to prime. We do not believe that any such alteration in the steaming capacity of a good Lancashire boiler would result from the addition of a superheater; and we may add that, indirectly, Mr. PATCHELL's figures are a further interesting testimony to the inadequacy of the ordinary water-tube type of boiler where heavy forcing is to take place. On the other hand, it is a very useful fact that the addition of a superheater to a battery of boilers liable to prime heavily when forced will turn all the primed water into good steam; though it may be doubted if this practice is altogether fair to the superheater.

Against the undisputed advantages of superheating, however, there are some disadvantages which it will be necessary to consider. These may be met with, firstly, in the apparatus used for superheating the steam, and, secondly, in the use of superheated steam in the engine. In order that the superheating surface shall be efficient it must be exposed to furnace gases at a much higher temperature than the steam. This will render it necessary either to have an independent firing arrangement, which may be shut off in the event of anything going wrong, or else that the superheater be placed in a very early part of the main flues of the boiler. In the latter case the superheater is subjected to conditions which intensify the risk of breakdown and, at the same time, render a breakdown disastrous and difficult to repair. It was this very consideration, we believe, which led Prof. KENNEDY to place the superheaters at the Edinburgh Supply Station in a later part of the flues, where, however, they could not be very efficient nor possess much regulating power. One of the speakers who took part in the discussion on Mr. PATCHELL's Paper expressed his opinion that a superheater was merely an extension of the boiler. Now, it is precisely in the contrary to this statement, and in the radical distinction between a superheating surface and an evaporating surface, that the principal trouble with the former will be found to exist. A true boiler surface will have furnace gases on one side of it and water on the other side, and danger arises the moment the water is replaced by steam through fall in the water level. A true superheater surface will have furnace gases on one side of it and steam on the other side; but in practice it often has both steam and douches of primed water on that side at which there ought to be only steam. No boiler maker would dream of constructing a boiler, as such, in which the evaporative surfaces would be exposed to the conditions which every superheating surface must withstand; and it is in this fact, as we have already stated, that the risk of breakdown of superheaters lies.

The troubles in the engine itself attendant on the use of superheated steam do not appear to be so formidable at the present day as they were in earlier times. One of the reasons assigned for the former abandonment of the practice was the injury which the superheated steam inflicted upon the valve faces, cylinder liner and glands of the engine. Yet neither the pressure of the steam nor the number of degrees of superheat approached present-day practice. Part of the ancient troubles no doubt arose from the use of vegetable and animal fats and oils for lubrication, which at the temperature of the steam liberated acids which attacked the metal of the engine. The use of mineral oils nowadays obviates any such difficulty. Another cause, probably, was the inferior quality of the metal used, whether for the cylinder or for the glands. There is also much reason in the hypothesis put forward by Mr. PATCHELL, that while superheated steam itself may not be injurious, the alternation of it with wet steam, exposing the surface now to the one now to the other, will cause pitting and cutting of the surface. And it is a very excellent argument against the intrinsic power of hot, dry steam to injure a metal surface, that in a gas engine such surfaces are exposed with impunity to gases very much hotter than the hottest superheated steam that ever has been used. On the other hand, we must not forget that in the majority of cases where superheaters are used the steam never enters the engine in a superheated condition. Even where it arrives at the engine stop valve in that

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state, its admission into the engine will generally be accompanied by so rapid an abstraction of heat by the cylinder walls that it swiftly changes into wet steam. Nor, during this change, will it be likely that the metal will be brought into contact with the dry steam, for the inevitable film of moisture on the surface of the metal will prevent this. Only where the degree of superheat is very considerable can it be expected that the cylinder liner will come into touch with really dry and superheated steam.

On the whole, then, the numerous advantages of superheating outweigh its possible disadvantages; and it seems probable that we are on the eve of a very considerable extension of the use of superheaters in stationary engine practice. The results obtained at the Maiden-lane station, and given in detail by Mr. PATCHELL, show that the modern superheater has stood the test not merely of short trials under test conditions, but that as an everyday adjunct to a battery of boilers it is reliable and economical. Its extensive use on the Continent at the present time, as well as the excellent results which have been achieved with it in connection with the Parsons steam turbine, are further evidence that the *renaissance* of superheating is not a fitful splutter but a permanent revival.

ON THE PRODUCTION OF ELECTRIC PHENOMENA BY MEANS OF ROENTGEN'S RAYS.*

BY PROF. AUGUSTO RIGHI.

1. It is noticed that the most salient properties of the X-rays, and especially the property of exciting fluorescence, and that of acting on photographic plates (which Röntgen suspects to be a secondary effect arising from the former) belong, moreover, in especial manner, to the less refrangible of the ordinary light rays. Since the latter are equally highly suitable to generate photo-electric phenomena, I have wished to investigate whether phenomena of this kind can also be produced from the X-rays.

As my investigation, although hardly begun, has borne fruit, I am at once communicating to the Academy the results obtained. But for the sake of clearness it is necessary to preface a brief remark on photo-electric phenomena in general.

2. A negatively electrified body rapidly loses its charge if it is exposed to radiation. According to the nature of the body and to the wave-length of the radiation used, the rate of dispersion of the charge is less or greater, whilst in the case of the greater number of bodies the phenomenon is produced only by having recourse to the rays of the smallest wave-length given out by the voltaic arc (and especially from that produced from carbon and zinc or aluminium), or even those given out by magnesium in combustion; for some bodies, such as amalgamated zinc, even sunlight is useful, and for others, like the alkaline metals, the most ordinary artificial light.

I should here mention particularly an experimental arrangement, that of the *photo-electric couple*.† A metal disc receives the active radiations after they have passed through a piece of metal gauze parallel with and close to it, and communicating with the earth. The radiations, in dissipating the negative charge, which (by the effect of the contact difference of potential) either the gauze or the disc possesses (the same having an instant before the experiment been put into metallic communication), cause a positive or negative deviation according to circumstances in an electrometer, communicating with the disc, and which gives sensibly the measure of that difference of potential.‡

If, in repeating the experiment several times, the disc is placed further and further from the gauze, the deviation augments in value if positive, and diminishes or is brought to zero and reversed if negative.

The immediate cause of this effect is a phenomenon shown at the end of my first researches on the electric phenomena of radiation, viz., that by virtue of which a discharged body charges itself positively when it is exposed to radiation.*

This phenomenon obeys a law which I have established by many experiments, and which may be enunciated thus: When the positive charge of the body which receives the radiations stops increasing, then the electric density has reached a certain value, constant for all given substances.

It follows from this law that the positive deviation, produced by the radiations, becomes smaller and smaller, if the body which receives the radiations approaches more and more nearly to a conductor communicating with the earth which does not increase the capacity. In order to show the positive charge generated by the radiations it is then needful that the body on which we are acting should not be too near to uninsulated conductors. In the opposite case—that is, that of the photo-electric couple—the generation of that final positive charge has no influence whatever on the deviation obtained.

3. In order to examine whether the X-rays also cause the dispersion of the charge of a negatively-electrified body, and whether they charge positively a non-electrified body, I have operated with methods similar to those now described, as follows:—

1st. I have given a charge of any amount whatever to a conductor, and then I have examined its potential, as indicated on a quadrant electrometer communicating with it, as to whether, when the X-rays fell upon it, it underwent a diminution more rapid than that proceeding from the usual loss of charge.

2nd. I have made the X-rays fall upon a photo-electric couple, and have observed whether they cause a deviation in the electrometer communicating with the disc, the gauze being in communication with the earth.

3rd. I have examined whether the same rays falling on a non-electrified body produce in it an electric charge.

In setting up a suitable experimental arrangement I have been obliged above all to do it in such a way that no doubt can exist as to there being any electric action whatsoever produced directly on the electrometer or on the bodies communicating with it by the apparatus generating the X-rays.

Therefore I placed the Crookes tube, together with the coil, the interruptor, &c., inside a large metal case communicating with the earth. One of the side walls of the case is composed for the most part of a thick sheet of lead furnished with a circular window, in front of which and inside at a little distance is that part of the Crookes tube which is struck by the cathode rays.

The window can at pleasure be closed either by a thick sheet of lead or by a very thin plate of aluminium. In either way, when the apparatus contained in the case is in action, no electric force whatever which proceeds directly from the internal charge to the case shows itself on the outside.

But when I placed conductors, electrified or not, in front of the window closed with aluminium, I observed the following phenomena:—

4. If a conductor charged negatively has just been placed in front of the window, the Crookes tube has hardly entered into action when the charge rapidly disappears.

If the conductor is non-electrified it electrifies itself positively, and by equality of conditions the final potential is different according to its nature—for example, greater for retort carbon than for copper; greater for copper than for zinc.

With this last metal the deviation is negative when the distance between it and the aluminium is small enough. This occurs because of the contact difference of potential, but at greater distances the positive charge produced by the X-rays prevails.

Finally, if a photo-electric couple is placed before the window, a deviation in the electrometer is obtained similar to that produced by ultra-violet radiations.

I have not yet been able to examine if this deviation is exactly equal to that which the latter species of radiations

* From the Proceedings of the R. Accademia delle Scienze dell' Istituto di Bologna.

† *Mem.* of the Royal Academy of Bologna, Series IV., t IX., p. 369 N. Cimento (1889), t 25, p. 20.

‡ *Mem.* of the Royal Academy of Bologna, Series IV., p. 351.

* *Mem.* of the Royal Academy of Bologna, Series IX., t. 9, p. 387, N. Cimento (1889), t. 25, p. 128.

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will cause. In actual experiment one may dispense with giving to one of the metals of the couple the form of gauze, seeing that thin metal plates, especially of aluminium, allow the X-rays to pass through. So one may substitute for the gauze a thin plate of that metal.

Consequently I can say: *The X-rays have, in common with the ultra-violet rays, the power of determining the dispersion of the negative charge, and of giving rise to a positive charge in non-electrified bodies.*

As was to be foreseen, the electric action of the X-rays diminishes if the bodies on which they act are removed further from the window whence the rays proceed.

Placing against the window a thick slab of pinewood, or a sheet of aluminium, or a sheet of glass, or the hand (placed in such a way as to entirely cover the window), &c., diminishes more or less the effect produced by the X-rays, but in general does not completely eclipse it. In particular it is noted that plate-glass less than a centimetre thick is more absorbent than pine-wood six centimetres thick.

5. The ultra-violet radiations do not produce a sensible action on positively-electrified bodies, since if in any case they seem to cause the dispersion of the positive charge, it can be recognised that the effect observed was due to the dispersion of the negative charge of the surrounding bodies.

Well, now, having given a positive charge to the conductor (retort carbon, copper, zinc, &c.), on which the X-rays fall, I observed the same action as in the case of the negative charge. Therefore: *The X-rays, unlike the ultra-violet rays, cause dispersion also from positively-electrified bodies.*

Naturally, whilst in the case of the initial positive charge the dispersion ceases when there remains in the conductor a charge equal to that which, when it has returned to its natural state, the rays have caused it to acquire, in the case of the initial negative charge the dispersion continues until the body is discharged; and then the process is resumed until it has produced the same final result that it had when the initial charge was zero or positive. This result can be explained by saying that the conductor communicating with the electrometer seems to behave like an exploring electrode immersed in a conducting medium, and which assumes the potential proper to the place it occupies, whatever be its initial potential. Under equal conditions I have not recognised, at least on first examination, any noteworthy difference in the rate of dispersion, according to the sign of the charge, in the bodies on which the vibrations fall. The phenomenon can also be observed two metres and more away from the window.

6. It is important to take note how the new properties here established are valuable as furnishing a means of measurement by the X-rays. I believe that any one wishing, for example, to compare the absorptions of various bodies, will prefer to express numerically these absorptions on the basis of the variations of the rate of electric dispersion rather than be contented with the approximation based on a comparison of the intensity of a shadow projected on a fluorescent screen or on a photographic plate.

Evidently these new properties should be kept in remembrance when the time shall arrive for discussing the various hypotheses proposed to explain the nature of the X-rays.

7. I have prepared a lecture experiment to show the dispersion of charge caused by the Röntgen rays. In this case I have dispensed with the metal case, preserving only the large sheet of lead with the window closed by aluminium. A disc of any kind of metal is placed at a few decimetres distant from the window at one side of the sheet of lead, whilst at the other side of it is the Crookes tube with the apparatus which excites it. The disc communicates with a gold-leaf electroscope. The insulation being good, a charge of either sign is given to the apparatus—for example, by a dry pile; the leaves remain for a long time motionless and diverging, but hardly has the Crookes tube entered into action, they fall down and remain vertical.

As soon as I close the aperture with a thick sheet of lead, the phenomenon ceases to be produced. If, instead, I place against the window other bodies such as the hand, or wood, &c., a mere slowing of the falling of the gold leaves is observed.

THE "SPERRY" STEAM ENGINE.

An account of a remarkable steam engine, designed by Mr. E. A. Sperry, is published in a recent issue of the *Electrical Engineer* of New York. So far as we can gather, the engine has not yet actually been built; but in the elements of its design it calls for some notice. These elements are not in themselves novel, though their combination and the purposes which they serve appear strikingly original. Before describing this engine it will be well to review the chief considerations which led Mr. Sperry to design it. The objects he sought to attain were: a high-speed dynamo driven by a slow-speed steam engine without gearing. What at the first glance may appear impossible of solution he has readily accomplished by means of link motion. This is, in fact, by no means the first instance of the application to linkages in engines for transforming reciprocating motion. Mr. Atkinson, in his famous "Cycle" gas engine, used a toggle arrangement of links for the purpose of causing four strokes of the piston to occupy the time of one revolution of the engine pulley. But in this gas engine the lengths of the four strokes were all different. Mr. Sperry has reversed the application of the toggle which Mr. Atkinson made, and has used it to produce two

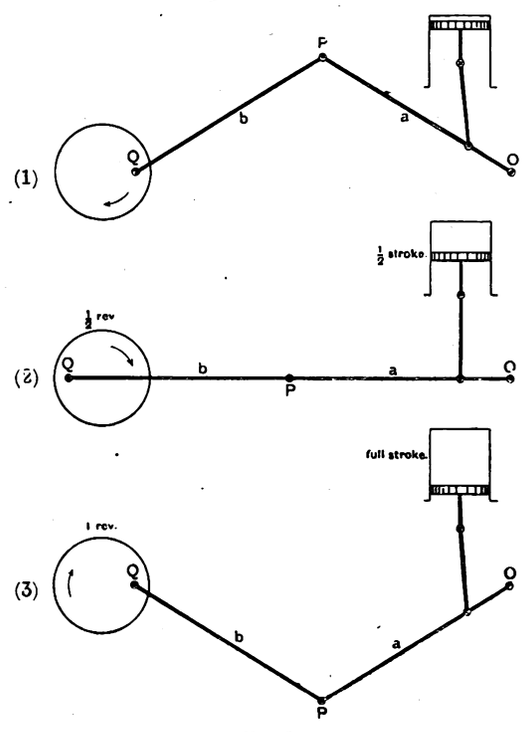

FIG. 1.

revolutions of the engine (and dynamo) shaft during the period of one double stroke of the engine piston, with the further modification that the engine strokes are all of equal lengths.

The main principle of the mechanism, by which the speed is increased in the "Sperry" engine, may be understood by reference to Fig. 1, which represents diagrammatically the several stages of one stroke of the engine. The piston rod is connected by its connecting rod to a point on a link *a*, which has a fixed pivot at O, and which is at P coupled to one end of another link *b*. The further end of this second link *b* is coupled to a disc crank on the dynamo shaft. In position (1) the piston is about to commence a down stroke. In position (2) the first half of this stroke is completed, and the extension of the toggle, composed of the links *a* and *b*, has produced a half-revolution in the crank Q. In position (3) the stroke is completed, and at the same moment the crank has also completed one revolution. During the return stroke of the piston another complete revolution will be effected, thus making two revolutions in the time of a double stroke. It will be noticed that by varying the lengths of the links *a* and

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b, or by altering the point of attachment of the connecting rod to the link *a*, a wide range in the ratio between the length of the piston stroke and the throw of the crank Q can be obtained, a matter which will be of some practical importance in balancing an engine of this type.

Such a design as the one under present consideration offers many interesting problems to the engine builder. Of these we may notice two which will always be of prime importance—viz., balancing against reciprocating reactions, and the provision of sufficient inertia to prevent undue irregularity of speed in the dynamo shaft. In regard to the first of these, the balancing of reciprocating actions in such an engine will be a more complicated and difficult matter than in an engine of the ordinary type, firstly because of the greater number of parts thrown into reciprocating motion, and secondly because both the transverse and the axial reciprocating forces will be greater than in an engine of ordinary type. Lack of careful balance would be liable to develop excessive vibration and shock, or pounding, in an engine of the "Sperry" type. In the actual engine it is proposed to use counterweights on the toggle, as well as to proportion the mass of the links to their speed and the stress to which they would be subjected. Fig. 2 gives a diagrammatic representation of the toggle with counterweights at A and B. These counterweights, properly proportioned and placed in suitable parts of the link motion, will not only serve to balance the parts, but may also be used in place of a flywheel to equalise the driving effort on the dynamo crankshaft. The counterweights will have an approximately simple harmonic motion, and during the first half of their swing will accumulate energy which they will restore during the second half. It may here be pointed out that the whole of the energy accumulated by them is restored, whereas in a revolving flywheel it is only a very small proportion of the total accumulated energy which

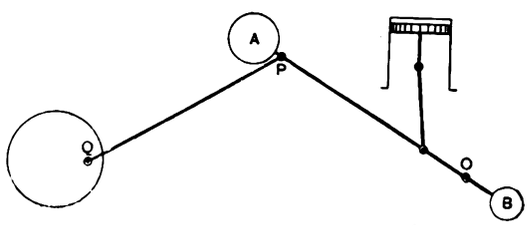

FIG. 2.

flows out of the wheel during each revolution. In other words, the accumulating efficiency of 1 ton of metal is much higher in a reciprocating mass that in a flywheel which may fluctuate only 1 or 2 per cent. in speed. As an illustration of this, Mr. Sperry takes the case of a 400 H.P. engine, making 100 double strokes and 200 revolutions per minute. The maximum velocity of the joint P (Fig. 1) in this engine is 52ft. per second, and occurs once during each revolution. One ton of metal located at this point would have an accumulated energy of 165·6 horse-power seconds, which it would liberate during the next half-stroke of the piston. It is clear that this, if well distributed, might be utilised to equalise the varying effort of the steam in the cylinder.

Practical experience is the final court of appeal in deciding the merits of such an invention. Yet it may be permitted, even at this stage, to doubt whether Mr. Sperry's ingenious invention possesses any advantage over more than one well-established method of driving a dynamo. The use of a slow-speed engine with Corliss gear may or may not be, in itself, more economical than a high-speed engine; but we feel sure that any economical superiority it may possess would be swallowed up in the extra frictional losses of the added link motion. Nor can we believe that this link motion would be found to possess a mechanical efficiency any higher than a simple belt or rope drive. To establish the superiority of the "Sperry" engine over existing types, it would be necessary to prove two things: firstly, that a slow-speed engine of given power is intrinsically more economical than one of double the speed and equal power; and, secondly, that the toggle link motion is superior to ordinary belt or rope gear. We do not think that it will be easy to establish either of these propositions.

HOUSE-WIRING.

RESUMED DISCUSSION OF THE PAPERS READ BY MESSRS. FRED. BATHURST AND SAM MAVOR BEFORE THE INSTITUTION OF ELECTRICAL ENGINEERS.

Speakers who have revised the abstracts of their remarks have asterisks against their names.

THURSDAY, FEBRUARY 13TH.

*Mr. J. D. F. ANDREWS said he proposed to devote his remarks entirely to concentric wiring. Mr. Mavor was good enough in reading his Paper to attribute the pioneering of that system of wiring to him (Mr. Andrews), and he had pleasure in thanking him for his courteous remarks and acknowledgment. The invention or conception of concentric wiring, even with a bare outer, was not in itself a matter which required much ingenuity, but at the time it was first introduced it was entirely opposed to the then existing ideas and principles, and its introduction was met by great opposition, more especially by the insurance offices, which at that time almost unanimously followed the Phœnix rules. It was a relief, however, to be able to say that that opposition has now begun to die out. Mr. Human, of the Guardian Office, was the first surveyor to recognise the advantages of the system from an insurance point of view. He was sorry to hear Mr. Mavor make proposals regarding inspection by the insurance offices. The tendency of the insurance offices to-day was a proof that they regarded electric lighting as quite a minor source of risk, and that it was unnecessary to employ special skill and issue elaborate rules. The Board of Trade had also begun to show a more generous spirit; in fact, negotiations were progressing satisfactorily with them for his system of concentric mains with a bare, or nearly bare, outer conductor to be laid in the streets of Guildford. The system there to be introduced was the three-wire, consisting of two independent armoured conductors, the armouring of both of which combined formed the middle wire. Great as would be the advantage of concentric wiring for street mains, the greatest advantage would appear in the reduction of the cost of *interior* wiring; this would be quite 20 to 30 per cent. less than with casing or with conduits. The wide introduction of concentric wiring was dependent upon a universal permission to earth the distributing network, a permission that would not alone be good for concentric wiring, but would also be beneficial to all systems of street mains and everything within range of their influence, for the simple reason that the course of the leakage currents would be reduced practically to the distance between the two conductors, instead of, as now, the course being of unknown distance through earth, and consequently having unlimited influence on everything in the course. By earthing the network he did not mean that it should be earthed only at one point; on the contrary, it should be almost continuously earthed, or at each house connection. By earthing one of the street mains he did not advocate that it should be bare; on the contrary, it should be protected against electrolysis and possible chemical action of the soil. The earth connection only should be exposed. The benefits of such a self-testing system would, he was convinced, entirely outweigh the cost of making the conversion. In the concentric system the outer conductor should be absolutely continuous from the dynamo to the lamp, it should be of large section, and entirely envelope the central conductor, also the switches and the fuses. It should be in such close proximity to the inner conductor that it would be impossible for an arc to be established without blowing the fuse. Following those fundamental principles was the only method by which the great advantages of the system could be secured, the reason for which would be obvious when they considered that if the inner conductor was exposed or easily reached at any joint it would be possible for leakage to take place from it without first touching the other conductors. If concentric wiring were to become general, two important changes might be looked forward to in wiring practice: the test to earth would vanish, and the high degree of insulation now required between the conductors would be looked upon as absurd. The insulating material in a concentric wire should be substantial in character and highly durable, but it was only required to insulate to such a degree as not to permit of a greater leakage to take place than might be negligible from a commercial aspect; if it could be possible to obtain reliable insulating material to work at so low a degree, for instance, a wire of 10,000 ohms per mile would only mean a leakage of one hundredth of an ampere with 100 volts. He did not advocate that as the correct degree of insulation to be adopted, but simply gave it as an illustration, and he would point out that it was 60,000 times lower than was at present insisted on in most double wiring.

*Mr. R. J. WALLIS-JONES said it was somewhat interesting to look back upon the progress of electric wiring since, say, 1881. He thought if they looked at the question broadly they would find that the art of wiring had really divided itself into three distinct periods. They might almost say there had been a stone age, a wood age, and an iron age. If the progress shown continued to follow the progress of civilization in other directions then probably the iron age had come to stay. The great difficulty in installation work was the question of moisture. If there was absence of moisture almost any kind of wiring was good enough. He might instance a case in his own experience some ten years ago where he had to wire a new building. In those days, as they well knew, there was no such thing as vulcanised wire in general use. The wires in this installation were simply covered by a pure rubber strip, and he was not at that time aware of the action of various cements and mortars upon the insulation of wire, but he did know this, that the action of plaster of Paris on bare wires was at least harmless, and he buried those wires in channels cut in the walls and fastened them in with plaster of Paris. At the present moment that installation would give as high a test as any he knew of. That was simply an instance proving that where one had no moisture one could do with very light

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insulation. One of the greatest difficulties of wood casing was the very great uncertainty of the action of damp on the cable inside. He knew one case in particular in which a 19/16 cable was absolutely wasted so that the conductor was dissolved right away and nothing remained but the copper salts. This, on being examined, was found to be caused by a very poor class of insulation around the copper and damp attacking it. The wall on which the cable was placed had become damp by the bursting of a water pipe. In new buildings, however, before the advent of the insulated conduit system, he had seen very successful work carried out with wood casing thoroughly well varnished and put in of a size larger than was absolutely necessary. The casing should be buried and plastered over, and in that way they would find that they could get a fairly good job. No doubt in a wood casing installation there were many mechanical difficulties which were unavoidable. The question of insurance had been touched upon. It seemed that the question of insuring central stations was considered by the fire insurance offices from a very unfair basis at the present time. They made no allowance for the difference in the class of building, but charged one rate whether it was a well-designed or badly-designed station. In one large central station in this country they had taken the matter into their own hands by simply refusing to pay the fire premium and fitting up the station with a proper fire extinguishing plant. In regard to insulated conduit systems he had had practical experience of an installation of about 800 lamps. As they well knew, there were three classes of these conduits—first, the plain bitumen paper tube, secondly, the brass-armoured tube, and then the iron-armoured conduit. The first was somewhat fragile and certainly not very sightly when fixed in position. There was an intermediate type of conduit which consisted of an insulated tube covered with an iron split tubing. He thought that, so far as present knowledge went, if they had to wire a new building with the two-wire system there was no system as good as the insulated conduit, and for this reason, that they could take the building in the carcase and place the tubes readily in position, plaster the whole of the work up, and draw the wires in when they had finished, and they might be quite certain there would be no trouble from bad insulation. As an instance of this he might mention that in this particular installation which he had to do with he tried the other day the experiment of placing a plain steel tube into the conduit for a considerable length. The insulation of that plain steel tube was practically infinity, and therefore a very poorly insulated wire would give very good results indeed. The general way of carrying out work at the present time was to run from the central switchboard a main to a fuse distribution board, and from this fuse distribution board circuits for seven or ten lamps were taken off. Wherever a joint was made a joint box was inserted. He thought the best way of doing work of this kind in the future would be to run the main to the fuse board and from the fuse board run a submain to a joint box, and then run into this joint box the seven or ten-lamp circuits having no joints at all. He had had the pleasure of seeing the concentric wiring as shown by Mr. Mavor. He did not, however, think it very sightly if they were obliged to place the wire on the surface. When Mr. Mavor mentioned sightliness in houses he was probably thinking of Scotch houses, where there were hollow walls and they could run the wires behind. In houses where the system would be placed on the walls it would be a very difficult thing to get a straight line with any flexible conductor such as they had in the concentric system. He had looked into the question of the possibility of drawing wires into insulated conduits system and found, of course, that by blowing soapstone into the conduit they could most easily draw in a considerable length. He should say the average length desirable for circuits was about 60ft. to 70ft., and he found that for the total area of the wires—that was to say, taking the outside of the insulation as compared with the inside area of the conduit—the average was something like 45 per cent. There was one way in which the conduit could be improved—by reducing the diameter. This was an important point in the question of cost, because unless they had a fairly small conduit they had to go so deeply into brickwork that it became exceedingly expensive to instal. From that point of view, of course, the concentric system was a great advantage.

Mr. G. L. ADDENBROOKE said before dealing directly with the question under consideration, he would say a few words on the financial aspect of wiring. It would be found as a sort of rough average that the cost of central stations, with mains, &c., came to somewhere about £100 a kilowatt. A kilowatt capacity of plant was about 25 8 c.p. lamps. They might say an average of 20 lamps, taking 8 c.p. and 16 c.p. together. Roughly, a central station provided for about double the number of lamps installed; therefore, if there was a kilowatt capacity in the station, there would be twice that in the lamps. Consequently, on that basis, they would have about 40 lamps wired for each kilowatt capacity in the station. Now they put these lamps down at an average of £1 apiece—*i.e.*, £40—which showed that whilst they were spending £100 on the central station, £40 were spent in the wiring of houses. The total sum spent on central stations amounted to some millions, and they might take a little less than half that for the cost of wiring This still left a very large sum expended in the past and to be expended in the future in wiring. Therefore, this wiring question was a very important one, and demanded the greatest consideration. For instance, it was greater than any one item in the central station except distribution; in fact, the cost of wiring was infinitely in advance of the cost of dynamos, or the cost of engines, or the cost of boilers, or any other single item. He was extremely pleased to hear what was said on the subject of earthing the middle wire. He must say it seemed to him, if it was not quite hopeless, it was very difficult to make the progress in wiring which they wanted unless that could be done. One of the great obstacles to the extension of the electric light now—and it was an obstacle which was more felt now that the Welsbach was a competitor—was the great cost of wiring houses and the frightful mess which it involved. For this reason numbers of people went without the electric light, although the mains were at their doors, who would gladly pay any little extra cost of the light itself. As to concentric wiring for houses, he had not absolutely made up his mind whether it should be taken simply as it was, or whether they should put in iron pipes. He saw that some wiring contractors, who did a high-class business, were putting in a large number of pipes in their houses. They found that they could put ordinary iron pipes in at something like 4s. a light, and wires were drawn into this; but they themselves had suggested to him that if the middle-wire earthing were attempted, all they would have to do would be to take a little more care in running those pipes, use the iron pipes as the outer, and run the wires inside. It seemed to him that that would make a sound job. It would be Mavor's concentric system, so to speak, so far as the fittings and so on went. It would get rid of the difficulty of burying the conductors, and they could be drawn out at any time.

*Mr. C. N. RUSSELL said Mr. Bathurst's Paper seemed to bring forward as the problem to be solved: "How is it possible to reduce the cost of wiring to one-half what it is at present?" In order to follow the matter he should be glad if Mr. Bathurst would let them know, at what figure he had assumed the present price of wiring. Also, was it proposed that by the use of insulated tubes they could reduce the cost of wiring by 50 per cent., or even 25 per cent? If so, it would be interesting if they could see some figures, of typical installations by way of comparison. The two systems before them, although differing widely, were most excellent each in their way, and if installed properly would do credit to any firm. At the same time it ought to be allowed, that good work could be, and was, done with wood casing, which was very suitable for face work in rooms that were already decorated, and free from damp. He was of opinion that wiring by the use of wood casing could be made to cost less than conduit work. He said could be, because wood casing lent itself to bad work. It could be cut with a pocket-knife and fixed with tin tacks, and as long as the mitres of the capping were fairly made, the job when finished looked all right. On the other hand, if a workman was employed who was paid a fair wage and did his work well, and who was not afraid of taking up the floor boards, for his work to be inspected, he did not hesitate to say, that the cost of wood casing *versus* any conduit system would be about equal, and in a big job would probably be in favour of the latter. Personally he was much in favour of conduit wiring, and would welcome any system that would reduce the cost of good work, but while he allowed the good quality of the systems before them, he failed to see any approach to reduction of cost. He had had considerable experience in conduit wiring, with plain iron tubes, coated with preservative compound, and could assure the members of that Institution that the bogeys raised by Mr. Bathurst in the way of rust, condensation, &c., had caused him (the speaker) no trouble, although the system was extensively used. So far as his experience had been with conduit wiring, he might say that it was well adapted for mills, workshops, and buildings in course of erection, and made a first-rate job, but it could not be done at a price to compete with the so-called cheap wiring at 15s. per lamp. The difference in prime cost between wood casing and plain iron tubes, having the same duty as regards current-carrying capacity, was in favour of wood casing by about 25 per cent., and in the case of insulated tubes, he took it the difference would be greater. As regards prime cost of wiring with plain iron tube conduit, in the case of a mill having 120 16 c.p. lights it worked out at 18s. per lamp, where each lamp had a separate switch, and the work was easy and straightforward. Those figures did not include main switchboard. He had had a few samples of fittings, as used by the London and Lancashire Electric and General Engineering Company, Limited, placed on the table that evening for the inspection of those interested. As far as the merits were concerned of the two systems of wiring before them, he did not think any practical man doubted their excellent qualities for a moment. But he did not see how either of them was going to assist them in reducing the cost of fitting. To do that, it seemed as though they must have a new system entirely, possibly a concentric one, with the outer earthed and with lamps and holders that could be fitted with as little trouble as a gas burner. The present form of Ediswan bayonet-joint lamp holder, so much in use, was in his opinion too complicated, and in too many pieces. The capping of the ordinary incandescent lamp was, he thought, capable of great improvement. A number of lamps of the cheap type, which he tested recently, had such a low resistance between the terminals, across the plaster setting, that in a damp atmosphere considerable leakage would have occurred. Referring again to insulated tubes, he did not quite see what was to be gained in the way of economy, by dividing the insulation and placing part on the tube and part on the wire. Taking the comparative areas of the copper conductor and the inside of the tube, the difference was enormous, and it would seem far cheaper to pay for a first-class vulcanised insulation on the conductor, than trouble to insulate the whole of the interior area of iron tube. There was, no doubt, a lot of bad wiring work being done by so-called electricians, and he thought it would be well if they could have registered wiremen, like the plumbers, who were, he believed, called upon to pass a practical examination.

*Prof. W. E. AYRTON said the points he wished particularly to deal with related to the wire itself. Some time ago he considered these questions: Why have contractors selected particular gauges to employ? What has guided them to certain results? Why, for example, should 1,000 amperes per square inch be selected as the maximum current density? Why should they take 2 per cent. drop between the consumers' terminals and the most distant lamp in the house when all were turned on? Was there any special reason for such numbers, or were they taken purely at haphazard? He thought contractors and electrical engineers had rather mixed up the totally distinct considerations: the question of the gauge which was safe, which did not heat by the passage of the current which it normally took, and the economic gauge to use. If they took the question of the economic gauge they would find that the cross-section was far greater than any cross-section that was liable to heat. The average contractor did not appear to be familiar with the actual cost of the wire.

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The price of insulated wire was but a very small fraction of the sum charged for putting a certain number of lamps into a house. In order to illustrate what he meant, he would take the case of all the lamps being on the top storey. He had worked out a case of ten 16 c.p. lamps on the top storey of a house with 100ft. of wire to go up and 100ft. to go down, assuming that there were no other lamps in the building; and he would consider what wire they would have to put in such a case if they were going to have 1 per cent. drop and if they were going to have 2 per cent. drop, how much it would each cost in such a case, and what was the difference. If they had the 2 per cent. drop, the actual cost of the wire, class S of the Silvertown Company's list, for those ten 16 c.p. lamps was 12s. If they took 1 per cent. drop, then the cost of this same 600-megohm wire was 17s. The difference in cost, therefore, was 5s. The labour was practically the same. Now was it worth spending that extra 5s.? In this case, as all the lamps were supposed to be at the top of the house, it would be possible to use lamps intended for a lower pressure than was maintained between the consumer's terminals. Suppose, for example, the declared pressure was 100 volts, they might use 98-volt lamps with the 2 per cent. drop or 99-volt lamps with the 1 per cent. drop. The difference would be about 1 per cent. in the current. Both gave 16 c.p., and they paid roughly for 1 per cent. more current to produce the same amount of light in the case of the 2 per cent. drop, than with the 1 per cent. drop. Supposing these lamps were turned on for 1,000 hours during the year, and the Board of Trade unit cost 6d., the total came to £16, or 320s., and 1 per cent. on that was little more than 3s. With a 2 per cent. drop they would in two years have more than paid to the supply company the difference in cost between 2 per cent. drop wiring and 1 per cent. drop wiring, and ever afterwards they would be gainers, supposing they had put up a thicker wire. Now take the real case—that was, where there were lamps all over the house and where it was quite impracticable to have lamps of different pressures on different floors. Taking an ordinary installation with a pressure of 100 volts, only 100-volt lamps would be bought, and on this top floor they would have 98 or 99 volts instead of 100. The difference of 1 per cent. at near the normal working pressure meant about 7 per cent. in the light. They had to pay extra for the same amount of light, or they got 7 per cent. less light than they had paid for. Then it came to this: If they put in the thicker wire for those 10 lamps at the top of the building they would pay 5s. more to start with, but they would save 7 per cent. on 320s., 21s. a year all the time they were keeping those lamps turned on for 1,000 hours during the year, and paying 6d. per Board of Trade unit. It was clear, then—and the same result came out whatever the number of lamps, and however distributed—that a 2 per cent. drop was an enormous extravagance—was an extremely bad investment for anybody who could scrape together enough money to have the thicker wire. Another interesting question arose: What was the best drop to have? He spent a good deal of time four years ago going into that problem mathematically. He need only give them the answer. The best gauge to use, the best cross-section, the most economical—assuming that they were going to pay for the installation out of their own pockets, and going to pay the supply company for electric energy afterwards—the most economical was copper as thick as they could put it in, so as not to materially increase the cost of labour. Therefore, for two mains going to any part of the building, if they had any choice between the two, if there was not sufficient difference in the thickness to make the cost of labour in wiring materially different, then the thickest was the best, provided they were dealing with glow lamps such as they now knew them, and with prices of wire and current as they now were. This result led to another very interesting one, and that was, it enabled them to dispense with a great number of fuses. The old idea was—and they found it probably still in some specifications—to put in a fuse wherever the gauge of wire changed. Was that necessary? If they followed out the first rule it was absolutely unnecessary. He held in his hand a flexible wire which took the current for a 16 c.p. lamp at about 450 amperes per square inch. This flexible wire was joined to a main wire. Now did they want a fuse. What current would this insulated wire stand? Nobody seemed to know. This wire had actually had 30 amperes passing through it for half an hour. The other which he held in his hands had had 35 amperes passing. If they had these flexible wires attached to a pair of mains which had a 10 or 15-ampere fuse, those wires were absolutely safe. Therefore, if they had a pair of mains supplying 10 or 15 separate lamps through pairs of flexibles the room would be absolutely safe if they had outside, where the mains entered the room, a fuse which would go at, say, 10 or 15 amperes without any separate fuses being used for each ceiling rose or lamp. It seemed to him extremely advisable that an installation should be so divided up that they could practically use everywhere the same fuse, or where that was impossible the fuses should be made absolutely uninterchangeable, so that neither a fuse of too large, or of too small a section could be inserted. Now about insulation: so far he had only been dealing with the cross-section of the copper. He was an advocate of high-insulated wire. He knew it would be said that the main leakage was at fuses, switches and lampholders, and it was no use asking for wire which would have 2,000 megohms after 24 hours' immersion in water at 60°F. That was not a right argument, because they could clean the switches, whereas they could not get inside the wires. Another thing: one of the reasons why so much of the leakage occurred at the switches and fuses was because so many of them were so extremely badly designed. They would find two screws attached to the two main wires a fair distance apart, but for the fact that between them was another screw which held the switch of the fuse to the board at the back and so the surface insulation was reduced most unnecessarily. It was quite easy to arrange switches, or fuses, or lamp holders, without having them perceptibly bigger than now, and yet increase the insulation. A list was given in Mr. Bathurst's Paper of the standards employed in different countries; but a high standard which was now employed by several companies in this country was left out—namely, 80 megohms per lamp. Could they get that insulation of 80 megohms in a comparatively new building? His experience was that they could if they used good material and attended to two important points: one was always to have the tape which was outside the insulated wire stripped off at the end so that it could never come into contact with a piece of metal which was part of the live system, and another thing was to take care that the screws which passed into the porcelain, and which were used to attach wires to it, did not go right through and touch wood or something else at the back. If they looked after those two things and got good material, his experience was that they could get that insulation even in buildings which had only been erected for two or three months. There was just one other point he would like to mention in passing, and that was about the iron tubes. He had some little doubt some time ago whether, in the case of two wires, the going and return conductor, drawn into an iron tube, the wires being a good deal smaller than would fill up the tube, there was not, with a 100-period alternating current, some self-induction effect that would interfere and cause a slight extra drop. Experiments, however, showed that that was not the case with the ordinary wrought-iron tube. With reference to the remarks of the last speaker as to an examination for wiremen, it would interest him to know that recently that had been started by the City and Guilds of London Institute—not only a written, but a practical examination to test their knowledge of jointing and things of that kind.

*Prof. S. P. THOMPSON said there was one paragraph in Mr. Bathurst's Paper which seemed to him very important. It was that if they had two conductors in a pipe, and one of those conductors broke down and made contact with the uninsulated pipe, a new condition of things was set up; and it was that new condition of things that he wished to emphasise. The wire which had made contact with the pipe had now virtually got an increased carrying capacity, owing to the fact that there was a pipe parallel with it, and the other conductor, therefore, would be more liable to over-heating. Further than that, the insulation having gone on one side and practically made an earth—it might be only a local earth for the time being—there was a greater strain thrown on the insulation of the other wire. If they got anything like 200 volts into their houses it was of the greatest importance that if they had a conduit system at all there should be some kind of mechanical insulation—it need not be a high insulation—inside the pipe itself. There was a great deal to be said for a double insulation. In other conditions of electrical engineering they absolutely must have double insulation, high electrical insulation and high mechanico-electrical insulation. There was that advantage in lining the pipe with an insulating material—it might be with ozokerited paper, or something of that sort—it did prevent mechanical contact between the wire that had broken down for the time being and the iron pipe. A double insulation, he contended, was a distinct advantage. He made an experiment in wiring some years ago. He put himself in the position spoken of by Prof. Ayrton. He did not want to save 6d., but he wanted something that was perfectly safe, and would not have an inch of wood casing anywhere. He employed stranded wires highly insulated in most cases, but in one part of the house where there was not the slightest likelihood of damp having any effect he employed a relatively lower insulation. But in every case, whether the insulation was of a really high character or only of a moderate character, the wires were enclosed, each separately, in a lead coating, which was drawn on, and then the two lead-coated wires were put together side by side with a little filling in between, and braided round together, so as to form a braided twin. He objected altogether to fuses being put up where you could not get at them—in ceiling roses and other places; he thought they ought in such cases to be objected to by the Board of Trade. He would like to have every fuse placed so that it could be replaced without difficulty when the lights were on. He had had no experience of concentric wires; he saw there were obvious advantages, but like the wiring in his own house, and like many other examples where wiring was put in that did not admit of replacement, there was the obvious disadvantage that they could not materially add to the number of lamps originally designed for. He had made a few experiments on the likelihood of different kinds of conduits breaking down, but they were not in such a state that he could quote them yet; but it seemed to him to be a great point that there was greater safety where a pipe, if of metal, was lined with a fairly strong and fairly good interior insulating material.

*Mr. MAVOR, replying to the discussion so far as it had gone, said Mr. Geipel was the first speaker, and he opened his remarks by criticising the high standards of insulation set up by the fire companies. He (the speaker) thought the fire companies were wise in setting a very high standard indeed, because of the susceptibility of double wiring and wood casing to the attacks of moisture, and to the other many ways in which faults were liable to occur. It was only by setting a very high—in fact, what seemed almost an impossibly high—standard of insulation that good work of this bad kind could be secured; any withdrawal from the high standard would lead contractors to become more careless, and to take any departure from that standard as a licence to do less careful work than they had been doing. Mr. Geipel favoured wood casing, because the work could be done by joiners. In his opinion the whole of the work had too often been done by joiners. We have all seen joiners' joints Mr. Geipel objected to concentric wiring, because it required tradesmen to erect it. He (Mr. Mavor) thought that was one of its strongest points. Mr. Geipel said cost alone was the vulnerable point of double wiring. He (Mr. Mavor) said it was not; the whole system bristled with vulnerable points. Every joint was a vulnerable point, every one of the double-contact lampholders was a vulnerable point; in fact, the whole thing was vulnerable unless they made it systematically damp proof from end to end. With regard to the comparative cost of double wiring and concentric wiring, it was a very difficult question. If he asked one contractor what was the cost of double wiring he would give one figure, whilst another would give 50 per cent. less. When they compared the cost of concentric wiring with the cost of double wiring it should be with a first-rate double-wired job, and where they did that concentric wiring was invariably cheaper. He had never seen a building yet which he

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could not wire more cheaply with concentric than with double wiring. Mr. McLean, of Oxford, asked how many concentric joints there were beneath the floors and behind plastered walls. Well, there were many thousands of them, and they had never had cause to get at any one of them yet. Mr. Langdon advocated the inspection of wiring by the supply companies. It seemed to him, however, that that was not the business of the supply companies at all, and they should have as little to do with it as possible. Mr. Swinton was in error in supposing that two staffs of wiremen were necessary if a contractor wished to adopt the two methods. That was quite a mistake, as several contractors who had adopted concentric wiring had found out; there was really nothing about it that any intelligent workman could not pick up in half an hour. Not only were two staffs of men not necessary, but the staff of men required to do any particular job was very much reduced. Mr. Swinton and another speaker had referred to the current-carrying capacity of the wires in relation to the size of fuses. He thought the current-carrying capacity of the wire had very little to do with the fuse at all. There was very little danger of the wire being heated throughout its length by the current. The danger was from the heat being concentrated at any one point. He thought, therefore, a fuse should not be proportional to the size of the cables, but to the current they had to carry, and should have as small a margin over that current as safely might be. This was an extremely important point, and since the rules of the Institution were under revision, one rule should be added, if it had not already been considered, and that was to limit the amount of current which might be allowed in any one conductor within a building, and he submitted that something like 50 or 60 amperes should be the maximum. They might increase the number of sub-mains, but the whole point was to keep down the main fuses to as small a size as possible. With regard to earthing the distributing system, his opinion was that the feeding points were the proper points to earth—insulated feeders up to the feeding point, and at every feeding point a definite earth, and of such a character that it could be removed for testing purposes, if necessary. Mr. Wallis-Jones spoke of the unsightliness of concentric wiring, and thought it not suited to internal house work. Mr. Wallis-Jones had not seen it. He (Mr. Mavor) would be very happy to show him examples of such work which would entirely remove his impression. Mr. Swinton was under entirely the same impression, and it had been removed. Mr. Addenbrooke said for ship lighting, concentric wiring was so obviously the right thing that he was surprised it was not more generally adopted. The reason was this: Wood casing was nearly always included in the ship builder's contract; when an owner asked for tenders for wiring the contractor tendered for wiring only, without the wood casing. Any tender for concentric wiring was obviously seriously handicapped. With regard to Prof. Ayrton's remarks, he wondered whether Prof. Ayrton was interested in some cable company; his views with regard to the size of cables would almost indicate that he was. Prof. Ayrton and many other speakers seemed bent on drawing wires in and out of tubes. Why on earth should they? If they put up a job to last, why should they want to keep pulling it out? He could not understand it. He never had occasion to do so. Why they should go to all the trouble of blowing in soapstone and so on he did not know. He had to thank them for the kind reception of his Paper, but he was rather disappointed that so much time had elapsed since the Paper was read, for many of the members who had spoken seemed to have forgotten that any Papers had been read, or to have forgotten what they were about.

The discussion was then adjourned until February 27th.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *Feb. 18, 1896.*

A New Parisian Electric Light Network.—Since the beginning of the year Paris has been enriched by a new electric light "sector" on the left bank of the Seine, which portion of the metropolis had not previously possessed any electrical system of distribution whatever. Many attempts were made to get to work, and in 1894 a concern, to which the concession had been transferred, hired a small continuous-current station, which had never been used, near the Place du Panthéon, and from this supplied a few customers whilst getting out the plans for a large station. This station is on the banks of the river at Issy, outside Paris, and is now partly constructed. Steam is supplied by seven multitubular boilers, each capable of giving 3,000 kilogrammes of steam per hour at 170lb. pressure; later on there are to be 20 such boilers. In the engine room there are horizontal compound 700 H.P. Creusot engines running at 125 revolutions. Each of these has between its two cylinders a Creusot-Zipernowski 400 kilowatt 3,000-volt alternator having a frequency of 42. The fine distributing board is situated on a large balcony 19 metres long. Felten and Guilleaume armoured, lead-covered, concentric jute and paper insulated cables are used, laid direct in the ground in a bed of sand. Two feeders of 200 sq. mm. cross-section start from the station down the Rue Lecombe and then divide, one going along the Boulevard des Invalides, and the other along the Boulevard du Montparnasse. They unite at the Boulevard St. Michel. This ring arrangement enables the supply to be kept up by one branch when work is being carried out on the other. The primary circuit feeds various transformer sub-stations, the secondaries of which consist of bare copper conductors run on insulators in cement conduits under the pavements.

X-rays at the Société Internationale des Electriciens.—The monthly meeting of this Society took place on the 5th inst. under the *ægis* of M. Violle, Vice-President. M. Perrin gave an interesting historical *résumé* on the subject of X-rays.

The New Heilmann Electric Locomotives.—The first Heilmann 800 H.P. electric "loco.," it will be remembered, hauled a light train at the rate of 108 kilometres an hour—say 67 miles an hour. In consequence of the success of the "locos." the Compagnie des Chemins de Fer de l'Ouest determined to test two more powerful Heilmann "locos." hauling heavy trains at high speed. These "locos." are now in course of construction at the Cail shops, and will shortly get to work. It is intended that they should haul trains of 290 tons at the rate of 62 miles an hour. The horse-power aggregates 1,900 H.P. The apparatus will be mounted on two 4-wheel bogies. The front portion of the cover of this moving central station is tapered to reduce the resistance of the wind. A single Willans engine drives direct on to two generators, one on either side. The electric motors are gearless, driving the axles through elastic couplings.

CORRESPONDENCE.

ELECTRIC TRACTION AND TELEPHONIC DISTRIBUTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I wish to make the following remarks with regard to the article in your issue of January 10th, "Electric Tramways and Telephonic Disturbances," by Mr. C. S. du Riche Preller:—

Most of the conclusions made in this article are incorrect and misleading. They tend to increase the amount of misinformation in regard to this important subject, not so much in well-informed electrical circles, as among the general technical public, who naturally assume that such statements made in a journal of the standing of *The Electrician* come from a perfectly reliable source. I therefore think it advisable to place before your readers the corrected facts.

First.—The method of suspending the contact wire on electric railways has nothing whatever to do with telephonic disturbances. It is perfectly immaterial whether the suspension wire clamps are soldered on to the wire, or whether they are mechanical clips. It is also unimportant in regard to the telephonic disturbances whether, on the suspension points, the wire is smooth or rough, whether these clamping pieces are two years old, as at Zurich, or only a few months in service, as at Basle. All this has not the slighest influence upon the production of the well-known *continuous* sounds produced in telephones by electric railway circuits, which are in close proximity to earthed telephone lines. Were the sounds actually produced by the interruptions of the current at the points of suspension, then they would not be continuous, but would be heard at intervals of from 8sec. to 15sec., according to the distance of the clamps. Everyone—not only an electrician, but every layman—who has once heard this peculiar continuous hum will at once recognise the incorrectness of the statement that the sparking at bad suspension points "is the first cause of telephonic disturbances."

Second.—Next comes the generalisation of some observations on certain Continental electric railway lines, which are operated with *trolley contacts* and others operated with *sliding contacts*. According to Mr. Preller, lines with trolley contacts cause serious troubles in telephone circuits, whilst those with sliding contacts do not produce such disturbances. This statement has no foundation from a theoretical point of view (the trolley has a larger surface in contact with the wire than the sliding rod), and is in contradiction

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with facts established long ago. The shape of the contact cannot and actually does not alter the conditions causing the telephone troubles, and I only need to refer to the experiments carried out at Leeds in 1893 by Mr. James Swinburne, a record of which is given in his evidence before the Joint Committee of Lords and Commons on Electric Powers (*The Electrician*, June 30, 1893, p. 236), and also to the series of experiments carried out at Zurich in 1895 with long sliding shoes in comparison with trolleys, to which Mr. Preller refers himself in his article.

Third.—The disturbances in telephone circuits are independent of the design of the motor, if this machine is an ordinary continuous-current motor for railway work. It was clear to every member of the electrical profession, up to the present moment, that the noise as produced by the spur or any other gearing between the motors and the car axles had nothing in common with the electrical phenomena of induction between railway add telephone circuits. It was reserved for Mr. Preller to consider for the first time even such an absurd possibility, and he states that chain gearing, when running noiselessly, has less effect on the telephone induction than the standard railway spur gearing! Well, I can assure the gentleman from my own experience that neither chain gearing, may it even howl as bad as on some older cars in Budapest, nor any other gearing can produce disturbances through electric induction in telephones, if other conditions for such influence are lacking.

Fourth.—This is not the proper place, nor is it my intention, to enter into the discussion of the real causes of telephone disturbances by electric railway circuits. This matter has already been thoroughly and carefully investigated from a scientific and practical standpoint by many competent electricians. I only need to refer to the proceedings before the Joint Committee of Parliament in 1893, already referred to above; to the long discussion of the Elektrotechnischer Verein of Berlin, in 1895 (*Elektrotechnische Zeitschrift*, 1895, pp. 417 and 443); to the articles of Mr. Vuilleumier, who investigated the matter as early as 1892 (*L'Industrie Electrique*, 1892) at Clermont-Ferrant from the standpoint of a practical railway manager; and of Messrs. Meyer and Muetzel (*Elektrotechnische Zeitschrift*, 1894), who made exact theoretical investigations and experiments on the electric tramways of Breslau. I only wish, in the name of the Maschinenfabrik Oerlikon, the firm which has constructed the lines of Zurich and Marseilles, to protest against Mr. Preller's inexact and incorrect conclusions, which are apparently based upon the accidental observations of a pleasure traveller on the Continent. Mr. Preller never carried out "tests" at Zurich or Marseilles in order to ascertain the causes of telephonic disturbances, unless he calls a speech in a public telephone station a "test." The real causes of the disturbances were, after careful examinations, found to be the following:—At Marseilles it was entirely insufficient insulation of the old telephone lines, which had earth returns only. At Zurich the disturbances were mostly due to the extreme softness of the soil; on all four lines the rails are placed in unpaved streets of the suburbs and the earth currents are thus allowed to spread out over a large area. Contrasting with these conditions is the situation at Basle. The whole line is only 1¾ miles long from one terminal to the other, and on its longest portion the rails are embedded in wood pavement, which acts as a good insulator against the earth currents.

I leave it to the reader to form his opinion about the value of Mr. Preller's observations.—Yours, &c., EMILE KOLBEN.

Oerlikon b. Zürich, February 12, 1896.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It will be patent to every impartial reader of the above letter that, whatever may be its intended effect, it is entirely vitiated by its animus.

In the Paper to which that letter refers, I advisedly abstained from mentioning names; and more especially of the electrical defects of the Zurich lines, I spoke with the greatest reticence. Herr Kolben is electrician to the Oerlikon Company, who, as he states, supplied the electrical equipment of those lines. His ebullition affords signal proof that the cap fits remarkably well. Moreover, his remarks are directed not only against myself, but, notably against Siemens and Halske's system, which, owing to its undoubted intrinsic superiority, has proved a great success at Basle, and has thus taken root in Switzerland. That fact is, no doubt, very unpalatable to the Oerlikon Company.

As regards the facts I brought forward in my Paper, Herr Kolben has not controverted them. As regards the conclusions I deduced from them, there may, of course, be divergence of opinion; but my conclusions are, at any rate, fully endorsed by some of the most distinguished French and Swiss electricians (not manufacturers), who, after publication of that Paper, wrote to me to that effect, and whose names I enclose. Herr Kolben is not an independent witness in this matter.

Moreover, my investigations were not only absolutely disinterested and impartial, but had a strictly professional and definite object, viz., in view of a specific case in Italy where telephonic interference was apprehended, I had to determine which of the various contact systems would be the most suitable; and in this inquiry I was guided simply by the maxim, "Examine everything, and choose what is best."

As regards the personalities in which Herr Kolben indulges, I can well afford to ignore them.—Yours, &c.

C. S. DU RICHE PRELLER.

P.S.—I may perhaps say that the tests of which I spoke in my Paper, were not measurements made on the line, or I would have given the figures. Such measurements had no direct bearing upon the immediate object of my investigations. The tests consisted in a large number of comparative observations of the effect of the working of the electric tramways at a variety of telephone stations, under varying atmospheric conditions, and at gradually increasing distances from the line. These observations extended, at Zurich alone, over a period of two months, and the results are very instructive.

I need hardly point out that the rattle of the gearing on the Zurich lines has, *per se*, nothing to do with telephonic disturbances, but that the uneven working of the motors produced by worn out, or otherwise imperfect, and therefore noisy gearing, gives rise to uneven currents in the line and hence aggravates telephonic disturbances.—D. R. P.

18, Margaret-st., Cavendish-sq., W.,
February 18, 1896.

COLONIAL ELECTRICAL ENGINEERING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 8th inst. I notice a letter from Mr. Geo. F. Pardoe on "Colonial Electrical Engineering," which afforded me no little amusement by its graphic description of the Moss Vale plant. Having had charge of two central stations in Australia, and having been engaged on the construction of others there recently, I am in a position to bring the information a little more up to date, and for the credit of electrical engineers now in the Colonies I would say that during the last two years or so much creditable work has been performed, and improvements effected in existing installations.

The wreck so faithfully described was superseded some two years ago by a 50 H.P. direct-coupled combination of Willans engine and Kingdon inductor alternator, the low-tension system being abandoned for high-tension alternating-current with transformers. This work was carried out by the Sydney branch of the Woodhouse and Rawson Company. The railway station and refreshment rooms are now lighted electrically.

The Newcastle (N.S.W.) central station was not long ago overhauled by a well-known electrical engineer now in Sydney, and has since given eminently better results. The only central station, I think, where underground mains are employed is that at Rockhampton. Low-tension distribution is used for the central area, high-tension alternating for suburban districts. At Brisbane, a small station, owned and worked by a local firm of electrical engineers, has been running successfully for a number of years. In the central

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portion of the city of Sydney an electric lighting company is earning large profits, and has been in operation about three years. The municipal central station at Redfern (Sydney) has now been running successfully for nearly four years.

The Ballarat (Victoria) Electric Lighting Company opened their works about twelve months ago, the plant being almost over-loaded before starting. Crompton-Pochin arc lamps of 3,000 c.p. each are used for lighting the broad streets of this beautiful city. At Nhill (Victoria) a small continuous-current central station has been running with success for three years. Several other central stations in New South Wales are of the kind which bring discredit on electric lighting, too many examples of which are still in existence.

I fail to see any justification for the use of countershafting at Melbourne central station, although the plant is an admirable one in its way. There seems to be an abnormal tendency in the Colonies to follow American practice, probably on grounds of economy. Rather a doubtful policy, judging from some results.—Yours, &c., HENRY J. SPENCER.

Martin's-chambers, 28, Martin's-lane,
Cannon-street, E.C., February 12, 1896.

X-RAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As it has been announced that Prof. Borgman has discovered that the Röntgen rays increase the sparking distance in a spark gap, an account of the results of a few experiments I have been making on this subject, under the guidance of Prof. Ewing, may be of interest to some of your readers.

For a spark gap I used two brass balls, about 8mm. in diameter, whose distance apart could be varied and measured. To screen ultra-violet light and electrostatic effects this apparatus was put into a metal box, with one side removed for purposes of observation, and with a hole in the opposite side covered with aluminium foil 0·04mm. thick. A Crookes tube was placed close outside this aluminium "window."

The spark gap connected with an induction coil was then adjusted to such a width that a spark occasionally passed; on exciting the tube the sparking considerably increased. Owing to variations of the potential it was not possible in this way to cause regular sparking when there had been no sparking before the tube was excited, but by counting the number of sparks per minute the effect of the Röntgen rays was very evident.

For example, in one experiment I used a spark gap 1·5mm. wide, and placed the tube 4cm. or 5cm. from it. I then counted the number of sparks per minute when the tube was alternately disconnected and excited; the mean number of sparks per minute was five when the Crookes tube was not in action, and 25·8 when it was in action, for ten minutes' observation. A piece of zinc 1mm. thick placed between the tube and the window completely stopped this effect. The tube being excited, the average number of sparks per minute was 1·5 when the zinc was before the window, and 22·0 when it was taken away for ten minutes' observation. Ebonite 1mm. thick made but little difference. Platinum 0·02mm. and iron 0·17mm. thick partially stopped the effect.

The tube I used for these experiments did not give good photographic results.

Another tube, which showed green phosphorescence very well, had no effect on the sparking when excited by an induction coil only; but when excited with a Tesla coil its effect was very marked.—Yours, &c., CHARLES J. P. CAVE.

Engineering Laboratory, Cambridge,
February 19, 1896.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In order to ascertain whether Röntgen rays will pass unaffected through a coal-gas flame, or whether they would cast a shadow of the flame upon a suitably arranged sensitive plate, the following experiment was tried: A pear-shaped Lenard tube capable of giving off the Röntgen radiation was suspended so that the rays passed out of the tube in a horizontal direction. A sensitive plate, enclosed within a light-tight wooden box, was then placed about seven inches from the tube and arranged to receive the radiation from it, while between the tube and the plate, at about five inches from the former, a small steady gas jet was lighted.

After twenty minutes exposure the plate was developed and the negative showed a clear image of the gas burner, but no indication of the flame whatever. The rays, therefore, had passed through the sheet of flame apparently unaffected and no shadow was produced; this is all the more curious when it is remembered how opaque carbon is to the rays, and that a quantity of it in a state of incandescence was present in the flame, to say nothing of the excessive molecular agitation taking place in its neighbourhood.

I may point out also that during some experiments made to compare the opacities for Röntgen rays of certain substances, camphor was found to be strikingly transparent; more so, considerably than amber, a particular specimen of which showed a marked transparency as compared with glass, topaz, mica, quartz (which is very opaque) and some others.

So far it seems difficult to classify substances with regard to electrical conductivity according to their behaviour towards the new rays. We cannot say, in fact, from the data that a particular substance is transparent to the rays, whether it will conduct electricity or not.

The metals, good conductors of electricity, are, except when very thin, generally opaque to Röntgen rays; but then so is glass and many other *non conductors* of electricity, while camphor, again, which is a non-conductor, is exceedingly transparent to the rays.

Up to the present, however, the behaviour of organic tissues appears more uniform, all being fairly transparent; feathers, skin, flesh and so forth particularly so. In order to get sharp "rontographs" I have found it an advantage, therefore, to use a leather layer to protect the sensitive plate from light during its exposure to the new radiation.—Yours, &c.,

Castle House, Shooters' Hill, Kent, C. E. S. PHILLIPS.
February 18, 1896.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At the suggestion of Lord Kelvin, I placed my sensitive plate in a tight zinc box, with an aluminium window in the lid. Objects such as small brass wheels were placed either inside the box, or outside on the aluminium window. The box was then earthed carefully, and placed between the poles of my large induction machine. The poles were 2ft. apart, to prevent sparking, as in all my experiments I have used the silent brush discharge. Good photographs were got in about half an hour. The object of placing the photographic plate in a metal box earthed was to prevent the possibility of discharge on to the plate.—Yours, &c., BLYTHSWOOD.

Blythswood, Renfrew, N.B., February 17, 1896.

American Government Engineering Laboratories.—The *Electrical World* of New York states that a Bill has been introduced into the United States Congress for the establishment, in connection with the State colleges and universities endowed with the proceeds of national land grants, of experiment stations for the mechanic arts, which shall, in their relation to engineering education and scientific investigation, be analagous to the several existing State agricultural experiment stations with respect to agricultural science. To accomplish this it is only necessary to extend the provision of the Hatch Act of 1887 to embrace the mechanic arts. It is proposed that the internal organisation of such engineering experiment stations follow closely that of the official stations now to be found in every large German town in connection with its university and technical school, and, especially, of the mechanical testing station at Charlottenburg. It is advocated that what has been done by private munificence in several of these lines of engineering in the laboratories of our technical schools, should be extended and made possible by federal aid in every land grant college and university.

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LEGAL INTELLIGENCE.

Edison and Swan United Electric Light Company (Limited) v. Williamson and Joseph.

This action came before Mr. Justice Romer, in the Chancery Division, on Friday and Saturday last, and was for an injunction restraining the defendants from selling or otherwise disposing of holders or sockets for incandescent electric lamps made in accordance with the patents comprised in a licence granted in July, 1890, by the plaintiffs to Appleton, Burbey and Williamson for less prices or under more favourable terms and conditions than the retail prices, and terms and conditions from time to time charged by plaintiffs for similar goods, and from making or allowing any discount, commission, rebate, return gift or allowance to customers greater than that allowed by the plaintiffs, who also claimed damages.

The plaintiffs granted to the licensees full but not exclusive licence to use, sell, and dispose of holders or sockets of incandescent electric lamps made by the licensees, the plaintiffs receiving a royalty of 10 per cent. on the Company's retail prices on all holders or sockets manufactured by the licensees or otherwise disposed of, with a minimum royalty of £50 per half-year, the licensees at the same time agreeing not to make or allow any discount, commission, rebate, return, gift or allowance to customers greater than the discount from time to time allowed by the plaintiffs off the retail prices. The plaintiffs alleged that the defendants, who were the successors in business of Appleton, Burby and Williamson, and assignees of the licence, had sold holders or sockets for less prices and under more favourable terms and conditions than those mentioned in the licence, and had allowed to their customers discount exceeding the maximum discount authorised by the plaintiffs. In particular the plaintiffs alleged that the defendants on May 17, 1895, sold to a Mr. John Clark a parcel of fifty holders at the lowest retail price quoted by the plaintiffs less the greatest authorised discount, and in addition thereto and in breach of the covenant made a gift to Mr. Clark of eight holders or sockets equivalent to a further cash discount of 16 per cent.

The defendants denied that they sold any holders or sockets the subject of the licence under more favourable terms than those stipulated in the arrangement with the plaintiffs, and also pleaded that the holders or sockets sold by them were not manufactured by the plaintiffs, and submitted that the fixing of the prices by the plaintiffs, after hearing the defendants or licensees, was a condition precedent to any complaint by the plaintiffs, and that by reason of the non-performance of such condition precedent the plaintiffs' action must fail. The defendants did not admit that any gift or present was made to Clark, and that if any such were made to him it was by a Mr. Congdon for his own benefit, and made by him without the authority and contrary to the express instructions of the defendants.

Mr. Fletcher Moulton, Q.C., and Mr. Eve, Q.C., appeared for the plaintiffs, and Mr. Gatey for the defendants.

Mr. MOULTON observed, in opening the case, that it was a matter in which perfect good faith must be observed among the licensees, else one selling at a lower price would be likely to get the whole of the trade. It was a duty cast on the plaintiffs to proceed against anyone for breaches of the restriction contained in the licences. They asked for an injunction, and with regard to damages, he submitted that they were entitled to an inquiry. This was a case in which they were unaware of the full extent of the breaches.

His LORDSHIP asked what the defendants' contention was.

Mr. MOULTON replied that they were going to say that these were not holders or sockets of a similar description to those manufactured by the plaintiffs.

Mr. GATEY said the defendants intended to raise that point. They were admitted to be articles not manufactured by the Company; they were manufactured by the defendants.

Mr. Justice ROMER: But the question is whether they are of a similar description.

After hearing the evidence,

Mr. Justice ROMER said he accepted the testimony of the plaintiffs' witnesses.

Mr. GATEY signified the willingness of the defendants to give an undertaking to abstain from a repetition of the acts complained of.

Mr. Justice ROMER: Mr. Eve, would not nominal damages suit your clients, say 40s.? It is better than a costly inquiry.

Mr. EVE: I think so, my lord.

Mr. Justice ROMER said there was a discrepancy of evidence; but as he had said, he accepted the testimony of the plaintiffs, and he must say that he thought Mr. Joseph, Mr. Congdon and Mr. Williamson were mistaken in their testimony. This was a case where admittedly there had been breaches of the licence previous to March, 1895. Since that time a further breach had been proved. He was not satisfied that that was the only one. Substantially, he thought what happened was this. He thought about March, 1895, or perhaps a trifle earlier, the defendants, or, at any rate, Mr. Joseph did, became alarmed about the granting of further rights, and were a little alarmed at the course they had been pursuing up to that time with regard to breaking the licence. He thought they communicated to their employés the fact that no greater discount should be allowed than 33⅓ per cent. He was not satisfied that there was only one instance of breach. Nobody could follow the transaction completely. He should say no more about it, seeing that the defendants had offered an undertaking which the plaintiffs accepted. The defendants tried to escape from the action by asserting that the holders which they had been selling were not of a similar description to those manufactured by the plaintiffs, and included in their price list. There was a difference between them, but it was not a material difference for the purposes of this case. The holder was similar to the holder sold by the Company and mentioned in their price list. He was supported in that view by the fact that defendants and their employés always treated the holders they sold as similar to the plaintiffs. He need add no more after what had passed except to say that he awarded the plaintiffs 40s. nominal damages instead of an inquiry, the paintiffs being willing to adopt that settlement. The defendants would, of course, pay the costs of the action.

Judgment for plaintiffs accordingly.

South Staffordshire Tramways Company v. Ebbsmith and Wain.

The hearing of this action was continued before the Lord Chief Justice. As stated in our last issue, it was brought to recover damages from the defendants for alleged fraudulent conspiracy in connection with certain transactions between the parties. A mass of evidence of the most conflicting nature was given, after which Mr. Ebbsmith addressed the Court on his own behalf. After hearing counsel, on Tuesday, the Lord Chief Justice summed up at considerable length, and the jury eventually found that, in the matter of the land, the defendants Ebbsmith and Wain had acted in concert, and had defrauded the Company to the extent of £7,313; that there was conspiracy between the defendants as regarded the patents, and on this head found damages to the amount of £1,650, and profits improperly made £500, in all £2,150; that, in respect to the packed meetings, the defendants were both parties to the misappropriation of the Company's funds to the amount of £362. The jury also found that the plaintiffs were entitled to interest on these amounts at 3½ per cent. Judgment was entered on Wednesday morning against the defendant Ebbsmith in respect of the land for £9,478, and against Wain for that sum less £800; against both defendants in respect of the patents for £2,568, and in respect of money misappropriated for payments to shareholders for £412. It was further decided that the defendant Ebbsmith was entitled to the reconveyance of the land, at his own expense, on payment of the debt and costs.

Hopkinson and Co. (Limited) and Dewrance and Co. v. Baldwin.

An action came before Mr. Justice North on Friday last, brought by Messrs. J. Hopkinson and Co. (Limited), of Britannia Works, Huddersfield, and of Queen Victoria-street, London, jointly with Messrs. J. Dewrance and Co., of Great Dover-street, London, engineers, to restrain the defendant, a brass founder, at Keighley, from infringing the joint patent rights of the plaintiffs, which they have united to maintain for the manufacture of improved water-gauges. The evidence showed the patent rights had become well established, and were in use by the Admiralty and other large steam users; that the defendant had recently commenced to make gauges having within them the principles of the patents of the plaintiffs, and that he was advertising them and supplying them to the trade. The defendant was perpetually restrained from continuing to infringe; was ordered to withdraw all infringements from his customers and his advertisements; to hand over his catalogues and drawings to the plaintiffs' solicitors for destruction; to deliver to the plaintiffs all infringing gauges; and to pay the costs of the action.

Gaskell and Grocott v. Gosling.

Judgment in this action was to have been given on Friday last, and was further postponed to Monday, and then again adjourned.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d., abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations issued February 6th.

NEW BOOKS AND EDITIONS.

The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices:—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

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"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.), Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables. 30s., post free.

"COMPREHENSIVE INTERNATIONAL WIRE TABLES FOR ELECTRIC CONDUCTORS."—By W. S. Boult, price 5s., post free.

TENDERS INVITED.—The Corporation of Sunderland invite tenders for steam engines, continuous-current dynamos, water-tube boilers, fuel economiser, water-softening plant, and cast-iron tank. Specifications, &c., can be obtained at the office of the Borough Electrical Engineer, the Electric Supply Station, Sunderland, and tenders must be sent to Mr. Fras. M. Bowey, Town Clerk, not later than 5 p.m. on Friday, the 13th March. Further particulars are given in our advertisement columns.

——— The Corporation of Bangor require tenders for the construction, supply and laying down of the necessary plant and mains for the installation and supply of electric current within the borough. The contracts are split up into two sections, and plans and specifications may be obtained from Mr. F. Hastings Medhurst, M.I.E.E., Westminster-chambers, 13, Victoria-street, London, S.W., after Monday next. Tenders must be sent in to Mr. W. H. Pritchard, Town Clerk, Bangor, by March 18th.

——— Tenders are requested by Mr. George White-Frazer, consulting electrical engineer, of 18, Imperial Loan Building, Toronto, Canada, for generators and motors to a total capacity of about 1,000 H.P. of each, in various sizes. The machinery is to be installed in a large paper mill in Canada. Our advertisement columns contain further particulars, and tenders should be forwarded promptly.

——— The London County Council require tenders for the supply of electric lighting sundries to Claybury Asylum for one year. Tenders to the Asylums Committee, 21, Whitehall-place, S.W., by March 4th.

——— The Corporation of Tunbridge Wells require tenders for the enlargement of their electric lighting station. Tenders to W. C. Cripps, Town Hall, by 25th instant.

——— The Metropolitan Asylums Board require tenders for providing telephonic communication, electric bells and fire alarms at the Brook Hospital. Tenders to the Brook Hospital Committee.

——— Tenders are being invited for building work, &c., in connection with the extension of the electric light station in Leeds. Tenders to Messrs. Milnes and France, 99, Swan-arcade, Bradford.

——— The Elberfeld Direction of the Prussian State Railways require tenders for the supply of the telegraph wire (iron and bronze) and porcelain insulators for the years 1896-9. Tenders to the Königliche Eisenbahn Direction, Elberfeld, by the 28th inst.

——— Tenders are invited by the municipal authorities of Mula for the concession for the electric lighting of the town for 50 years. Tenders to El Ayuntamiento de Mula (Murcia), Spain.

——— The municipal authorities of Herne invite tenders for the concession for the construction of a tramway to be operated by electric or other motive power between Herne and Recklinghausen (nearly six miles). Tenders to Der Verwaltungs-ausschuss, Herne, Germany, by March 18th.

——— The District Council of Chesterton (Cambs.) require tenders for lighting the district for seven years. Tenders to Mr. J. Spearing, 15, Sidney-street, Cambridge, by the 28th inst.

TENDERS ACCEPTED.—The tender of Messrs. Fellows and Wheatcroft, for fitting up the municipal baths for the electric light at £120, has been accepted.

TENDERS ACCEPTED.—The District Council of Swadlincote have received the following tenders for lighting the thoroughfares of Stanton by electricity:—

Hewes and Geary, Church Gresley, Burton (*accepted*)	£120	0	0
H. M. Edwards, Wakefield	186	10	0
Ellis and Ward, Birmingham	179	0	0
Ernest Scott and Mountain.....	157	0	0
Walsall Electrical Company	151	0	0
Electric Construction Company	145	0	0
Cutting Bros., Derby	119	0	0
Fletcher, Hirst and Co., Burnley	117	0	0

——— Four tenders have been received for wiring and fitting up "Bellevue," Southport, for the electric light for Sir G. A. Pilkington, J.P. The tenders varied from £283 (Mr. A. Maund) to £345. 3s. (Messrs. G. Hill and Co.), and Mr. Maund's tender has been accepted.

——— The Gas and Electricity Committee of the Bradford Corporation have decided to recommend the acceptance of the tender of Messrs. Sir John Brown and Co., Sheffield, for the supply of the boilers, fans, &c., for the electricity works.

———The Metropolitan Asylums Board has accepted the tender of the Private Wire and Telephone Installation Company for work in connection with the electric bell system at the Fountain Hospital.

LETTERS PATENT.—Particulars appear in our advertisement columns of a notice of application for leave to amend the specification of Letters Patent No. 4,554, of 1894, granted to Mr. Charles Adams-Randall for "Improvements in Telephony and Telegraphy."

APPOINTMENTS VACANT.—All whom it may concern are reminded that the applications for the post of electrical engineer to the Queensland (Australia) Government have to be sent in by Monday, March 2nd. All necessary information can be obtained from the Agent General for the Colony, 1, Victoria-street, Westminster, London, S.W., to whom applications have to be sent in. Further particulars are given in our advertisement columns.

——— The Professorship of Mechanics and Mathematics at the Royal College of Science is vacant. The commencing salary is £600 per annum. Applications to the Secretary of the Science and Art Department, South Kensington, S.W.

DIVIDEND.—It is expected that a dividend will shortly be announced in the failure of Samuel Elliott, electric casing and moulding manufacturer, timber merchant, and smoke annihilator. Those of our readers who are interested in the forthcoming dividend may take it for granted that the division will be very, very small.

FRASER V. SOUTH and SOUTH V. DADGE.—Mr. Harry South, of Garrick-street, Covent Garden, W.C., writes us in reference to the statement made by the Judge at the Westminster County Court, in which he described the Dadge partnership as a "juggle." Mr. South explains that the first action was lost by him more through carelessness than from any other cause, and as he has in contemplation further proceedings he invites others who (like himself and Messrs. Verity and Co.) have also been involved to come forward with information.

BANKRUPTCIES.—The first meeting of creditors in the bankruptcy of Charles Frederick Fox, electrical engineer, late of 14, High-street, and 1, Bond-street, Halifax, takes place at the office of the Official Receiver, Halifax, on the 24th inst., the examination at the County Court on March 9th.

——— Notice is given of the release of the trustee (Mr. G. Wreford, Bankruptcy Court, Carey-street) in the bankruptcy of Wm. H. Akester, electrician, 897, Fulham-road, London, S.W.

——— The discharge of Walter Andreae, 132, Hurlingham-road, Fulham, and lately trading as an electrical engineer at 47A, Lower Belgrave-street under the style of Walter Andreae and Co., has been suspended for two years.

——— A meeting is to be held at the offices of Mr. J. H. Buchanan, 8, York-place, Edinburgh, on March 5th, to consider the discharge of the trustee in the failure of Browning and Gardner, electrical engineers.

J. D. F. ANDREWS AND CO.—We are asked to state that Mr. J. D. F. Andrews on the 1st inst. severed his connection with the firm of this name carried on at Westminster, and has started in business on his own account under the same name at premises situate at Putney Bridge Station, London, S.W., where plant has been erected for the manufacture of a new wire specially devised for the Andrews system of concentric wiring.

REDUCTION IN PRICE OF ELECTRIC CURRENT.—The Directors of the House-to-House Electric Light Supply Company have decided to reduce the charge for current supplied for lighting purposes to 6d. per unit, from Lady Day next. The discounts now in operation are to be cancelled.

NEW COMPANIES.—We are asked to make a correction in the list of signatories to the General Construction and Tramroads Company (Limited), particulars of which were given in our last

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issue. The name of Mr. William Mather should be substituted for Mr. Edward Mather.

OBITUARY.—We regret to announce the death, after only a short illness, of Mr. John A. Bird, Managing Director of Messrs. Rose and Bird, Limited, of Newgate-street, London. Mr. Bird had for some years taken a great and successful interest in the manufacture of incandescent lamps. He was only 41 years of age, and was at business but a few days back. He died on Friday last at his residence at Shortlands, Kent, and was buried on Monday at Hanwell cemetery. The cause of death was gastritis.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The fourteenth annual issue of this publication is now ready. The new volume is very up-to-date, and even contains the revised Board of Trade Regulations issued last week. The Directorial Section of the work is equally forward, and will be found to contain corrections and new names and addresses complete up to the 5th of the current month.

BATH.—At the meeting of the Town Council on Wednesday a report from the Electric Lighting Committee on their application for a Provisional Order, and their negotiations with the City of Bath Electric Lighting and Engineering Company for the purchase of their undertaking, was mentioned; but as a deputation from the Council and the Company were to meet and discuss the whole matter before the Board of Trade, the report was formally adopted without discussion.

BELFAST.—At the half-yearly meeting of the shareholders of the Belfast Tramways Company (Limited), last week, the Chairman (Mr. George Richardson) referred to the contemplated introduction of a system of electric traction on the Company's lines. He said the general tendency of all tramway companies was to discard horses in favour of electricity. It was an undisputed fact that in various Continental and American cities systems of electric traction were working in a most satisfactory manner, and had proved highly successful from a financial point of view. In order not to be behind the times, the Directors of the Company had gone into the whole question very carefully, and they had deposited a Bill in Parliament asking for powers to work their lines electrically. Mr. Richardson then referred to the attitude of the Corporation towards the Bill, and he thought they would be able to come to a mutually satisfactory arrangement as to the rent to be paid by the Company, the length of lease, &c. If not the Bill would be dropped.——In order to obtain information on the question of electric traction and to personally inspect some of the tramway systems at work on the Continent a deputation from the Belfast Corporation (headed by the Lord Mayor) this week visited Havre and Paris. At the former place the deputation were conducted over the generating station, &c, by M. Papeteray, the manager of the Electric Tramways Company. It is the intention of the deputation to also visit Brussels.

BOLTON.—At the last meeting of the Gas Committee the tender of the Manchester Edison-Swan Company for extensions to the switchboard at the electricity works was accepted. It was decided to make some extensions to the mains in Knowlsey-street and also to lay mains along the Manchester-road, and the tender of Messrs. Siemens, Bros. and Co. for the supply of the mains was accepted. The tender of the Brush Company for the supply of armature coils was also approved. The position of the electricity department is a highly satisfactory one, as there is at present an equivalent of 9,230 c.p. lamps connected. This is an increase of 100 per cent. for the past 12 months.

BRADFORD.—The Gas and Electricity Committee has decided to proceed with the extension of the electric light mains along Manningham-lane as far as Queen's-road, and has also decided to obtain for the purpose 25,000 high-voltage lamps similar to those in use at Edinburgh.

BRAY.—It is satisfactory to announce (and the statement will probably have an interest for the creditors of J. E. H. Gordon and Co. (Limited), in liquidation) that arrangements have been made under which the Bray Commissioners purchase from J. D. A. Norris, of Suffolk House, Laurence Poutney-hill, E.C., liquidator, the electric light works at Bray for the sum of £3,060. It is proposed to put in some new machinery and apparatus, and to bring the station up-to-date in its appointments. As a preliminary, the Commissioners propose to select a consulting engineer to report as to the condition of the works, and generally.

BRISTOL.—The Sanitary Committee have just presented a report on the application of the British Tramways and Carriage Company for a Provisional Order authorising the construction of tramways in the city of Bristol and at Kingswood. In addition to the construction of further tramways power is sought to work the whole of the existing lines by means of the overhead trolley system of electric traction as used on the Kingswood section. The Committee's report recommends the Council to sanction tramways 1 to 5 in the Order, but not to consent to a general power being conferred upon the Company to work the whole of their tramways by the overhead trolley or any other system of electric traction involving the laying of electric wires over or under the streets, or to erect power stations within the city, until further consideration shall have been given to the subject upon a definite proposal by the Company for so working the whole of their tramways within the city. The Committee further recommend that on certain conditions consent be given to the Company's application for power to work the tramways to Fishponds by means of the overhead system.—— At the last meeting of the Electrical Committee a long discussion took place on Mr. H. Faraday Proctor's report on the supply of electric current for motive power purposes. The Sanitary Committee having decided to recommend the Council to sanction an extension of the electric tramways from West-street to Fishponds-road, the Electrical Committee's report endorses this recommendation, but if any further extensions are to be made within the city boundaries the Committee will insist upon the Corporation supplying the necessary power. The matter is to be discussed at to-day's meeting of the Council. Applications for current for lighting purposes are increasing in a gratifying manner, and a surplus on the year's working, after paying all expenses, sinking fund, &c., is anticipated.

BRITISH NORTH BORNEO.—The *North Borneo Herald* a short time back contained an article on the value of small motors for launches. It is now suggested that electric launches should be used, a plentiful supply of water power being available for charging purposes. There are many rivers in the country likely to afford abundance of power.——In the same journal for January 1st an interesting account appears of the work done by Mr. O. V. Thomas, superintendent of Telegraphs to the North Borneo Government, in connection with the telegraph line in course of erection on the Government's territory, and which is to connect the Eastern Extension Company's submarine cable system at Labuan with Sandakan, the chief British North Borneo town. Mr. Thomas has traversed Borneo from east to west, being the first European to visit a large portion of the country. About 180 miles out of 305 had been erected up to November 14th last, and the completion is expected to be made by the end of June. Heavy floods have caused delay at times, but otherwise progress has been fairly satisfactory. Naturally the difficulties have been very great, the value of the rivers for transport purposes having been much over-estimated. In some parts the work has had to be done in a tract of country where no population exists, where there there is little or no food to be obtained, a way having to be cut through dense jungle, no road for transport existing. In connection with the urgent necessity for roads being made in order that the successful completion of the line may be effected, Mr. Thomas urges that in the more promising districts of Lumbawan and Sapong a good means of ingress and egress would undoubtedly pay, and he even has the temerity to suggest that an electric railway should be constructed. Mr. Thomas and his assistants are certainly to be congratulated on the result so far of their heavy labours, and we hope that that upon the completion of the line their work will meet with full recognition.

CARDIFF.—There always seems to be trouble at Cardiff, where circumstances seem to combine against the even working of the electric lighting undertaking. An inquiry was recently made by Mr. H. J. Hallett into the circumstances which led to the suspension of one of the assistant engineers at the electricity works, and Mr. Hallett's report recommends several alterations in the composition of the staff. He advises also that certain alterations in the machinery would render its working more efficient, There is, however, nothing serious to report, and the complaints made were, in the main, non-existent. The chief objection taken by Mr. Hallett is in the status of the mechanics under Mr. Appleby, the head of the works, who has under his immediate supervision a number of skilled mechanics, each of whom is possessed of certain ideas as to how the work should be done; and, as each has a comparatively free hand, confusion—to put it mildly—results. Mr. Hallett suggests that in future one of the four mechanics should hold a leading position, and this and some other suggestions have received the approval of the Council.

COATBRIDGE.—Notice of motion has been given for the next meeting of the Town Council for the appointment of a committee to consider and report upon the advisability of the Council purchasing the undertakings of the local electric lighting and gas companies.

COVENTRY.—At a recent meeting of the Electric Lighting Committee, Mr. Calcott complained that the cost of the electric light appeared to be greater in some cases than in others, and the Chairman (Ald. Hill), in reply, stated that, though no official complaints had been made, yet he thought there was some reason for dissatisfaction, but no blame could be attached to the Committee. The cause of the trouble here, as elsewhere, was that some of the consumers had been induced to put up cheap second-rate foreign lamps and fittings, instead of adopting the recognised standard fittings, which had always proved satisfactory. He concluded by stating

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that the Committee or the electrical engineer would advise consumers on the question of fittings if applied to.

CROSBY.—The District Council have arranged with the Liverpool District Lighting Company not to oppose the Company's application for a Provisional Order for the district.

DUBLIN.—At the meeting of the Corporation on Monday last a long discussion took place on the electric traction question. Two proposals for the construction and equipment of electric tramways in the city had been submitted, that of the Dublin Southern District Tramways Company (owners of the electric tramway from Balls Bridge to Kingstown), being a very extensive one. On the advice of the city engineer, the Corporation approved of 13 miles of the Southern Company's scheme at an annual rental of £4,000, these terms to be subject to revision at the end of each term of five years. By 21 votes to 17 the principle of the overhead trolley system of electric traction was approved.

EXHIBITION.—The Deparment of Science and Art have been informed through the Foreign Office that a National Exhibition is to be held at Budapest this year. The Exhibition will be opened on May 2nd. As the Telegraph Conference is also to be held at Budapest this year, that city will have more than usual attraction for British visitors.

HAMPSTEAD (LONDON).—In the course of a discussion on the progress of the electric light at the last meeting of the Vestry, Mr. Farmer suggested the insertion of advertisements in the local papers and the issuing of fresh circulars calling attention to the advantages of the light, but the Clerk stated that it was impossible to connect any more customers at present, as they had reached the limit of the capacity of their plant. The Clerk is engaged in preparing a full report on the undertaking to the end of 1895.

HANLEY.—At a meeting of the Traders' Association last week Mr. G. Stokes called attention to the revised scheme of charging for electric current recently adopted in the borough. He took exception to the view that the revised rates would prove beneficial to traders except the large users, and suggested that if the Corporation wanted to benefit the traders they should reduce the price of current to 5d. per unit. He agreed that everyone should pay towards the electricity scheme, "for even those people who did not use electric current received benefit owing to the reduction (through the competition it caused) in the price of gas." If the price of electric current had been reduced to 5d. there would have immediately been a drop in the price of gas. A deputation waited on Mr. Lobley, the borough engineer, on the following day, when he was able to satisfy them that the revised rates were in the traders' interest.

HARWICH.—At the last meeting of the Town Council the Public Health Committee reported that they had considered the tender of the Town and Village Electric Lighting Company for putting down an electric lighting installation, but as the Company had withdrawn their offer to purchase the Provisional Order of the Corporation, they recommended that the negotiations be terminated. In moving the adoption of this report the Mayor said they had been given to understand that the Company were going to supply the plant, &c, but they had declined to do this. The initial outlay for plant would be so great that the Council were justified in retreating from the position they took up in November last. The report was then adopted.

HUDDERSFIELD.—At the last meeting of the Tramways Committee a letter was received from the London and Provincial Electric Lighting Company with regard to lighting the trams electrically.

HULL.—At a special meeting of the Electric Lighting Committee, last week, Mr. Councillor Skinner was elected Chairman of the Committee, *vice* Dr. Holder resigned.

LEITH.—The Town Council have appointed a special committee to consider and report upon the question of the establishment of the electric light works in the town.

LLANDRINDOD WELLS.—Some time ago the District Council entered into negotiation with Messrs. Jevons and Thomas, electric lighting contractors, of Birmingham, for the introduction of the electric light into the district. At the last meeting of the Council Mr. E. Davies, of Llandinam, stated he was prepared to form a company, who would provide an electric light installation, and to light the streets by means of 32 c.p. lamps at 40s. each per annum, against 58s. 6d. under the proposed contract with Messrs. Jevons and Thomas, while he would supply current for private lighting at 6d. per unit, against 7d. and 8d. under the contract. After a long and acrimonious debate it was decided to accept the proposals of Mr. Davies and to break off negotiations with Messrs. Jevons and Thomas.

LOCHEE (DUNDEE).—The electric light has just been introduced into the baths and library. A Parker dynamo is employed, and power is obtained from the engine which drives the laundry machinery. Three 1,000 c.p. Jandus arc-incandescent lamps illuminate the swimming bath; 19 16 c.p. and 3 50 c.p. incandescents are used in the library and reading room, and arcs of 1,000 c.p. each are fixed at the entrance door of the baths and library. The work of installation has been carried out by Messrs. James Maxwell and Son, of Dundee, and as this is the first public installation in Lochee it has aroused considerable interest.

LIVING PHOTOGRAPHY.—Accepting an invitation to a Press view of the "Cinématographe" at the Polytechnic, Regent-street, yesterday afternoon, we were agreeably surprised with the life-like movements of the different pictures shown upon a screen. The apparatus in question was invented by MM. A. and L. Lumière, and scenes of real life were reproduced. The photographs had been taken on a continuous band at the rate, it was said, of 900 views per minute, and by means of electric light these were projected life-size upon a large screen at exactly the same rate, so that a changing picture was produced almost perfect in its fidelity and naturalness.

MAIDSTONE.—The Town Council have decided to ascertain the feeling of the ratepayers as to the proposed transfer of the Maidstone Provisional Order to Mr. Thomas King, a local electrical engineer, and a public meeting is to be held on Friday next for the purpose of considering the question.

NEWPORT (MON.).—On the recommendation of the Electric Light Committee the Town Council have decided to make considerable extensions to the electric lighting mains.

PORTSMOUTH.—It has been decided to lay electric light mains in Goldsmith-avenue at a cost of £1,500, and to light the avenue by means of 28 lamps.

SHIP LIGHTING.—The new twin-screw Russian steamer "Kiew," which was launched from the yard of Messrs. J. and G. Thomson (Limited), Clydebank, on Tuesday, has, in addition to the usual electric light installation, with which nearly all steamers are now provided, been fitted with a very complete system of electrically-driven ventilating fans.

SHOREDITCH (LONDON).—The Finance Committee recommend the Vestry to borrow £31,381 from the London County Council for electric light and dust destructor purposes. An effort is to be made to obtain this sum at 2⅞ per cent. interest.

SOUTHAMPTON.—The County Council have resolved to offer the Southampton Electric Light and Power Company (Limited) the sum of £16,100 (in addition to the cost of the Provisional Order recently obtained) for the purchase of their plant, machinery, &c. In the event of this offer being accepted, the Council propose to considerably extend the electric lighting of the borough.

SOUTHEND.—We understand that the Pier Committee of the Southend Corporation have adopted incandescent gas lamps at the Pavilion and for lighting some portions of the pier. If it be true that this decision was come to owing to a supposed difficulty in obtaining high-voltage electric lamps, this difficulty certainly no longer obtains.

STOCKTON.—Some three months ago reference was made to the tardy progress of the electric lighting question at Stockton, and it was then stated that Mr. Ford, the experienced and talented manager of the Stockton Corporation Gas Works, has always held the view that "at any moment an invention might take place which would infinitely cheapen the lighting of towns by electricity." Mr. Ford still holds this view, and Stockton is without the electric light, although the Corporation recently appointed a committee to visit various Corporation supply stations with the view of reporting to the Council.

TAMPERING WITH FIRE ALARMS.—At the Eastern Police Court, Glasgow, on Saturday last, a man named Johnstone was fined £10, with the option of 60 days' imprisonment, for maliciously breaking the metal covering and glass of a street fire alarm.

TOLLERTON.—This is the name of a village a few miles from Nottingham, which may be termed progressive. It consists of a parish church, the manor house, and a few straggling houses; but, this notwithstanding, the electric light is in full operation in the village, the parish church and the manor house both being lighted electrically. The work has been carried out by Messrs. Thomas Danks and Co., of Thurland-street, Nottingham. The plant includes an oil engine and a battery of storage cells. At the manor house 200 16 c.p. lights are fitted.

TORQUAY.—At the special meeting of the Town Council, on Friday last, Mr. W. H. Trentham's report on the electric light question was discussed. Mr. Trentham recommended the Council to establish electricity works, and he estimated the cost of plant capable of supplying current to 4,000 16 c.p. incandescents and 70 arcs, buildings, &c., at £23,716. On the basis of a charge of 6d. per unit the revenue would amount to £4,322, and, on the presumption that the necessary power would be obtained from refuse

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destruction, the working expenses were put at £3,234, thus leaving a net profit of £396, after allowing for interest, sinking fund, &c. The report was, after a lengthy debate, adopted by 15 votes to 3.

TRAMCAR LIGHTING.—Last week the I.E.S. Accumulator Company carried out some experiments in the electric lighting of tramcars at Plymouth. The experiments were made on cars belonging to the Corporation and the Plymouth, Stonehouse and Devonport Tramway Company. Two Ediswan incandescents were fixed at each end of the car, and current was supplied from an I.E.S. accumulator placed under the seats. It is stated that the trial proved very satisfactory, the light being good and unaffected by the jolting of the cars. It is claimed that after the initial cost the electric light is as cheap as oil, and, in addition, there is a great saving of labour in cleaning and attention.

WILLENHALL.—At the last meeting of the District Council it was decided to provide a system of electric calls between the fire station and the residences of the firemen at a cost of £70.

WORCESTER.—At the last meeting of the Watch Committee, on the recommendation of the Electric Lighting Sub-Committee, it was decided to erect 26 additional arc lamps in various streets of the city. The initial outlay for laying down the necessary mains, &c., is estimated at £1,850, and the annual upkeep charges for 26 lamps (which are to replace 74 gas lamps, 55 being double burners) will amount to £650.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

January 27, 1896.

1,848. C. ADAMS-RANDALL. London. Improvements in electric velocipedes and other vehicles electrically driven.

1,860. J. L. KENDAL. Manchester. Improvements in the method of and means for, protecting electric lamp fittings for corrosion and for preventing "short-circuiting."

1,867. S. W. BAYNES. London. Improvements in apparatus for straining electrical conductors in culverts.

1,888. S. Z. DE FERRANTI. London. Improvements in dynamo-electric machines.

1,905. H. MAXIM. London. Improvements in furnace blasts, and in process, and in means or apparatus for electro-thermally treating materials for the reduction of metals, production of carbides, acetylene, cyanogen, cyanides, nitrides, and the fixation of nitrogen.

1,927. M. L. WOOD. London. Improvements in electric railway systems.

January 28, 1896.

1,958. J. T. ARMSTRONG AND C. G. G. BRAUNERHJELM. London. Improvements in and relating to electric gaslighters and extinguishers and the like.*

1,963. S. GLOVER. Manchester. A new or improved electrical switch.

1,979. W. H. [illegible]. London. Improvements in conduits for conductors of electricity.

1,992. E. J. BAGNALL and G. ARNOLD. London. Improvements in electric arc lamps.

2,003. H. H. LAKE. London. Improvements in telegraphic repeaters. (B. F. Merritt, United States.)*

2,029. R. B. ROXBY. London. An improvement in electric glow lamps.

2,043. T. B. DIXON. London. Improvements in multiple telegraphy. [Date applied for under Patents, &c., Act, 1883, Sec. 103, 12th September, 1895, being date of application in United States.]*

January 29, 1896.

2,051. H. R. J. BURSTALL and H. F. W. BURSTALL. London. Improvements in electrical resistance thermometers.

2053. L. W. HEATH. Manchester. Improvements in so-called uni-polar dynamos for generating continuous electric currents, applicable also to continuous current motors and continuous current transformers.

2056. R. BRYAN-HAYMES, H. E. C. WALCOTT, J. B. COLLIER and E. G. BRYANT. Bournemouth. Improvements in and connected with magneto-electric machines for electrically lighting cycles and other vehicles.

2074. J. PARKER. Bradford. Improvements in the construction of lamp and bracket reflectors for electric, gas, and other lights.

2106. SIEMENS BROS. & CO., (LIMITED). London. Improvements in lightning discharges for electrical installations. (Siemens and Halske, Germany.)

2,107. J. IMRAY. London. Improvements in telephones. (La Société Anonyme pour la Transmission de la Force par l'Electricité, France.)

January 30, 1896.

2,161. P. DAWSON. London. Improvements in apparatus for conveying electric current from overhead conductors to motors on tramcars or like vehicles.

2,176. A. B. PINTO. London. Preserving meat by the help of electricity.*

2,194. O. BONDY and A. JORDAN. London. Improved means, applicable for use in electric arc lighting, for regulating the distance between the carbon points.

2,197. E. HERMITE, E. J. PATERSON, and C. F. COOPER. London. An improvement in the preparation of electrolysed chloride solutions for disinfecting and like purposes.

2,199. J. IMRAY. London. Improvements in apparatus for transforming alternating into continuous electrical currents, or conversely. (La Société Anonyme pour la Transmission de la Force par l'Electricité, France).

2,224. C. O. BASTIAN and H. C. HODGES. London. Improvements in prepayment mechanism for electrical or other meters.

January 31, 1896.

2,233. C. BÄKER. London. Improvements in the combination of writing tubes and incandescent lamps.

2,248. H. HIRST. London. Improvements in electrical cut-outs.

2,249. H. HIRST. London. Improvements in and connected with fuses for electrical cut-outs.

2,254. F. WALKER and W. C. SANDERSON. Barnsley. New or improved electrical appliance for extracting broken drills from bore-holes.

February 1, 1896.

2,324. J. H. TUCKER. Birmingham. An improved electric coupling.

2,328. J. B. BRUCE. Birmingham. Improvements in hanging lamps for gas, oil, or electric light.

2,335. W. MCWHIRTER. Glasgow. Improvements applicable to electric meters.

2,337. G. E. SAUTTER and H. HARLÉ. London. Improved means for use in working apparatus by electricity.

2,348. J. M. HUISMAN and H. C. GOVER. Glasgow. Improvements in electric switches.

2,382. H. H. LAKE. London. Improvements in dynamometers. (G. W. Lewin, United States.)*

February 3, 1896.

2,419. F. JONES. London. Improvements in electric pendulum indicators.

2,427. E. H. GRIFFITHS. London. An improvement in apparatus for measuring electrical resistances.

2,435. C. BUDERUS and J. MENZ. London. An improved dialytic process of decomposing salts and thereby creating electrical energy.

2,437. A. HIRSCH. London. Improved means of applying the heat of the electric arc for welding, soldering and other purposes.

2,447. MUIRHEAD AND CO. and F. L. MUIRHEAD. London. Improvements relating to telephones.

February 4, 1896.

2,501. A. S. KROTZ, W. P. ALLEN, and O. S. KELLY. Manchester. An improved system for conveying and furnishing electricity to railway cars and devices used in connection therewith.*

2,523. A. CASAZZA. London. An electric railway system.

2,545. H. H. Lake. London. Improvements in automatic current-regulators. (S. C. C. Currie, United States.)

2,570. W. A. HOUTS. London. Improvements in telephone systems.

2,581. E. W. SMITH and THE NEW PHONOPHORE TELEPHONE COMPANY Limited. London. Improvements in telephonic apparatus.

2,594. A. J. BOULT. London. An improved electrolytic process for extraction of caustic alkali and of hydrochloric acid from a chloride. (F. Villani, Italy.)

February 5, 1896.

2,610. E. S. G. REES. Wolverhampton. Improvements in the construction of dynamo electric machines and electromotors.

2,623. W. W. MCLAUCHLAN. Manchester. Electric targets and the like.

2,665. S. P. BLACKMORE. London. A new non-inductive adjustable carbon resistance.

2,666. J. E. PRESTON. London. An improved fluid for use in galvanic batteries and the like.

2,674. P. R. JACKSON and Co. (LIMITED) and J. S. LEWIS. London. Improvements relating to armatures for dynamo electric machinery.

2,683. G. HOOKHAM. London. Improvements in electricity meters.

February 6, 1896.

2,707. A. J. HOWARD. Taunton. Improvements in incandescent electric lamps, holders and the like.*

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2,717. F. H. Royce and E. A. Claremont. Manchester. Improvements in controlling switches for dynamo-electric machines.*

2,745. B. M. Drake and J. M. Gorham. London. Improvements in apparatus for blowing organs by electric motors.

2,767. A. R. Bennett and G. J. Somerville. London. Improvements in telephonic systems and in switching apparatus for use therein.*

2,772. Siemens Bros. and Co., Limited. London. Method and apparatus for effecting the connection in parallel of alternate current and polyphase dynamos and motors. (Siemens & Halske, Germany.)

2,773. C. N. Ganzentes. London. Improvements in and connected with portable electric lamps.

February 8, 1896.

2,873. H. L. Doulton and C. E. Morris. London. Improvements in culverts for electrical conductors, and means of supporting the conductors therein.

2,875. H. H. Hall and W. D. Cheyne. Manchester. Improvements in or connected with electric incandescent lamps.

2,894. A. H. Webb. Glasgow. An improved electric alarm clock.

2,909. L. Falero and H. Lumley. London. Improvements in secondary batteries.

2,915. A. Czarnikow. London. An improved electric gas igniting and extinguishing apparatus.*

2,923. W. C. Johnson, L. J. Steele and J. W. Ewart. London. Improvements in alternate-current dynamos.

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price o 8d. each.

1895.

437. Barton (Jandus). Arc lamps.

527. Burstall and Hicks. Galvanometer, lamp, stand and scale.

1,202. Langdon. Telephonic apparatus.

1,536. Brown and Others. Electric motors.

2,303. Hermand. Electric lamps.

2,804. Imray (Diehl). Effecting electro-chemical decompositions.

3,087. Lake (Shea and Another). Telephone system.

3,521. Kamm. Printing telegraphs.

5,003. De Ferranti. Electric condensers.

5,086. Cox. Electric lamps.

5,236. Ravenshaw and Others. Starting electric motors.

5,336. Blackburn and Boyden. Dynamo electric machines.

5,521. March. Electric couplings.

5,936. Siemens Bros. & Co., Limited (Siemens & Halske). Electrically propelled vehicles.

8,148. Gisborne. Magnetic needles.

11,748. Hodgson and Edwards. Electric bell systems.

18,036. Leitner and Reicher. Battery electrodes.

19,374. Cox. Incandescent electric lamps.

19,838. Adams. Arc lamps.

22,006. Murphy and Pierce. Electric railway systems.

23,354. Le Roy. Electric heating devices.

23,658. Rosenholz and Poehlman. Electric railways.

23,865. Edison and Swan United Electric Light Company (Limited) and Proctor. Electric switches.

24,166. Edison and Swan United Electric Light Company (Limited) and Gimingham. Incandescent electric lamps.

COMPANIES' MEETINGS AND REPORTS.

Kensington and Knightsbridge Electric Lighting Company (Limited).

The ninth ordinary general meeting of this Company was held yesterday at 1, Great George-street, Westminster, Mr. Granville R. Ryder presiding.

The SECRETARY (Mr. R. S. Erskine) read the notice convening the meeting.

The CHAIRMAN: With regard to the year just passed I think the report and accounts afford sufficient evidence that there is plenty of vitality in the Company, and that our progress is steady and continuous. Our main mileage has increased by 1¼ miles in the course of the year; the houses and shops connected have increased by 201, from 908 to 1,109; the lamps supplied by us by 14,102, from 80,678 to 94,780; the sale of electricity by 250,977 units, from 977,789 to 1,228,734; and our net revenue has also increased from £9,289 to £10,988, an addition of £1,698. These figures are of a satisfactory character, but I have to point out that the comparison of the year 1895 with 1894 is not necessarily a very favourable one, because in the first half of 1894 the price charged was 8d. per Board of Trade unit, and during the last six months it was reduced to 6d., whereas during the whole of the year 1895 the price was at the lower rate. And I may add that during a considerable portion of last year, about five months, the reconstruction of the works was going on at Kensington after the fire in February of 1895, and the consequence was that our business was carried on with some difficulty, and the greatest credit is due to Mr. Crompton and Mr. Miller for having managed to keep things working so well while all these reconstruction works were going on. With regard to some of the items in the accounts I should like to say a few words and give a few explanations. There is an increase in the capital account which, I am afraid, will be an annual matter. It has increased in the year by £21,280, the greater part consisting of 4 per cent. debenture stock. The larger items on which that money was expended are these: £5,840 in the purchase of property. This was a purchase of some freehold premises close to our Kensington station, which are of very great advantage to the working of that station and have given us elbow room, which we very much required. The next large items are £7,350 for engines, dynamos and boilers, £1,351 for meters, £4,442 for mains, and £1,121 for batteries. These figures make together upwards of £20,000. Another point I wish to call your attention to is the very considerable sum carried forward as cash at bankers at the end of the year, £11,871. Well, that sum, which is a larger amount than we usually favour our bankers with, was owing to the fact that the Debenture stock issue had taken place in December, and the greater part of that £11,871 consists of the money subscribed for that Debenture stock. In the circular about that debenture stock which we sent to the shareholders, by whom it was entirely subscribed, we stated that the reason for issuing it was that we wanted to purchase some freehold properties. This purchase we carried out in January. The freehold properties in question was the frontage to our works at Knightsbridge, and consisted almost entirely of shops, and not only for the possibilities of future extensions, but also, as you are aware, with regard to manufacturing premises, it was a great thing to have considerable margin around you outside your works. I may add, with reference to these premises which we have brought, that the rents accruing from them are more than sufficient to pay the interest on the purchase money after making allowance for empties, insurance and repairs, so that they, will not stand us in anything at all in the way of loss of income. The next point I wish to call your attention to is the cost of the manufacture of electricity, the first item on the debtor's side of the revenue account. That amounts to £6,068, an increase of £927 on the preceding year, but that £927 has produced an increased output of 251,000 units, which has realised in cash £3,400, so that that is by no means an unsatisfactory item. All the things I have mentioned up to the present time have been of a pleasant nature, but there are sometimes disagreeable things at the bottom of the bowl, and the point to which I now wish to allude is of this kind and it is also one that refers to the future. I speak of our rates. A new assessment has been made, and although we fought the matter and obtained some reduction, the general result is that in future we shall have to pay four times as much in rates as we do now. Instead of our rates being about £500 per year they will be about £2,000. This is a very disagreeable thing, but we cannot help ourselves. Public companies in these cases appear to be at the mercy of the vestries, and so far as I can see there is no public opinion in our favour. As to insurance, I may say that our rate has been 5s. per cent. up to the present time, but that has now been increased to 10s. 6d. We shall do our best to find if it is not possible to get it reduced, but so far our efforts in that direction have not been successful. We now pay for insurance £236 per annum, but if we have to pay the increased rate it will in future cost us about £500 yearly. These are two standing expenses which we have to face in the future, and for which, so far as I can see, we shall get no return. One other point to which I will speak is the amount we have placed to the renewal fund and the sum we have provided to write off the item of goodwill. We have always felt that as we become more and more flourishing we ought to write down to some extent the more unsubstantial elements of our capital account, and as we rather think the goodwill comes under that definition, we have written off against that, £1,000. To the renewal fund we have placed the large sum of £4,270, after paying the whole cost of maintenance for the year, £2,208. That, of course, is a large sum, but I think it is very important that the renewal fund should be kept up. Electrical science is a progressive one, and consequently new things are constantly being invented to facilitate working, which it is necessary that we should possess ourselves of. Therefore it is extremely important that we should have a large sum in hand on that account to enable us to meet anything that may arise of that kind. I am sure that it is the right policy for the Board to pursue, and I hope you will agree with us in thinking so. These are the only points which occur to me as worth mentioning, but I shall be happy to answer any question. Mr. Hopkinson reminds me of another matter about which I might say a word, and that is with regard to the premiums we received on the issue of the debenture stock. As stated in the report, the Board thought that the best way of dealing with that money was to use it in paying the expenses and buying up the debentures, and you will observe in the accounts that the £755 received from premiums has been so applied. I will now move—

"*That the report and accounts now read be adopted and entered in the minutes.*"

Mr. G. H. HOPKINSON seconded the resolution.

Mr. WATERS congratulated the Board very heartily on the satisfactory progress made by the Company during the past year. If the Chairman could tell them conveniently, he should like to know what amount stood in their books for goodwill?

The CHAIRMAN: £14,000.

Mr. WATERS, continuing, said he believed the shareholders would appreciate the importance of placing a substantial amount to the renewal fund in order to put the Company in a position to take advantage of any improvements that electrical science might introduce.

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Mr. NEVILLE asked how the amount arose for goodwill. He thought the Company was started as a new concern.

The CHAIRMAN: We bought up the Kensington Court Company, which was paid in shares.

Mr. NEVILLE, referring next to the conversion of the debenture bonds into Debenture stock, said he failed to see that it had been an advantageous financial transaction, as the Debentures were paid off at 105.

Mr. HOPKINSON explained that the Debentures were not redeemable at a less premium than 105, and in order to do so at the earliest date they had to give six months' notice in August last. Besides saving a certain amount of interest by the conversion they would be able to issue in the future Debenture stock at 4 per cent. or at a less rate of interest.

The CHAIRMAN then moved—

"That in respect of the Ordinary capital of the Company the interim dividend at the rate of 5 per cent. per annum paid for the half-year ending June 30th last be approved, and that a further dividend at the rate of 7 per cent. per annum be paid for the half-year ending December 31st last, payable on and after the 21st inst."

Mr. HOPKINSON seconded the resolution, and it was carried.

On the motion of Mr. HOPKINSON, seconded by Mr. NEVILLE, the Chairman was re-elected a Director.

Mr. CROMPTON then moved, and Mr. NEVILLE seconded, the re-appointment of the auditors—Messrs. Lovelock, Whiffin and Dickenson—at a fee of 50 guineas, which was agreed to.

On the motion of Mr. WATERS, seconded by Mr. NEVILLE, the Directors were voted £600 for their services during the past year.

A vote thanks to the Chairman brought the proceedings to a close.

Westminster Electric Supply Corporation (Limited).

The ordinary general meeting of shareholders of this Corporation was held on Wednesday at the offices, Eccleston-place, Eccleston-street, Belgravia, under the presidency of Mr. James Heslop Powell.

The SECRETARY (Mr. Frank Iago) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: I regret extremely that Lord Suffield is unable to be here to-day. He has suffered a very long and painful illness, but I am happy to say that he is now better and at Brighton, and able to get about, so that I hope we shall have him among us again before long to give us the benefit of his advice in the conduct of the business. I should now like to address a few remarks to you on the report and accounts, which I think must be considered satisfactory by every shareholder in the Company. They go to prove that the public has become aware of the advantages of electric light—that it not only gives the best illuminating power, but is accompanied by no bad air or undue heat to disturb the enjoyment of life or to injure the health of those who use it, which is not the case with all other illuminants. They further prove that the public believes our system to be safe, reliable, and inexpensive, and we believe it is capable of still further improvement. Not only do we find a considerable increase in the number of lamps newly installed during last year, but the increase in number steadily goes on. It has climbed up steadily from 167,703 installed on January 1, 1895, to 210,982 at the end of that year, giving an increase of 43,279 lights, and applications were received last month for 6,478 lights in addition. In the previous year the increase was not so great, being only 36,133 against 43,279 last year, and the consumers in the previous year were 526 more against 631 more last year. Therefore, both in the number of consumers and in the number of lights there has been a substantial increase, which is steadily maintained, although the field we draw upon has decreased. In January of this year we added 5,840 lamps. As may be expected, the capital expenditure has also increased, to the extent of £33,000, which is about 8 per cent. upon the previous capital; but then you have the very gratifying fact that our revenue has increased in a very much larger proportion—that is to say, our increase of revenue has been as much as 32 per cent. In 1894 our revenue was £53,407, and in 1895 it reached £70,511. Our net revenue has also increased very materially—as much as £12,410 on a capital expenditure of £33,000. The figures I quote to you are figures of increase and not figures of revenue. We regret to notice that the charge for fire insurance has increased. We have taken every possible means that we have of to make our buildings practically fireproof, and we have purchased and have on the premises every mechanical appliance known to us for extinguishing fire if unfortunately one takes place. We have also taken the further precaution of having our men periodically drilled in the use of these appliances. I may mention in regard to our revenue that the revenue per lamp is fractionally—only fractionally—higher than it was in 1894. The increase in our business is not spasmodic, it is all along the line; and whether we regard it from the number of units sold or from the number or class of our customers—the occupants of private houses and shops, the proprietors of clubs and of chambers, and hotel proprietors—or the gross revenue we receive from all these added together—all and each point to a general appreciation of a bright and safe light, which is a comfort to those who use it, and is the best preservative of internal decoration that has ever been presented to the public in the form of artificial light. This is a characteristic of electric lighting which should not be overlooked in calculating the cost of it. With respect to depreciation, our experience is that shareholders differ as to how much should be carried to that account. Some have gone out of their way—and we thank them for it—to write to us, commending our judgment in placing so large a sum to this account, and a few—a very few—having regard to how we have dealt with this item in the past, have expressed the opinion that the sum of £9,784 is an excessive amount to put by. The Board have not fixed on this figure by their own volition or as a matter of guess work, but have followed implicitly the advice of their eminent consulting engineer, Prof. Kennedy. He has divided the respective values of our plant and machinery according to their cost, and has allowed different percentages on each class, with a due regard to how they are likely to wear out. I have been personally warned that in the past our allowances were insufficient. My opinion on such a subject is worth very little, but I may say that I have seen in other undertakings very evil effects arise from not having carried right principles into practice in dealing with depreciation. In addressing you from this chair on a previous occasion, I explained that it was necessary to establish a sinking fund to provide for the recoupment of the money we had paid for our leases, and that we ought to have a reserve fund to provide against any contingency that might happen. I hope no misfortune will ever befall us that will require the use of such a fund; but should new discoveries antiquate our machinery, or some accident befall it, particularly at a time when the business life of the Corporation is coming to a close, and the Corporation may be unable to issue new shares advantageously, or to borrow on the security of our undertaking on low terms, a reserve fund—a real reserve fund, invested outside our business in first-class trustees' securities—will prove very useful to us. And even if no contingency arises or accident happens, such a reserve fund would be a very pleasant bonus for the shareholders to receive—something certainly not to be despised—at the end of our career. We have, therefore, invested a sum of £3,773 as the nucleus of a reserve fund, and £8,000 the premium on the new shares issued last year, and the interest already received on the investments. Interest and compound interest invested, and I hope some additions to the principal, will bring these funds to a very respectable sum in a short time. We have made some additions by purchase to our property. The property which we have lately acquired here and in Milbank-street adjoins our works, and will, when needed, be adapted for them. It was absolutely necessary in your interest that we should be possessed of this land before we required it immediately, for were our immediate wants known to adjoining owners, the price would have been raised against us. We are now independent of this. The property acquired here has been let for a term at a rental which is remunerative to us and fair to our tenants. I have now only to thank you for the patience with which you have listened to me, but I cannot conclude without expressing thanks to our consulting engineer for having steered us so safely through the many quicksands that were round about us in starting a new and, I may almost say, untried undertaking and to our manager for his energy and tact in dealing with the business of the Corporation. Without this co-operation of science and business, and, I may say, the valuable help given by our engineers, staff, and workmen, we should not have so early arrived at a time when we could declare a dividend at the rate of 9 per cent. per annum, and make all the needful provisions which I have described for the future to place this Company in a safe position. With these remarks I beg to move the adoption of the report.

MR. EDMUND BOULNOIS, M.P., seconded the motion.

The CHAIRMAN, in answer to a shareholder, stated that he had expressly said, in dealing with the question of the reserve fund, that they might add to it a further sum of principal. He could not, however, bind himself as to what the amount was to be, because the Board had not determined this question. He then put the motion, and, having declared it carried unanimously, proposed—

"That a dividend be declared for the half-year ended December 31, 1895, at the rate of 9 per cent. per annum, payable on March 1st next, making, with the interim dividend already paid, 7 per cent. for the past year."

Mr. J. BROWNE MARTIN, in seconding the motion, said he thought that everyone must be satisfied at the progress which the Company had made. They owned, he thought, the most wealthy district in London, and possibly in the world; and considering that electricity was simply in its infancy, he did not think there was the slightest probability of its going back. It must go forward. When they considered that the Directors had not made a single mistake in expending the shareholders' capital, either on experiments or other purposes, he thought it must be satisfactory to every shareholder.

The resolution was carried unanimously.

On the motion of Lord GALLOWAY, seconded by Mr. LESSELS, Mr. Powell was re-elected to his seat as a Director, as was also Mr. Martin, on the motion of Capt. GRANT, R.N., seconded by Mr. DARNTON HUTTON.

Sir MARK J. McT. STEWART, Bart., M.P., afterwards proposed a resolution that the Board of Trade auditor should act as auditor of the shareholders. He reminded them that the matter was discussed at their last meeting, and that the object of the resolution was to save the Company an expense of about 50 guineas, and to avoid the inconvenience of preening the books after they had been approved by the Board of Trade. It was the unanimous opinion of the Directors that it was not necessary to burden the funds of the Company with an expenditure upon auditors apart from the audit of the Board of Trade.

Mr. STRATTEN BOULNOIS seconded the motion, which was carried unanimously.

Lord GALLOWAY afterwards proposed a vote of thanks to the Chairman, Directors and staff.

Sir MARK STEWART seconded the motion, which was carried unanimously.

The CHAIRMAN, in acknowledging the vote, stated that they had all worked very hard to bring the Company to the position in which it now was. Mr. Browne Martin had said that the Directors had made no mistakes. Probably they had made some, but very few at any rate, and it was gratifying to the Directors to meet the shareholders under such pleasant auspices as on that occasion.

The proceedings then terminated.

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House-to-House Electric Light Supply Company (Limited).

The eighth ordinary general meeting of this Company was held on Thursday at the Company's central station, Richmond-road, Kensington, Mr. William Page (Managing Director) presiding.

The SECRETARY (Mr. Thos. J. Owens) read the notice calling the meeting.

The CHAIRMAN: Gentlemen, the report is not a very startling one in any respect. There is nothing in it that is very exciting one way or the other. There are no very great things to report, and, on the other hand, there are no calamities to announce. Perhaps the most satisfactory thing is the continued increase in the number of connected lights, which have now reached 44,162 of eight candle-power each. The revenue, too, has gone up from £5,010 in 1890 to £15,394 in 1895, and it is still increasing. The number of lights connected last year was more than in 1894, and from the number of applications received since the beginning of the present year, we have every reason to believe that during 1896 the connections which will be made will exceed in number those of 1895. In the first six weeks of last year the number of applications was 831, while during the first six weeks of the current year it has been 1,420, so that although the increase last year was the biggest we had ever had we are doing a great deal better still this year, and that is a satisfactory feature. Unfortunately there has been an increase in the expenditure. For several years we kept the expenditure practically at the same level. In 1892, 1893 and 1894, although the output was greatly increased, we kept the expenditure quite steady. During the past year that has not been so, and there have been several reasons that we do not anticipate will occur again, at any rate not for some time, which have operated to bring this about. First, I may say, we carried out last year several expensive alterations in the works, among others the raising of one of our chimney shafts, and also alterations of the position of our plant, which we found to be necessary, and while this was being done the working department had to some extent to go to the wall. That is to say, we often had to run three units of plant when in the ordinary way two would have done the same work, and, of course that led to some of the extra expenditure. Another matter is that our system of having such a large number of converters distributed over the district, some of them being of rather an old type, it comes rather expensive. They take a great deal of current, but I may say that we are gradually changing them, banking the converters, and supplying, to some extent, the low tension; and as the result of this we expect to considerably decrease our coal bill. Even during the last week or two, since we have modified our working arrangements with the further plant we have had brought in, there has been a considerable saving shown in the coal bill; but I do not wish to say too much on this point, because as yet we have had only a short experience of the effect of these alterations. However, I may say that I shall be very dissatisfied if there is not a good many hundreds of pounds off the coal bill for the current year, although we shall doubtless supply a considerably increased quantity of current. So far as our reputation goes in the district, I think we stand very well as regards the steadiness of our light, for I have again and again heard that no other supply company in London equals ours in this respect. Certainly we go to a considerable expense to avoid anything like a breakdown, and we always manage to keep running. Of course, as has been mentioned more than once at these general meetings, we are in a district which is entirely residential, and that is not conducive to very heroic things in the way of returns; but we hope when we get our number of lights sufficiently increased that this undertaking will prove far more profitable than it is at the present time. We have added considerably to our plant during the past year, which enables us to look forward with confidence to our being able to meet any demand that may be made on us. Of course we should have to continue to add to our plant every year. The £1,800 spent for this purpose last year was, I think, disposed of by Mr. Bowden, our manager, with a great deal of wisdom, and in a manner which will be of great advantage to the Company. With these few remarks I will move—

"*That the report and accounts be adopted.*"

Mr. R. A. GERMAINE seconded the resolution.

The CHAIRMAN: I should have mentioned that I am sorry for the absence of our Chairman (Mr. H. R. Beeton). We quite expected until a couple of days ago that he would have been with us; but, unfortunately, he has been kept at home these last few days with sickness, and so is not able to be here to-day.

The resolution was then agreed to.

The CHAIRMAN: I now beg to move:—

"*That the remaining dividend on the Seven per Cent. Cumulative Preference Shares be declared and paid forthwith.*

Mr. FROST seconded, and it was carried.

The CHAIRMAN, in reply to a question as to whether all the shares of the new issue were taken up, said: I cannot say exactly how things stand, but a considerable number have been taken up. I daresay quite as many as we want at present.

On the motion of the CHAIRMAN, seconded by Mr. W. F. LEESE, the retiring Directors—Mr. W. R. Davies and Mr. R. A. Germaine—were re-elected.

The auditors—Messrs. Miall, Wilkins, Randall and Co.—were reappointed at a fee of 40 guineas per annum.

The proceedings terminated with a vote of thanks to the Chairman.

The Directors' report above referred to states that the revenue account shows a credit balance of £6,840. 16s. 1d. which, with £108. 11s. 5d. brought forward, £49. 11s. 8d., dividend on shares in the Yorkshire House-to-House Company, &c., makes a total of £7,011. 9s. 7d. After deducting £1,907. 18s. 4d. interest on debentures and £875 for interim dividend on the Seven per Cent. Cumulative Preference shares, the Directors recommend that the balance be dealt with as follows:—Reduction of preliminary expenses, £500; depreciation, £2,000; balance of dividend on Seven per Cent. Cumulative Preference shares, £875; reduction of construction business development account, £788. 11s. 11d.; carried forward, £64. 19s. 4d.; total, £4,228. 11s. 3d. The amount of £829. 9s. 4d. received as premiums on the issue of £10,000 Debenture stock is to be applied in further reduction of the construction business development account, making that item £15,000.

The progress of the Company's electric lighting business since 1890 is shown as under:—

Year.	Equivalent of 35 watt lamps connected.	Increase in 35 watt lamps.	No. of houses connected.	Gross revenue.	Expenditure.	Net revenue.
1890	13,665	9,145	248	£5,010 9 2	£4,624 6 5	£386 2 9
1891	19,388	5,723	373	8,328 3 11	6,077 14 10	2,250 9 1
1892	23,700	4,312	471	10,688 18 6	7,851 19 6	2,836 19 0
1893	28,429	4,729	599	12,063 10 10	7,832 6 8	4,231 4 2
1894	35,858	7,429	755	13,695 11 8	7,431 16 8	6,263 15 0
1895	44,162	8,304	932	15,394 16 11	8,554 0 10	6,840 16 1

The increase in the lights connected during 1895 was equivalent to 8,304 8 c.p. (35 watt) lamps, being the largest increase since 1890, the increase in revenue being £1,699. 5s. 3d., and in working expenses £1,122. 4s. 2d. During the year various alterations and additions to the plant have been made, which, it is anticipated, will tend to reduce the cost per unit of current in the future. £18,532. 8s. 9d. has been expended during the year on additional plant, mains, and buildings, and the expenditure for 1896 to meet the increased demand is estimated at £15,000. In order to provide for this outlay a further issue of capital is necessary.

With regard to the construction business development account, the Directors regret that they have been advised that the accounts of the Leeds and London Electrical Engineering Company (Limited), to whom this business has been leased, do not admit of the distribution of any profit.

During the year 1895 a further £10,000 of Four and a-Half per Cent. Mortgage Debenture stock has been issued, bringing up the total issue to £50,000, being the full amount created.

National Telephone Company (Limited).

The seventeenth ordinary general meeting of this Company was held yesterday (Thursday) at the City Terminus Hotel, Cannon-street, under the presidency of Mr. J. S. Forbes.

The SECRETARY (Mr. Albert Anns) read the notice calling the meeting, and the report of the Directors was taken as read.

The PRESIDENT, in moving the adoption of the report and the payment of dividends therein recommended, said: The report is made up mostly of figures, placed in such a way as to be easily understood, even by those whose business it is not to have to master very much the details of accounts; and the several paragraphs reveal all the essential facts to be known in order to appreciate the progress and position of the undertaking. There had been a substantial increase in the aggregate income of the Company during the past half-year—an increase of £43,860, which is equal to 11·58 per cent.; and the working expenses had increased by £11,344, or 5·52 per cent. The result is that the balance of profit available shows an increase of £29,231, which is equal to 21 per cent. The satisfactory feature there is that a larger income earned at a lower expenditure makes the greatest progress in percentage in the net income, and that is a combination which we shall all accept, no doubt, with gratitude. As I have said, the income of the December half of 1895, compared with that of the corresponding period of 1894 shows an increase of £43,860; but that is subject to a very considerable reduction in the nature of a 10 per cent. royalty to the Post Office in respect of all income earned from other sources than our private wires; and the Post Office [illegible] has increased in the half-year from £34,963 to £38,238. The net result of the half-year's working is a profit balance of £167,873, as compared with £138,642 at the corresponding period of 1894. The income was earned last half-year at 56·32 per cent. of the earnings, showing a reduction over the corresponding percentage at December, 1894, of 3·36 per cent. Debenture and other interest charges have increased from £26,437 at December, 1894, to £33,564 last half-year, but I daresay that you will not be alarmed at that increase when I tell you that the account has been charged in the last half-year with £7,126, being the interest on our reserve fund, whereas in the corresponding period of the previous year we had not yet commenced that method of dealing with the reserve fund. The Preference and Ordinary dividends, which depend on your confirmation to-day of our recommendations, will involve the payment of £96,593, or £12,114 more than at December, 1894, the increase being exactly the amount of the additional ½ per cent. dividend, which we propose to pay on the Ordinary shares. That leaves a balance of £35,000 to be carried to the reserve fund, and then it is proposed to carry forward £6,623, as compared with £3,379 a year ago. The item of rentals carried forward I must explain, and it is a very interesting and important one. It represents the amount of money paid by subscribers in advance in respect of periods not covered by the particular half-year under review. That is to say, a gentleman who begins on December 1, 1895, pays us a subscription in advance for 12 months, so we have to attribute to that month in 1895 one-twelfth of the amount of the subscription, the balance being carried forward. We, however, have that money in hand, and in that way we hold the considerable sum of

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£354,635, which is £40,656 greater than at the corresponding period of last year. I have now given you the result of the past half-year's working as compared with that of the December half of 1894, but now I will draw your attention to the results of the complete years 1894 and 1895. Last year we had a gross increase in our revenue of £80,353; we paid the Post Office for royalties £7,451 more, and we had a net income of £744,360, showing an increase of £72,900. The working expenses show the moderate increase of £31,882, and the net result for 1895 was £320,195, or £41,000 more. The working expenses on the whole year diminished by 1·44 per cent. We transferred to the reserve fund in the year 1895 £70,000, or £11,517 in excess of the amount transferred to that fund in 1894. We have now to deal with an available balance of £138,217, and the Board recommend the payment of a dividend at the rate of 6 per cent. per annum, less income tax on the First and Second Preference shares, 5 per cent., less income tax, on the Third Preference shares, and 6 per cent. per annum, free of income tax, on the Ordinary shares. That 6 per cent. on the Ordinary shares opens a new state of things. Up to two or three years ago we paid 6 per cent. pretty regularly, but in face of the combinations of certain companies and of competition which threatened us, and in face of those sacrifices, which we perfectly foresaw, we should have to make in reference to the New Telephone Company, the Mutual Telephone Company, and all those combinations which were promoted and run in order to be bought off, we thought it prudent to restrain a little the dividend and to reduce it to 5 per cent. That was a prudential matter, which was fully explained to and acquiesced in by the shareholders. We have had nearly three or four years' experience of that lower dividend, and we are able now to estimate not only the probabilities in the expansion of our business, but also to discount with a little more accuracy the agitation that is continually going on in order to get up opposition to the Company. In the face of those combinations we have thought it prudent and proper to recommend the shareholders an additional ½ per cent. for the half-year. Under some circumstances the report would be considered meagre, but a difficulty presents itself when we have nothing to say. Paragraph 7 deals with a matter of great importance, for it tells you that the agreement with the Post Office--which has been a very long time about—has been executed by the Postmaster-General, and is now a valid and binding agreement on both parties. We are now waiting to be paid. As we say in the report, the sum is "practically agreed," and it is not only the amount which we are to receive in exchange for the surrender of our trunk wires, but many important matters of detail, involving considerable matters of principle respecting our future relations with the Post Office and the public, have been settled by discussion. We do not know what will happen, but what we hope is that the Post Office and ourselves will so work in harmony that the public will not find any very great inconvenience from the change which must ensue from splitting this business into two portions. We shall try to protect the public from any inconvenience from that cause. When our money is paid, which I understand will be very soon, we shall take it with a certain amount of thankfulness; but I suppose we should have preferred really, had it been anything but Hobson's choice, to have remained as we were. One cannot look very far into the future and foreshadow what will happen, but I suppose that by hook or by crook these trunk lines will be enormously increased as the benefit and value—the great commercial and social value—of the telephone become realised by the public. We long ago enunciated the common sense fact that the value of the telephone must depend on its more or less universality, and if our subscribers, in addition to the local use, for which they may primarily subscribe, are enabled to enjoy from year to year a great extension of the valuable and convenient depatch and receipt of telephonic trunk messages, it will make the local exchanges more valuable. We believe that, and it is to that we look as one of the sources of our future income and of the multiplying of our subscribers. We have not received an intimation of the acceptance by the Post Office of the figures in the form which would make it prudent for us to state them until we have them in black and white. I will therefore not commit myself to saying what the amount is, but it is a considerable and equitable amount. I do not propose to volunteer many criticisms upon competition that is talked about. I only know, when I hear so much [illegible] what is being done in Stockholm in connection with the telephone, that I lived there [illegible] It is a charming place, and one can get just as charming a house there for £50 a year as can be got in London for £500 a year; and all the conditions of life in Stockholm are subject very much to the same comparison. I daresay the telephone is very acceptable to people there at £6, but that is because that charge happens to be in proportion to the standard of values there. But Stockholm is not London. Yet we are repeatedly being told that someone is coming to London to give us a telephone for £5 or £6. We, however, will not delude ourselves that that is possible. I should be very sorry to be a party to inducing the shareholders of this Company largely to increase their capital in order that they might provide telephones in London or any great centre of commercial and social life for £6 or anything like it. We know something about this matter, and have had opportunities of learning a great deal; but when you come to meet these suggestions by the dreadful process of reducing them to facts and figures you see how fallacious they are. I therefore tell the shareholders not to be too much alarmed at the combination of defence, which is going on against the extortion, &c., of the National Telephone Company. Whatever arises we shall probably be prepared to meet it, and we shall meet it with this advantage—that we know the facts, and that certain hair-brained philosophers do not. Up to comparatively recent times people would not regard the telephone as a practical thing, but viewed it simply as a toy. That has changed now. We have already got 82,093 subscribers of a class who represent a great deal more in the active control of commerce than a great many hundreds of thousands of the ordinary population, and these 82,000 odd are growing from year to year at the rate of about 8,000 or 9,000, and we have to find a large amount of capital each half-year in order to take them on. Every subscriber who comes on costs so much money in connection with the instrument, the attachments, wages, and so on. In the past year we have increased our number of subscribers by 8,740, and I may say that the subscriber who has one wire pays the maximum charge—suppose we say £10, or in London £17 (it used to be £20). If, however, he takes a second wire he gets a reduction, and if he has a third wire he obtains a still further reduction, so that brings down the average subscription much below the maximum charge. In 1895 we spent in the year £337,905 in order to meet the demands of those 8,740 additional subscribers, and that works out at an average outlay of £38. 13s. 2d. per subscriber. Every man, in fact, who comes on to the system costs on the average, at the outset, from £38 to £40. In the past half-year, for our additional subscribers, we spent in this way £187,970, and that works out at an average of £41. 18s. 7d. He then went through the principal items in the net revenue account and balance-sheet, pointing out that the reserve fund amounted at the 31st of December £315,630, of which £279,545 had been reserved from profits, the balance being on premium account. The stock of materials amounted to £204,853, which seemed a large amount, but was really a comparatively small item when it became distributed in poles, wires, instruments and copper in many hundred places. He concluded with expressing great regret at the loss which the Company had sustained at the death of their late colleague, Sir Henry Calcraft.

The VICE-PRESIDENT (The Right Hon. Lord Harris), in seconding the motion, stated that when he joined the Board a few months ago he felt that he did so in a somewhat independent and critical attitude, owing perhaps to his having had something like ten years of public life. He thought that public criticism was a good thing, and he did not consider it was unnatural that the public, which was only beginning at present to take an interest in telephones, should take up a critical attitude. After all it was difficult to draw a very broad line of distinction between the telephone service and other services which were conducted by the Government of the country respecting which there was the utmost freedom of criticism both in the Public Press and Parliament. He rather welcomed public criticism, therefore, as it would stir them up to make their system as efficient as possible. That ought to be their object, and he hoped as they went on, and their knowledge of the instrument and its connections improved, they would be able very materially to improve their system. After all, however, as regarded criticism, it must eventually come down to £ s. d. The president had mentioned that they had about 90,000 subscribers, but the telephone was used by an infinitely greater number of persons in connection with those subscribers. The Company, a private body of shareholders—not the taxpayers --had conferred on the public all this great advantage, and he suggested that it was perfectly legitimate for them to reply to their critics that they must come down to £. s. d., and agree to pay a fair return on the capital which had been embarked in the undertaking. According to "Whitaker," the country had spent £11,375,000 odd upon the postal and telegraph service, including superannuation, as far as he could make out, and its receipts amounted to some £15,167,000 odd, or a profit, if "Whitaker" was correct in his figures, of £3,791,000 odd on the service as supplied by Her Majesty's Post Office. That, he thought, substantiated his argument —that men of business recognised that a profit must be paid to those who embarked their capital in giving a service such as the Company gave. Their representatives in Parliament had sanctioned these figures, which showed that the Post Office was worked at a profit, and surely that being so, they could not deny the same privilege to private persons. So far as he could see, every effort was being made to improve the service, and to secure the most efficient amount of work from the *employés* of the Company, whose services, he believed, were of the most loyal character.

The resolution was carried unanimously.

On the motion of Mr. CHAPMAN a cordial vote of thanks was passed to the President, Directors and staff.

The PRESIDENT, in acknowledging the vote, recognised the devotion and loyalty of their officers. There were certain annoying incidents which occasionally occurred in connection with the use of the telephone, but it must be taken for what it was worth, the same as anything else in life was taken. All they could do was to do the best they could to serve the public in connection with it, and they might rely upon it that everything would be done to render the service which they gave to the public as efficient as it could possibly be made.

The proceedings then terminated.

Northampton Electric Light and Power Company (Limited).

The annual report of the Directors of this Company states there is now an equivalent of 6,130 8 c.p. lamps connected, as against 4,600 in 1893, and 5,300 in 1894. The revenue, notwithstanding reductions in the price of current, has steadily increased, and amounted to £2,111. 7s. 11d. for the past year; the expenditure (including £250 for depreciation) came to £1,541. 11s. 7d., leaving a balance of £569. 16s. 4d. Of this sum £265. 16s. 8d. is to be applied in the payment of interest on Debentures, and £62. 1s. as interest on temporary loans, leaving a balance of £325. 11s. 2d. The Directors propose to pay 1½ years' dividend on the Preference shares to the end of June last. This will absorb £278. 8s., leaving £47. 3s. 2d. to be carried forward. The Directors state that they have been considering the question of further reducing the price of current and meter rents, and they hope to announce very shortly an alteration in the tariff. The report states that considerable additions to the plant and machinery will be necessary before next winter. Messrs. H. Manfield and W. Tomes are the retiring Directors, but seek re-election at the annual meeting to be held on Thursday next, the 27th inst.

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Sulphide Corporation (Ashcroft's Process), Limited.

The statutory general meetiug of this Company was held on Tuesday last, at the Cannon-street Hotel, the Earl of Kintore, G.C.M.G., presiding.

The CHAIRMAN said: Although this is a statutory meeting, I am glad to say that such substantial progress has been made with this Company's affairs that I have several matters of interest to communicate to you. The whole of the share capital has been allotted. One of the first matters which occupied the attention of the Board was the engagement of gentlemen of first-rate ability and experience as heads of the several departments of the Company's business, and I am glad to be able to inform you that Mr. Ashcroft's services as technical manager have been secured for a period of two years. As the inventor and patentee of the process which bears his name, he will be able to render invaluable assistance in the erection of the Company's works, and in establishing them on a permanent basis. Mr. J. H. Smith (late Chairman of the South Australian Railway Commissioners), as Manager of the Company's London office, is a gentleman of the highest reputation in Australia for his powers of organisation and general business knowledge. Mr. H. H. Schlapp, late chief metallurgist of the Broken Hill Proprietary Company, who is intimately conversant with the Ashcroft process, has accepted the post of consulting engineer to the Company in Australia, and is at present co-operating there, with Mr. Ashcroft on this side, in the preliminaries connected with the erection of the Company's works. Dr. Schnabel (Royal Counsellor of the Prussian Mining Department) and Prof. Hampe (Professor of Chemistry at the University of Clausthal) have been retained as consulting chemists to the Company in Europe, and Messrs. Gibbs, Bright and Co., of Melbourne, have agreed to act as our Australian agents, under the instructions of the local Board, Messrs. J. S. Reid, Saddler and Keating. The property acquired by the Company consists of (*a*) patents securing the rights in the Ashcroft process for all parts of the world (exclusive of North and South America; (*b*) the Central Broken Hill Silver Mine in New South Wales, containing large deposits of sulphide ores suitable for treatment by the process; and (*c*) experimental ore reduction works at Grays in Essex, where the success of the process when worked on a commercial scale has been conclusively proved by a series of continuous trials carried on under the supervision of Mr. Fletcher Moulton, Q.C., Mr. Otto Stalmann and Mr. James Swinburne. With regard to the patents, they have been subjected to a searching examination by a committee of legal and technical experts, who consider their validity fully established, and the necessary assignments have been duly executed, vesting them in the Company, and our business will mainly consist in operating the process protected by these patents. Sites near Newcastle, New South Wales, seem to offer exceptional advantages for the erection of works, premises, being situated on the sea, with good port and harbour facilities, and having ample supplies of coal in the immediate vicinity. Newcastle has also the advantage of possessing good wharfage and railway accommodation, and an abundant supply of salt and fresh water. It is also a port of call and coaling station for steamers to and from all the leading Australian ports, so that freights can be easily arranged for, both in respect of plant and machinery and the Company's ores and products. The Board's final decision will largely depend on the question of price and the prospect of obtainiug special rates for the carriage of the various descriptions of traffic which will result from the establishment of these large works. We are advised that there will be no difficulty as to this, seeing that the works, when completed, will bring an addition of some 900,000 tons per annum to the railways of the Colonies. So soon as a site is definitely decided upon works will forthwith be erected in accordance with Mr. Ashcroft's plans. The plant will consist of concentrating, roasting, leaching and electrolytic machinery, arranged in "cyclic" order, so as to obtain the best and most profitable results with the greatest economy of time and labour and the least possible expense, both in regard to capital outlay and cost of maintenance. The material and machinery have been ordered from firms of the highest standing, under Mr. Ashcroft's personal supervision, and no pains have been spared to secure the utmost efficiency and reliability. The works, when completed to their full extent, will be of a capacity sufficient to treat a minimum of 5,000 tons of crude ore per week. It is intended, however, to erect them in sections. The thought and labour involved in the planning of an entirely new plant of such dimensions and importance can be readily understood, and the Directors desire to record their appreciation of the energy with which Mr. Ashcroft has applied himself to the task. The first section will probably be in profitable operation by the beginning of next July, and the second by the beginning of next October. As to the mine, this is situated on the main Broken Hill line of lode, which has in recent years yielded such large and valuable quantities of oxidised silver ores. In many of the mines these ores have been largely worked out, and the sulphide ores, which exist in very large bodies, have hardly as yet been worked, owing to their highly refractory nature having hitherto prevented their profitable treatment by any known method. The experts who reported on the Central Mine last year, after a careful examination of the property, estimate that in one chute only, between the 400ft. and 600ft. levels, there are upwards of a million tons of sulphide ore. At the 600ft. level "the deposit exists as a solid floor of sulphides," and as the Broken Hill sulphide bodies have been proved to a depth of 1,400ft., with strong indications of going deeper, you will see what a valuable property we have acquired, and its importance in furnishing us with a constant supply of raw material, and making us independent of outside sources. In conclusion, I have only to add a word or two about the experimental works at Grays. The object for which these were erected—namely, the demonstration of the success of the process when worked on a commercial scale—having been fully attained, they are no longer required and are therefore being closed down. A considerable portion of the machinery and plant is in course of shipment to Newcastle, New South Wales, to be installed at our works, and the remainder, together with the bullion produced at Grays, will be sold. I should mention that besides effecting the particular object for which they were erected these works have been very useful in two other respects. First, they have enabled Dr. Schnabel, of Berlin, to whom I have already referred as one of the Company's consulting chemists in Europe, to make a thorough personal investigation of the process in actual operation, his opinion being embodied in a highly favourable report. Secondly, the experience gained by their erection and operation will be of great value in putting up and running the Company's permanent works. I have now gone over the various points which the Board thought it would be of interest to you to hear, and I will just add the satisfactory news, conveyed by our latest advices, that arrangements have been made for the free use by us, if we require them, of two sections, measuring altogether 480ft., of the Government wharf at Newcastle for a period of 21 years.

On the motion of Mr. MATESDORF, seconded by Mr. G. WILLIAMS, a vote of thanks was passed to the Chairman, and the meeting separated.

India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The thirty-second ordinary general meeting of this Company was held yesterday (Thursday) at Cannon-street Hotel, Mr. S. W. Silver (Chairman) presiding.

The CHAIRMAN, in moving the adoption of the report, said: I may congratulate the shareholders on the result of the operations of the past twelve months. We have passed through a period of many changes, but they have not in the least affected the trade of the Company. The general business has been good throughout, and the electrical department has been fully employed in the erection of installations for several important cities, including Brussels. We have manufactured and laid about 300 miles of cable for the Cuba Submarine Telegraph Company, and this work has been acknowledged by that Company's engineer to have been carried out in a satisfactory way. This has given employment to two of our steamers. The works at Silvertown are well occupied. Since the commencement of the year 600 miles of submarine cable have been supplied to the satisfaction of the contractors and of the Japanese Government, and I may say that the amount in payment has been received by the Company. The factory in France is also well employed. In passing, I may just remark, as stated in the report, that acting on the suggestion of our vigilant auditor we propose before the next accounts are presented to make certain alterations in the Articles of Association as to the form of the balance sheet and profit and loss account which have been in use for so many years. In our late colleague, Mr. Henderson, we have lost one whose business capacity and sound judgment were of great value to the Company. I feel I need make no further comment, and now move the adoption of the report and accounts, and that the dividend of 7½ per cent. (or 15s. a share), tax free, be now declared.

Mr. ABRAHAM SCOTT seconded the resolution.

Mr. WRIGHT asked whether the item "Debts owing to the Company, £275,376," was about the average sum due at the end of the year, and how much of that sum was the auditor unable to certify. He asked that question because in his certificate the auditor reported that there were certain debts included in that item which he was unable to certify. Then as to "debentures and shares in other companies, £210,589," he should like to know what they were, because the auditor remarked that he was unable to certify as to the correctness of the value placed on them. Perhaps the Chairman would also say how the reserve fund was invested. With regard to the proposed alteration in the form of the balance sheet, he expressed the hope that, whatever form was adopted, it would be of such a nature as to enable the shareholders to form a better idea as to the affairs of the Company. He certainly hoped that the new form of accounts would give more information than the present ones did.

The CHAIRMAN: As there are no other observations I will answer very shortly the remarks which have been made by Mr. Wright. We are prevented from publishing more details, as by doing so we should supply valuable information to be used against us by our competitors. We are a trading company, and we have to be very jealous about what we say. As to the reserve fund, I may again remind you that, as has been stated from time to time, it is used as an auxiliary fund in the business.

The resolution was then carried.

Mr. MATTHEW GRAY (Managing Director) moved the re-election of the retiring Directors—the Chairman and Mr. Scott.

The Hon. HENRY MARSHAM seconded the motion, and it was agreed to.

The CHAIRMAN returned thanks in his own name and in that of Mr. Scott, and in doing so said: I cannot look forward to my appearance here for years to come, because I find a want of elasticity in my system such as should caution me not to exert myself even in the interests of this institution, which is very dear to me outside the mere question of pounds, shillings and pence. But I must remind you that as an industrial undertaking our success depends on the efficient state of the works as well as the judicious selection of materials, and last, but by no means least, the care exercised in the counting house. To these I trace to a great degree the success we have met with during the past year.

Mr. COCHRAN then moved the appointment as auditor of the firm of Turquand, Young, Weise, Bishop and Clarke. He observed that this year they were proposing to appoint Mr. Clarke's firm instead of himself personally, so that in the event of any unfortunate events there might be no break in the audit. Referring to the accounts, he said that in his opinion the shareholders were entitled to additional information, and pointed out that other trading companies gave it without having their interests adversely affected.

Mr. BLANKLEY seconded the motion, which was agreed to.

The CHAIRMAN, in acknowledgment, said: I may just say again that

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we cannot see our way to extend the information given in the accounts without damaging the interests of the Company.

A SHAREHOLDER: Are the Directors satisfied with the valuation of the items in the accounts?

The CHAIRMAN: Perfectly.

The proceedings then terminated.

British Electric Traction (Pioneer) Company (Limited).

The first ordinary general meeting of this Company was held at Winchester House, Old Broad-street, yesterday (Thursday), Sir Rivers Wilson, G.C.M.G., C.B., in the chair.

The SECRETARY (Mr. T. Vincent Kitchener) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, as the secretary has just informed you, this is merely a statutory meeting at which no business will be transacted and no resolution proposed. It is a meeting called in conformity with the provisions of the Companies Act which requires that a meeting of the shareholders shall be held within four months of the registration of the Company. However, I will just give you a very short account of the proceedings of the Company up to the present time. It may be of interest to you who are present and to the many shareholders who are absent. You will remember that our capital is £100,000, and that 5,000 shares of £10 each were offered. Our friends responded very readily to the invitation to subscribe, and the amount asked for was subscribed many times over. I am afraid there was some little disappointment among some of the persons who applied for shares, but I can only assure you that the Directors did the very best they could, and made as fair and equitable a distribution as was in their power, looking to the very large number of applications made. I am happy to say that among the 165 shareholders that we have there are a number of very influential gentlemen connected with financial matters in the City and also many gentlemen of technical knowledge, whose experience will no doubt be at the service of the Company and be a great use to us. Since the date of allotment, November 19th last, your Directors have been very actively employed in pursuing the objects which the Company has in view. In the first place they have sought in various quarters for localities where the application of the electric traction system might be applied, and where the localities were anxious it should be applied. Then we have also turned our attention to other localities where they have at present certain methods of traction of what we may now call an obsolete character, and where it might be to the advantage of the locality to substitute electric traction for the more old fashioned system. Then we have also sought out for places where it might be possible to absolutely obtain possession by purchase of the existing obsolete systems, if I may so call them, with a view to the substitution of electric traction for these old methods. That is the three-fold division of the direction in which we have been working. Then to come from generalities to particulars, I will just mention that we are at present promoting a Bill in Parliament for the construction of electric trams from Kidderminster to Stourport, a distance of 3½ miles, an undertaking which will involve an expenditure of some £30,000 or £40,000. We are also promoting a Provisional Order for the construction of electric tramways from Oldham to Ashton and Hyde, a very important route, passing through a thickly-populated district in the neighbourhood of Manchester. I mention these two cases in particular, but you must not at all imagine that these are the only negotiations we have in progress. On the contrary, we have several very important negotiations connected with a variety of localities, but owing to circumstances which, I think, you will readily appreciate, it would be premature at the present moment to allude to them further. It is rather a delicate matter to carry on negotiations of this description, and you must leave it to the Directors at this moment without pressing for information. I can only tell you we have some very important matters in hand; but you know it is not always an easy matter to deal with municipalities and corporations, and overlaying, or overlapping, and often conflicting interests. You must take it from me that the two particular cases advanced to a public state do not constitute by any means the limit of the operations we have in progress. There is one matter in respect to which I am sure you will like to receive some information, that is the question of what shall be the system of electric traction which is likely to be introduced, and to become the system of the future. [illegible] present in operation, you have heard of the trolley system—the overhead trolley system—as to which a great deal may be said in its favour, but it has certain features of unpopularity and certain features also of inconvenience. The unpopularity is on æsthetic grounds and the inconvenience is with reference to its introduction in the crowded streets. My colleagues and I had quite recently an opportunity of seeing this system at work in what I may call its latest development at Bristol, and all I have got to say is that the æsthetic and the urban inconveniences are really reduced to a minimum. I should like to say that because the overhead trolley, owing probably to the extremely clumsy and inartistic manner in which it has been introduced in some foreign countries, notably in America, has become unpopular, which it hardly deserves to be if the system is properly carried out, and from the economic point of view—that is the Company's point of view—I will not say it is ideal, but has much to recommend it. However, we must not lose sight of the fact that there are these objections to which I have referred just now. Therefore we have turned our attention in other directions also. You are aware that there are in some places the conduit system, with the open slot. That also has its practical inconveniences, and it also has this paramount inconvenience, that it is extremely expensive. We are applying our minds most anxiously to this important subject. We believe we have acquired the right to a system, which is the result of the work of a most intelligent and eminent American engineer, which partakes of the nature of a closed conduit system, which will be unattended by any of the inconveniences I have referred to and will be extremely economical. I feel very sanguine I may say, but it hardly behoves me to ask you to share my sanguine expectations; but if these expectations should be realised as the result of experiments we are in process of inaugurating and which I hope will be carried out in the course of a very few weeks, I predict the very greatest possible advantage for the company which will succeed your pioneer company. I will just in conclusion remind you of what our Company is. In the first instance it is not—nor will the company which will succeed it be—a construction company. It is purely and entirely a financial company for promoting the objects I have alluded to; and our object is during our more or less short existence—I hope a very short existence—to set in train such a number of promising undertakings as will enable us to come forward in a very short time, comparatively speaking, and present a certain number of well-matured and promising undertakings, which may form the fie'd of operations of a very much larger company than our humble introductory pioneer Company. I cannot tell you at what date we shall be able to focus a sufficient number of these undertakings as the basis of a larger company, but in view of the work we have done and in view of the provisional engagements we have already entered into, and the expectation we have of forming others, I believe in a very short time we shall be able to offer attractions of a very remarkable character. That is my firm belief and expectation, which is shared by my colleagues. I think that really is the substance of all I need tell you to-day, but I should not be doing justice to my own feelings nor the feelings of my colleagues, who sit on my right and left, if I did not say how very much we owe, in all we have done, to Mr. Garcke, our managing director. I assure you I have some experience of public business myself, and of various descriptions of it and it, has never fallen to my lot to see more single-minded industry combined with intelligence than Mr. Garcke has devoted to your service and interests, and I assure you that having entered into this business with very little practical knowledge of the objects we had in view, I am emboldened to believe that I may continue to work this undertaking with every hope of success, in co-operation with our colleague, Mr. Garcke. I have no resolution to propose, and I can only thank you for your attendance to-day and hope that when we meet again we shall have something a little more substantial to put before you.

The proceedings then terminated.

Central London Railway Company.

The report of the Directors of this Company for the half-year to December 31st last, which will be submitted to the first half-yearly meeting of shareholders at the Cannon-street Hotel, E.C., on Wednesday next, at three o'clock, states that the sum of £506,420 has been received on account of shares, and that the amount expended up to the end of the half-year was £168,285. 6s. 2d., leaving a balance of £338,134. 13s. 10d.

The engineers have been engaged in negotiations with the local authorities respecting the details of the stations and other works, and the contractors (the Electric Traction Company, Limited) have proceeded, as far as possible, with the acquisition of the necessary land for the station sites, and a commencement will shortly be made with the actual construction of the railway.

Under Clause 28 of the Central London Act of 1892 an arrangement has been come to with the Waterloo and City Railway Company whereby, in consideration of a contribution by them to the cost of construction, and afterwards of maintenance, they will have access by a subway from their City terminus to the system of public subways to be constructed by the Central London Company in connection with their Central City station. This arrangement will facilitate the exchange of passengers between the two Companies.

The Board of Trade have given the necessary certificate relative to the payment of interest during the construction of the Railway, in accordance with the Central London Act of 1894.

The passing of the formal resolution sanctioning the issue of the capital authorised by the Act of 1892 does not involve any increase in the amount of capital offered for subscription in June of last year. Sir Francis Knollys and the Hon. Algernon H. Mills (Directors) offer themselves for re election, as does one of the auditors (Mr. Pannell).

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 30 1/16d. per oz. (Feb. 20th). Consols (2¾ per cent.) 109⅞—110 for money, 109⅞—110 for account; 2½ per cent. 106½—107 (Feb. 20th). Stock Exchange Settling Days: Consols, March 2nd; Stocks and Shares Continuation Day, Feb. 25th; Ticket Day, Feb. 26th; Pay Day, Feb. 27th; Mining Share Carry-over Day, Feb. 24th.

LIVERPOOL.—At the meeting of the shareholders of the United Gas Light Company, held on Tuesday, Mr. A. B. Gilmour, who presided, referred to the increased consumption of gas. They had not advanced by leaps and bounds as in former times, but there had been a steady increase, amounting to between 2 and 3 per cent. The incandescent gas light was, in his view, becoming a rival of electricity—"It was a better, purer and more agreeable light than electricity." Notwithstanding the extended use of electricity in the district they were able to announce this increase in the consumption of gas. They were now, however, face to face with a more powerful form of competition in reference to electricity than before: the Corporation of Liverpool were entering the lists as their rivals, and they would have to meet this severe competition as best they could. One point would be remembered, and that was that electricity was not cheap, and therefore this competition was not likely to be so severe as would otherwise be the case.

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Notting Hill Electric Lighting Company (Limited).

The Directors of this Company have issued their report to December 31st last, and this will be submitted to the meeting of shareholders to be held at the offices, Bulmer-place, High-street, Notting Hill, W., on Tuesday next, at 5:30 p.m. The report states that the expenditure on capital account to date is £84,038. 14s. 1d., the largest item in the current year's expenditure being for an additional battery of accumulators, which has been rendered necessary by the expanding business of the Company. The necessary capital has been obtained by the issue of Ordinary Preference shares, and owing to an increased demand for these shares, the Directors have been able to obtain a premium of £2 a share in recent allotments. The whole of the remaining unissued shares, amounting to £11,380, have been applied for at the same premium. The revenue account shows a profit of £3,227. 14s. 10d. compared with profits of £2,101. 17s. 8d. in 1894; £1,481. 7s. 1d. in 1893; £112. 6s. 1d. in 1892; and a loss of £554. 18s. 6d. in 1891. The number of lamps has increased from 15,669 in 1894 to 20,307, an increase of 4,688 lamps for the past year. The increases in 1892, 1893 and 1894 were 3,382, 2,715 and 3,516 respectively. The amount received from the sale of current shows an increase of £1,686. 12s. 2d., against £687. 4s. last year, and reached a total for 1895 of £5,881. 0s. 10d. Expenditure on repairs and maintenance was £780. 3s. 3d.

£700 has been set aside for depreciation and renewals, and after writing 3 per cent. off preliminary expenses, &c., a balance remains of £2,323. 9s., from which the Directors recommend a dividend of 6 per cent., less income tax, on the Ordinary Preference shares, £901. 17s. 2d., and 2 per cent., free of income tax, on the Ordinary shares, £1,290. 8s. 0d., carrying forward £137. 3s. 10d. The Provisional Order from the Board of Trade for powers of supply over the northern part of Kensington was duly obtained, and the Confirming Bill brought into Parliament; but, unfortunately, it had not passed through its final stages at the time of the recent dissolution, and it will therefore be proceeded with again during the present Session, no opposition being anticipated.

The Engineer and Manager, whose valuable services have before been referred to by the Directors, reports that the machinery, plant and mains are in good condition, and no accident of any kind has occurred.

Messrs. William Crookes and Sydney Waters offer themselves for re-election as Directors, as do the shareholders' auditors, Messrs. Fox, Sissons and Co.

Charing Cross and Strand Electricity Supply Corporation (Limited).

The report of the Directors of this Company for the year, to December 31st last, is issued, and will be presented at the meeting to be held at 2, Craig's-court, Charing Cross, W.C., on Monday next, at 12 o'clock:—

The Directors give a satisfactory report of the working of the Company for the year, and state that there has been a constant increase in the demand for current. On December 31, 1894, the Company were supplying current to the equivalent of 41,216 8 c.p. lamps, and on December 31, 1895, to 51,302 8 c.p. lamps, an increase of nearly 25 per cent., and 48½ per cent. over 1893. The supply station has been maintained in a high state of efficiency, but the Directors have decided to carry £3,000 to depreciation account.

The Provisional Order enabling the Corporation to supply electricity in the district of the Strand District Board of Works was granted by the Board of Trade, and the Bill confirming it passed a Committee of the House of Lords; owing, however, to the dissolution of Parliament, the Bill could not be dealt with by the House of Commons, by whom it will be considered in the present session of Parliament.

In view of the large increase in the business of the Corporation, a wharf and spacious premises, covering an area of 29,000 sq. ft., have been secured in the Commercial-road, Lambeth. The necessary alterations to render the premises suitable for an electric lighting station are now being made, and trunk mains laid connecting up the proposed station with the existing station of the Corporation at Maiden-lane.

The net earnings have amounted to £12,587. 3s. 11d. £700 has been written off preliminary expenses; £300 from law costs suspense account; £3,262. 10s. has been paid in respect of interest on Debentures up to December 31st last; and £2,899. 18s. 10d. was distributed in payment of an interim dividend at the rate of 4 per cent. for the half-year ended June 30th last. Out of the remaining sum of £5,729. 14s. 11d., it is proposed to pay a dividend (less tax) at the rate of £6 per cent. for the half-year ended December 31st, making, with the interim dividend paid in August, £5 per cent. per annum for the whole year (£4,350, 1s. 2d.), carrying forward £1,379. 13s. 9d.

Mr. Stefano Gatti and Mr. Richard Chadwick offer themselves for re-election as Directors, as do the auditors, Messrs. O. R. Johnson and Son.

HOOPER'S TELEGRAPH WORKS COMPANY (LIMITED).—Notice is given that all persons holding certificates of the bonus appropriation made in February, 1873, of the capital in the Great Western Telegraph Company (Limited), must apply at once to Mr. J. O. Chadwick (one of the trustees), 95, Finsbury-pavement, E.C., for the shares to which they are entitled of the proceeds of the above-mentioned bonus appropriation. The trustees retain the right of paying the balance remaining undistributed at the expiration of a calendar month from the 19th inst. into Court for the account of such claimants thereto as may appear and be admitted by the Court.

NEW COMPANIES, STATUTORY RETURNS, &c.

BROOK TIME-CHECKING CLOCK COMPANY (LIMITED).—This Company was registered on February 15th, with a capital of £5,000, in £1 shares, to acquire the invention of Mr. Frank Brook, for improvements in apparatus for checking or indicating the time of arrival and departure of workpeople, and also the business of a clock manufacturer carried on by the said Frank Brook at Market-street, Huddersfield, and to carry on the business of checking clock manufacturers, manufacturers of and dealers in electric batteries, electric clocks, and all electrical instruments and apparatus, electricians, &c. The first directors are: R. A. Robinson, Tom Brook, S. H. Robinson, A. Money, J. C. Arrol, Frank Brook and F. Marsland, all of Huddersfield.

ELECTRIC LIGHT INSURANCE AND MAINTENANCE COMPANY (LIMITED).—This Company was registered on February 14th, with a nominal capital of £10,000, in shares of £1 each, to enter into contracts for electric lighting and other purposes connected with electricity, for the supply of electrical energy for power or any other purpose, and for carrying out electrical installations, manufacturing, fixing, maintaining, selling, hiring or otherwise dealing with wires, lamps, secondary or storage batteries, and all other electrical appliances, and to enter into contracts and issue policies of insurance for the maintenance in proper order of all electrical appliances, and to repair and replace any of such appliances as may be defective or out of order. The subscribers, with one share each, are: W. M. Maxwell, T. C. Crawfoot, R. H. Webb, R. H. W. Hanna, W. Bowles, W. Webb and H. W. Webb.

HEADLAND'S PATENT ELECTRIC STORAGE BATTERY COMPANY (LIMITED).—The statutory return to February 12th has been filed. The whole nominal capital of £15,000, in £1 shares, has been taken up, and 14,993 have been issued as fully paid. The full amount has been called on the remaining seven shares.

WESTRALIAN ELECTRIC LIGHTING AND SUPPLY COMPANY (LTD).—The statutory return to January 23rd has been filed. Out of a capital of £80,000, in £1 shares, 70,000 have been taken up, and 40,000 are considered fully paid. The full amount has been called on 4,400 shares, and 10s. per share on the remaining 25,600.

WIMSHURST, HOLLICK AND CO. (LIMITED).—The annual return to January 3rd has been filed. The capital is £40,000, in 4,000 Ordinary and 4,000 Preference shares of £5 each. All the Ordinary have been issued as fully paid, and the full amount has been paid on 895 Preference shares.

CITY NOTES.

BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).—The transfer books of the First Debenture Stock of this Company are closed from the 19th inst. to the 3rd prox. inclusive.

CITY AND SOUTH LONDON RAILWAY COMPANY, (LIMITED.)—The traffic returns of this Company for the week ended February 16th were £949, against £998 in the corresponding week of 1895, a decrease of £49. The total receipts for the half-year amount to £6,946, against £7,039 for the corresponding period of 1895, a decrease of £93.

GREAT NORTHERN TELEGRAPH COMPANY.—The coupons falling due on March 1st on the 1883 Debentures (Series B) of this Company, will be paid at the office of Messrs. C. J. Hambro and Son, 70, Old Broad-street, E.C., where lists may be obtained. Coupons must be left three clear days for examination.

ISLE OF MAN TRAMWAYS AND ELECTRIC POWER COMPANY (LIMITED).—Notice is given that the Directors of this Company intend to apply, at an extraordinary general meeting of the shareholders, for sanction to purchase the Snaefell Mountain Railway. The purchase money has been fixed at £72,500, payable in cash and shares. The capital of the Company is to be increased to £175,000.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended the 16th inst. amounted to £1,134. The amount for the corresponding week last year was £843. Increase, £291.

SANITAS COMPANY (LIMITED).—The Directors of this Company recommend the payment of a final dividend of 1s. and a bonus of 9d. per fully-paid share, making, with the interim dividend already paid, a total distribution of 13¾ per cent. for the past year.

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to appoint a special settling day in the shares of the Sulphide Corporation (Ashcroft's Process), Limited, and the Westralia Electric Lighting and Supply Company, Limited. The Committee have also ordered the further issue of £34,000 sterling Four and a-Half per Cent. First Mortgage Debentures (Nos. 1201 to 1540) of the Royal Electric Company of Montreal to be quoted in the official list.

TRAMWAYS UNION COMPANY (LIMITED).—The report of the Directors of this Company states, in reference to the circular addressed to the shareholders on July 1st last on the question of electric traction, that considerable progress has been made towards obtaining the necessary powers therein alluded to. A meeting of the shareholders of the Company takes place at Winchester House, on Tuesday next, at 2:30 p.m.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY, (LIMITED).—This Company's traffic receipts for the week ended February 14th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,818.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half-month ended February 15th are £2,698, against £2,835 in the corresponding period of 1895. The October receipts, estimated at £4,257, realised £4,281.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Feb. 12.	Price Wednesday, Feb. 19.	Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending Feb. 15. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	18/0	Anglo-American ..... xd	47 49	46 48	5 4 2	Jan., Apr., July, Oct.	48	47½
£2,993,560	Stock	36/0	Do. Preferred ..... xd	83½ 89½	87 88	5 13 8	" "	89½	87
£2,993,560	Stock	5/0	Do. Deferred	7⅞ 8	7⅞ 8	..		..	..
£175,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)....	100 104	100 104	3 17 4	January and July ..	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	10 10½	10½ 10⅝	..		10⅝	10⅛
130,000	£10	3/0	Brazilian Submarine	14 14½	14 14½	4 15 8	Mar., June, Oct., Dec.	14⅝	14
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110 114	110 114	4 12 9	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	160 170	160 170	4 2 10	Jan., Apr., July, Oct.	163	162½
16,000	10	3/0	Cuba Submarine ..... xd	12½ 13½	12½ 13½	5 14 4	February and August	13 7/16	13½
6,000	10	10%	Do. Preference 10 per Cent. ..... xd	20½ 21½	20½ 21½	4 13 0		..	..
12,931	5	2/0	Direct Spanish (fully paid)	4 5	4 5	4 0 0	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 8	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104% 107%	104% 107%	4 4 5		..	..
60,710	20	2/0	Direct United States Cable, 1877	9 9½	9 9½	4 4 3	Jan., Apr., July, Oct.	9⅜	9
400,000	10	2/6	Eastern	17 17½	17 17½	3 14 4		17⅝	17½
70,000	10	6%	Do. 6 per Cent. Preference	18 18½	18 18½	3 4 10	" "	18⅝	..
£1,227,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	127 130	128 131	3 1 8	May and November	129⅝	129½
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899.....	105 108	105 108	4 12 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17½ 18	17½ 18	3 17 9	Jan., Apr., July, Oct.	17½⅜	17⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	126 129	127 130	3 1 8	February & August	127⅛	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900	100 104	100 104	4 16 7	January and July ..	..	..
£30,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb.,1900 .	100 104	100 104	4 16 7	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) ..	105 108	105 108	3 14 1	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 115%	3 10 2	May and November	..	..
180,227	10	1/6	Globe Telegraph and Trust	10 10⅛	10 10⅛	3 18 6	Jan., Apr., July, Oct.	10⅛	10⅛
180,042	10	6%	Do 6 per Cent. Preference	16⅛ 17	16⅛ 17	3 10 7	" "	16⅝	16⅜
150,000	10	5/0	Great Northern.....	22½ 23	22½ 23	3 14 9	Jan., April, and July	23	23⅛
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue.....	104 107	104 107	4 15 6	March & September	..	..
17,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	48⅛	47
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	107 111	107 111	5 10 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942..	108 111	108 111	3 12 5		..	..
11,889	8	4/0	Reuter's	4½ 5½	5 6	..	April and October..	..	..
3,881	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	127 132	128 133	4 10 3		..	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	..	January and July ..	..	..
£238,800	100	5%	* Do. 5 per Cent. Debentures (red.).....	101 104	101 104	4 18 3	March & September	..	..
30,000	10	2/0	West Coast of America	1 2	1 2	..	January and July ..	..	..
£150,000	100	3%	Do. 3 per Cent. Debentures, 1902	94 99	94 99	3 3 3	June and December	..	..
88,321	10	1/3	West India and Panama	1 1½	1 1½	..	..	1⅜	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 11	10½ 11	5 8 1	May and November	11	10½
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108 111	108 111	4 10 8	June and December	..	..
64,248	15	3/0	Western and Brazilian	8⅜ 9⅛	8⅜ 9⅛	5 5 8	May and November	9⅛	8⅜
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	..		..	..
33,129	7½	1/6	Do. Deferred Ordinary.....	3 3½	3 3½	..		..	..
£165,300	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	102 106	102 106	5 13 2	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	102 106	102 106	5 13 2	" "	..	..
£1,177,000	£1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds....	113 118	113 118	6 0 8	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	102 105	1 14 107	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3⅛ 3⅜	3⅛ 3⅜	..		..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance ..	1/16 1/8	1/16 1/8	..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid).....	1/16 1/8	1/16 1/8	..	Yearly	..	..
484,597	5	2/6	National	6⅛ 6¼	6⅛ 6¼	3 12 9	June and December	6⅜	6⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)....	16 17	16 17	3 10 7	" "	..	..
119,224	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅛ 6⅜	6⅛ 6⅜	3 12 9		..	..
1,100,000	Stock	5⅛%	* Do. Debenture Stock, 4½% (red.)	104 107	104 107	3 5 9	January and July	105½	105
58,000	5	3/0	United River Plate	3 3⅛	3 3⅛	..	" "	..	..
£146,783	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.).....	94 99	93 98	5 2 4	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	14 15	14 15	1 18 4		14⅝	14½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid).....	16 17	16 17	3 10 7		16½	16⅜
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	134 138	134 138	3 12 10	June and December	..	..
19,900	£5	..	Electricity Supply Co. for Spain.....	.. ..	.. ..	..		..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5½ 5⅝	5⅝ 6⅛	..		5 7/16	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..		..	..
22,475	£8	..	County of London & Brush Prov. Ord. (fully paid).	8 9	8 9	..		..	..
10,000	£10	9½d.	Do. Pref. (£8 paid)	10⅛ 11	10⅛ 11	..		..	..
8,822	£5	..	House-to-House Electric	.. ..	.. ..	..		..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	.. ..	.. ..	..		..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid).....	.. ..	.. ..	..	January and July ..	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 8⅛	7⅞ 8⅛	3 13 10		..	..
111,000	5	..	London Electric Supply.....	.. ..	.. ..	..		..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	12 12½	12 12½	2 18 1		12⅝	12 1/16
£150,000	Stock	4½%	* Do. 4½% Debs.	115 118	115 118	3 16 6	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9	8½ 9	..		..	..
..	..	..	Rand Electric	½ ⅝ prem.	1/16 1/8 prem	..		..	..
19,980	£5	5/8	St. James and Pall Mall	9½ 10	9½ 10	..		10	9⅝
20,000	£5	7%	Do. 7 per Cent. Preference.....	9 9½	9 9½	3 13 8		9⅝	..
59,900	5	2/6	Westminster Electric Supply (fully paid)	8½ 9⅛	9½ 9⅝	3 11 10		9⅝	9½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	8	1/6	Brush Electrical Engineering	1 1½	1 1½	12 1 0		1	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1½ 1⅝	1½ 1⅝	6 17 3		1 11/16	1 1/16
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures.....	113 115	112 115	3 19 10	March & September	115	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref..	2½ 2⅝	2½ 2⅝	..	January and July ..	2⅝	..
89,261	5	1/6	Edison and Swan United..... xd	1⅝ 1	1½ 2	..		..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	103 106	104 106	4 5 6		102	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	.. ..	.. ..	..		..	..
110,000	2	..	Electric Construction.....	3/16 1/4	3/16 1/4	..		..	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2 2⅛	5 11 0		..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	5/16 7/16	5/16 7/16	..		..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1/2 5/8	1/2 5/8	..		..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	20½ 21½	20½ 21½	3 9 9	February & August	21½	20⅜
£300,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 17 1	March & September	..	..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	..		..	..
16,000	£10	..	Do. 8 per Cent. Preference.....	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid).....	1/8 1/4	1/8 1/4	..		..	..
37,350	12	12/0	Telegraph Construction and Maintenance	38 41	38 41	5 17 0	March and July.....	45½	38
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	102 105	4 15 8	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)..	.. ..	.. ..	..		..	..
41,098	£5	..	Do. Preference (fully paid).....	.. ..	.. ..	..		..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary.....	13½ 14½	13½ 14½	4 2 9		14⅝	14½
£30,000	10	7/0	Do. 7 per Cent. Preference	16 17	16 17	4 2 4		16⅝	..
£50,000	Stock	4½%	Do. 4½% Mort ge Debenture Stock.....	108 111	109 112	4 2 0		..	..
			RAILWAYS AND TRAMWAYS.						
£680,000	Stock	1½%	City and South London Railway Con. Ordy.	40 42	40 42	2 16 6	May and November	41½	40½
7,650	10	5%	Do. 5% Perpetual Preference	14½ 15	14½ 15	3 6 8	..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130 132	130 132	3 1 2	May and November	132	..
25,500	£10	3½%	Liverpool Overhead Railway	13⅞ 13⅞	13⅞ 13⅞	2 5 10		..	..
10,000	10	5%	Do. 5% Preference	16 16¼	15⅞ 16	3 2 6		..	..
125,000	Stock	4%	Do. 4% Debenture	112 114	112 114	3 10 2	January and July ..	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

QUITE by the way, and in answer to a hardy-annual type of question by a Mr. TULLY, the Secretary to the Treasury, as representing the POSTMASTER-GENERAL, made on Monday evening an important announcement in regard to the telephonic policy of the Post Office. It was not, he said, the intention of the Government to take over the entire telephone business of the country before the expiration of the National Telephone Company's licence on December 31st, 1911. That being so, we trust that in the interests of the public and of telephonic progress, the Post Office will, at any rate, permit a few experiments, such as a municipal exchange or a rural network erected by local capital. Between the dead-weight of an over-capitalised, over-grown company, and the lack of interest of an over-burdened Government department, we are in danger of an aggravated attack of telephonic torpor. We shall hope to see the Department rise superior to purely pecuniary considerations, and taking a large view of what constitutes "a satisfactory service," grant local licences with no niggard hand, even though the departmental income derived from that 10 per cent. levy on the gross receipts of the National Telephone Company might conceivably suffer a microscopic diminution.

DRY batteries have so many theoretical advantages that it is not surprising to find new types of cell being brought forward from time to time, which promise some superiority over their predecessors. Dr. LESSING's dry cell is one of the latest examples; and upon another page will be found a lengthy report on its merits by Dr. WALMSLEY. The misleading results that are liable to arise by testing only one cell of any particular type are well illustrated by the various measurements that are given of E.M.F. and internal resistance, which differ considerably among themselves. On that account it would have been preferable to test each cell separately rather than in groups of three in series. It will be observed that the internal resistance is initially low; but the polarisation appears to be somewhat rapid, and the life, when supplying a current continuously, is shorter than might have been expected. The cell, however, seems to be well made; it shows no sign of bursting when supplying a relatively large current, and would probably last well when used for intermittent work. The true commercial test, however, must be that of its life under ordinary working conditions, and this test cannot be more than approximately imitated by laboratory experiments, although these are of some interest in themselves. An ordeal which dry cells have not hitherto come out of very well is the very common one of being left to themselves for a few weeks or months; when called on to do a little work after a prolonged period of rest they too often fail to exhibit any signs of life whatever—a very irritating idiosyncracy.

IN last week's *Nature*, under the title of "Science and Morals," Prof. RAMSAY raises an issue of considerable and increasing importance. It is, says Prof. RAMSAY, becoming more and more the custom after the announcement of an interesting discovery, for a number of persons to at once proceed to make further experiments and to publish their results. To Prof. RAMSAY "it appears fair and courteous, before publication, to request the permission of the original discoverer, who probably has not merely thought of making identical experiments, but who has in many instances made them already, and has deferred publication until some grounds exist for definite conclusions." "No original idea undeveloped is," he truly observes, "of much value; before it produces fruit much work must be expended; and it is precisely after the publication of the original idea, that sufficient time should be allowed to elapse, so as to give the author time to develop his idea, and present it in a logical and convincing form." All this and much more may be conceded in a general way, but there is much that is vague in Prof. RAMSAY's phraseology, and having been bold enough to openly raise this delicate question, it would be as well if he were to go on and state definitely what he complains of in regard to his own invaluable researches on argon. Certainly we should not without Prof. RAMSAY's exegesis have given Prof. ARMSTRONG's remarks at the Chemical Society in 1894 the sinister meaning it is alleged they bear. As a precaution against scientific breaches of the eighth commandment Prof. RAMSAY thinks it may be necessary to make heavy investments in extra-strong laboratory locks and to abandon "the pleasant and friendly intercourse which is now universal" among scientific men.

HAS not Prof. RAMSAY mixed up two charges in his indictment? The eagerness with which any new scientific discovery is seized upon by pushing persons as a means of advertising themselves and of acquiring experimental fame at a cheap rate is, indeed, a well-marked and regrettable characteristic of the present day. But must not the blame for this

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ugly symptom be in a measure laid at the door of the discoverers themselves? Do they not habitually indulge in premature publication of "original ideas undeveloped" in order "to take date"? "Sufficient time" for further development ought, of course, to be allowed even to the maker of the crudest suggestion, but who is to settle what is sufficient? Better by far to defer publication until one can safely defy interference. The second half of the indictment is decidedly more serious and more definite than the first, and the allegation is one that has been unpleasantly rife of late in the usual *sub rosa* fashion. It simply amounts to this: Such is the low state of morality in scientific circles at the end of the nineteenth century that an investigator cannot talk to a friend about that which most occupies his thoughts for fear lest his friend should straightway appropriate the germinating idea. If such breaches of social law are in truth as frequent as some would have us believe, we ought not to shrink from ostracising a prominent offender here and there; one or two examples would, in all probability, prove effectual.

In the tangle of facts and hypotheses which has collected round that thorny and attractive nucleus the essential reactions occurring in a common storage cell, much that is true or may be called good guessing is mingled with many dubious "facts" and untenable theories. A clue to the maze was thought to have been found when some persevering investigators discovered persulphuric acid in the electrolyte, and made known its properties to the electrical world. It was felt that a substance produced by the electrolysis of ordinary sulphuric acid, powerfully oxidising in its action and pleasingly unstable, was a very godsend. To the cautious student possibilities suggested themselves which were well worth the pains of experiment. Many investigations have been made from time to time, and much controversy has resulted. The latest word limits the scope of persulphuric acid in the accumulator in a marked degree. Elbs and Schönherr, in a Paper recently published in the *Zeitschrift für Electrochemie*, point out that experiments on the production of persulphuric acid performed with platinum electrodes cannot be used to foretell what will happen with lead electrodes. With the latter the yield is much smaller, the difference being indeed so great that no maker of persulphates (which are now articles of minor trade) would venture to substitute lead for costly platinum. Further, persulphuric acid is not only capable of peroxidising lead, but it may fulfil the opposite function and reduce lead peroxide The authors quoted deny in the clearest terms that persulphuric acid plays any significant part in the reactions of a lead storage cell, but they concede it a possible mischievous activity in destroying lead frames, presumably by its double-faced tendency to oxidise or reduce according to its company. To rehabilitate this substance a stout champion will be needed; he must, indeed, be *ion*-clad.

Our contemporary, *Nature*, a publication of irreproachable sobriety, has given modest space to a paragraph purporting to foreshadow the possibilities of an electrolytic method for making chlorate of potash, known by the name of the Blumenberg process. From this pronouncement we learn that the chlorate of potash is produced "by the action of the direct electric current upon tanks of potassium chloride"; that "important by-products are also obtained"; further, that the Alkali Union has reduced the price of the chemically-made salt "from 17 to 10 cents a pound"; while, lastly, there rings forth this knell of foreboding, that in spite of the spirited action of the Union "the new manufacturers will probably undersell them in all the markets of the world." That the application of the process is "another of the wonderful potentialities of the Niagara water power" goes without saying. For roundness and precision of statement the paragraph is exemplary, but as a means of slaking legitimate curiosity it is sadly lacking. Electrolytic processes for the manufacture of chlorate of potash we have always with us. One or two are even said to have survived their infancy, but as far as authentic information goes the market has not been wholly swamped by their output. Seeing that vast trade changes are said to be imminent—changes tending to the glory (and profit) of the electrolytic industry—we may perhaps be pardoned if we follow the good example set by Oliver Twist and ask for more wherewith to satisfy our curiosity as to the nature of the process and the status of its exploiters. Indeed, for the boldness of its predictions and the meagreness of its information, this paragraph would do credit to a latter-day prospectus.

As many enquiries are being made in regard to Sir John Pender's condition, we may say that, while his bodily health has improved, the power of speech and writing has not, so far, returned.

The Dalkey Electric Line.—On Friday last the inaugural trip over the electric lines, viâ Pembroke, Blackrock, Kingstown and Dalkey took place.

The French Association for the Advancement of Science.—The French Association for the Advancement of Science is this year holding its meeting in Tunis from April 1st to 4th next.

Röntgen Radiation.—The March number of the *Photographic Review* contains a large amount of illustrated literature, of the lighter and more popular order, dealing with the photographic side of the new radiation.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Puerto Plata—Martinique...	December 19, 1895 ...	—
Perim—Obock ...	... January 2, 1896 ...	Jan. 27, 1896
Odessa—Constantinople	... January 17, 1896 ...	Feb. 17, 1896

Appointments.—Prof. J. J. Thomson, F.R.S., has been elected Rede lecturer at Cambridge University for the present year.——Prof. Ramsay has been appointed an Elector to the Jacksonian Professorship of Natural Philosophy at Cambridge.

The Northern Society of Electrical Engineers.—The adjourned discussion on Mr. Robert Hammond's Paper on the "Paralleling of Alternators," read by him before this Society on the 10th inst. at Manchester, will now take place on Monday, March 9th, instead of Monday, March 2nd.

Electro-Optics.—A course of four lectures on "Recent Advances in Electro-Optics" is announced for delivery by Prof. Silvanus Thompson at the Finsbury Technical College on Thursday evenings in March. These lectures will deal with the experimental work of Hertz, Lodge, Tesla, Lenard, and Röntgen. Particulars will be found in our advertising columns.

Appointment Vacant.—Owing to the appointment of Prof. W. Wilson, M.A., as principal of the Municipal Technical School, Salford, the Professorship of Electrical Engineering and Applied Physics at the Merchant Venturers' Technical College, Bristol, will shortly become vacant. Commencing salary, £250

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per annum. Applications by Tuesday, March 11th. Some further information is given in our advertisement columns.

The Hopkinson Three-Wire Patent.—The time for caveats in connection with the petition for the prolongation of the Hopkinson three-wire patent, due to expire in July next, terminated on Monday last. We understand that notices of opposition have been lodged by the Corporations of Glasgow, Hull, Bradford and Dundee, and by the National Electric Supply Company of Preston. The motion before the Judicial Committee of the Privy Council is not yet entered in the list, and cannot therefore be heard before Easter.

Electrical Bills in Parliament.—The total number of Electric Lighting Provisional Order Bills relating to England, Ireland and Wales before Parliament this session amounts to 38, the capital for carrying out these schemes being placed at about 1¼ millions sterling. There are 22 Tramway Bills relating to the construction of 103 miles of tramway, and the raising of capital to the extent of about 2⅓ millions sterling. In more than one-half of these schemes electric traction is contemplated. Besides the 22 Bills, there are 15 Tramway Provisional Orders asked for, in nine of which electric traction is specifically mentioned

The Jandus Arc Lamp.—We have received from Messrs Drake and Gorham a copy of a report of this lamp made by Prof. Houston and Mr. A. E. Kennelly. These gentlemen state that they found the average rate of burning of the positive carbon (½in. diameter solid) to be 0·057in. per working hour, and of the negative carbon (½in. diameter solid) 0·015in. per working hour. The average current was 5·60 amperes, and the power consumed at 110 volts pressure was 616 watts. The pressure between the carbons of the lamp when in operation averaged about 80 volts, and the resistance permanently inserted in the lamp effected a drop of pressure of approximately 30 volts, thus enabling the lamp to be used on a 110 volt circuit. They found the arc to be very quiet, and rarely to flicker. In measuring the candle power of this lamp, both globes were of clean and clear glass. The *maximum* candle power observed in any position was 1,295 standard British candles. For a detailed description of this lamp see *The Electrician* of November 1, 1895, p. 11.

Students' Conversazione at the Finsbury Technical College.—This *conversazione* which was held on Thursday, February 20th, proved a grand success. Perhaps the best part of the evening's entertainment was the lecture by Prof. Silvanus P. Thompson, on "Invisible Light and its Photography," which he had to deliver twice. Prof. Thompson showed various experiments with different vacuum tubes, and explained all about Röntgen rays. He actually took a shadowgraph of a few coins and keys through a piece of cardboard, and showed several of hands, feet, &c., which he had lately taken at the College. During the lecture he repeated the experiments of Prof. A. Righi, of Bologna, which were described in last week's *Electrician*. Amongst the exhibits were some automatic electric welders shown in operation by the Electric Welding Company. A number of samples welded by the process were on view, amongst which we noticed carriage tyres, butt-welded iron and steel tubes, samples of welded iron rods, bent double at the weld without cracking, and a good assortment of chains; also a unique collection of welds on finished gun parts, which is said to be quite a new departure. Mr. Robert W. Paul exhibited an apparatus for the production of "living photographs" thrown upon a screen by means of an electric lantern.

Expiring Patent.—On Friday next, March 6th, will expire patent No. 1,079, of 1882, granted to William Crookes, F.R.S., for "Improvements in the Construction and Manufacture of Incandescent Electric Lamps and in Apparatus used therewith." Among the claims are the following: "First: The production of carbon filaments for incandescent lamps from animal fibres such as silk, hair, wool, silk-worm gut, or animal matters such as horn or gelatine and parchment, by treating such materials with cuprammonia or other solvent, and then carbonising them. Second: The production of carbon filaments for incandescent lamps by the carbonisation of cellulose or like matter precipitated from solution in cuprammonia or other solvent. Third: The method of forming the junction between the carbon filament and the conducting wires by the use of a cement of graphitoidal carbon. Ninth: The process of improving and strengthening carbon filaments by depositing carbon thereon from a chloride of carbon or, it may be, a bromide of carbon. Twelfth: The method of at one operation equalising and measuring the resistance of carbon filaments, by arranging them in series and coupling them with resistances in a Wheatstone bridge arrangement, then applying an electric current, by which the filaments are raised to incandescence in contact with carbonaceous vapour, and continuing the current until it appears by the indicator of the arrangement that a balance has been obtained."

The Electrical Drying of Fruit.—There would appear to be a good opening for the use of electric heating in connection with the fruit trade. It is well known that fresh-gathered fruit must be dried before being packed. This process, although an apparently simple one, necessitates great care, and the temperature must be well regulated, otherwise there is danger of the fruit being damaged. Large drying rooms are in use in some cases, heated by means of steam, and although this system may be cheap to work on a large scale, it is not always so satisfactory on a small one. Fuel, moreover, is often expensive, and water power, in parts where the fruit trade flourishes, is usually abundant. In such situations electric heating could be used with advantage. The perfect regulation allows of any temperature being obtained, and, what is of great consequence in such an installation, practically no attention would be required. The electrical plant, too, could be used for lighting, and a few motors to aid the packing could easily be laid down. Uses such as this offer a fine field for development, and the gain made by bringing in cargoes of sound fruit would far more than cover the cost of running the necessary machinery. The above remarks have special reference to the storing, packing and shipment of fruit to the English market; but the same treatment as to drying might well be adopted in connection with our English fruit gardens, and it is quite possible that some such process might materially assist in making our orchards more profitable, and lead to extensions so much to be desired.

The Telephone in Parliament.—On Monday evening Sir J. Brunner asked the Secretary to the Treasury, as representing the Postmaster-General, whether it was the intention of the Department, after the transfer of the telephone trunk lines from the National Telephone Company, to close these trunk lines at the hours of closing of the various post offices, and thus to deprive a large body of subscribers of the convenience hitherto enjoyed by them of making use of the telephone at all hours of the night. Mr. Hanbury replied that from the best information in the hands of the Post Office it appeared that, except in a few cases, the telephone trunk wires were scarcely ever used at night, and the Department would not, therefore, be justified in going to the expense of providing attendance after the ordinary official hours. In the first instance, therefore, it was proposed that the hours for telephone business should be the same as for telegraph business; but the Department would give careful attention to the matter and ascertain where the requirements of the public justified an extension of the hours. At many of the larger offices the telegraph service was open to the public all night, and there, of course, the telephone service would also be open. ——On the same evening Mr. Tully asked the Secretary to the Treasury, as representing the Postmaster-General, whether he could state what steps the Post Office authorities proposed to take in reference to the numerous complaints as to the inefficiency and expensiveness of the telephone service supplied by the National Telephone Company; and whether it was the intention of her Majesty's Government to terminate the monopoly of this Company by taking over the entire telephone business as was done in the case of the telegraphs. Mr. Hanbury replied that if it were proved in any case that the Company were not affording a satisfactory service, the Government would be prepared to consider the question of the establishment of a limited competition by the Post Office. It was not the intention of the Government to take over the entire telephone business before the expiration of the Company's licence.

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ELECTROMAGNETIC THEORY.—LXXXIII.*

BY OLIVER HEAVISIDE.

(*Continued from page 406.*)

§ 331. It is often to be observed that a property, first noticed in a special case, then in others, if it be really a general property, admits of simple proof. Perhaps the more general the property the simpler the proof. The last equation is an example. It is a particular case of the known reciprocal relation between the two solutions of the ordinary equation of the second degree. The proof is simplest in terms of V and C. Thus, let

$$-\frac{d\mathrm{V}}{dx}=\rho\mathrm{C}, \qquad -\frac{d\mathrm{C}}{dx}=\kappa\mathrm{V}, \tag{18}$$

be the connections. Here ρ and κ are, in the simplest case, the resistance of the wires and the conductance of the insulator, per unit length of circuit. They may be any functions of x. More generally they are operators, functions of p the time differentiator, when variable states are concerned, as well as functions of x. The characteristic of V is

$$\frac{1}{\kappa}\frac{d}{dx}\frac{1}{\rho}\frac{d\mathrm{V}}{dx}=\mathrm{V}. \tag{19}$$

Now let v_1, c_1 and v_2, c_2 be any two solutions subject to (18). Then, since

$$-\frac{d}{dx}(v_1c_2)=-v_1\frac{dc_2}{dx}-c_2\frac{dv_1}{dx},$$

we have, by (18),

$$-\frac{d}{dx}(v_1c_2)=v_1\kappa v_2+c_2\rho c_1. \tag{20}$$

Similarly,

$$-\frac{d}{dx}(v_2c_1)=v_2\kappa v_1+c_1\rho c_2. \tag{21}$$

Now if we make p be a constant, and the *same* constant in the two systems, κ and ρ become identical functions of x in the last two equations, so that the right members are the same. Therefore

$$\frac{d}{dx}(v_1c_2-v_2c_1)=0, \tag{22}$$

and consequently

$$v_1c_2-v_2c_1=m, \tag{23}$$

where m is constant. This is the reciprocal property.

If the two systems coexist, making $v=v_1+v_2$, and $c=c_1+c_2$ be the voltage and current, the product vc is the total energy flux, and its rate of decrease with x is its leakage, or the activity per unit length of circuit. It consists of the sum of the leakages from v_1c_1, v_2c_2, v_1c_2 and v_2c_1; and the reciprocal property in the form (22) asserts that the parts depending on cross products are equal. When p is real, the systems are real, and their energy, &c. When p is imaginary, the best way is to imagine it to be real, for the sake of the electrical argument. It is easy to generalise the property by extension to space distributions of electric and magnetic force, but we do not want that at present.

That p is to be the same constant in the two states, limits us to any two solutions of the ordinary equation which the characteristic (19) becomes, when the differentiator p is replaced by a constant. For example, ϵ^{qx} and ϵ^{-qx}, or combinations; $\mathrm{I}_0(qx)$ and $\mathrm{K}_0(qx)$, or combinations; and so on to other kinds. In terms of the v's only, the reciprocal property is

$$v_1v'_2-v_2v'_1=-m\rho, \tag{24}$$

where the accent indicates differentiation to x; and, in terms of the c's only, it is

$$c_1c'_2-c_2c'_1=m\kappa. \tag{25}$$

Thus (24) relates to the two solutions of (19), and (25) to those of the corresponding characteristic for c, which is not the same. If the two v solutions taken specially are in constant ratio, m vanishes, of course. When not in constant ratio, they are said to be independent. The independence is, however, of a limited nature, since, when one is given, another can be deduced by the reciprocal property.

§ 332. By means of the reciprocal property we are enabled to obtain the operational solutions for sources e and h. It will be convenient to denote two independent solutions by u and w, instead of v_1 and v_2, so that the property is

$$uw'-wu'=-m\rho. \tag{26}$$

Now there is a discontinuity at a source, so two forms of solution for the potential are required, say

$$\mathrm{V}_1=(u_x-\alpha w_x)\mathrm{A}, \qquad \mathrm{V}_2=(u_x-\beta w_x)\mathrm{B}, \tag{27}$$

where V_1 is on the left side of the source and V_2 on the right. These are operational, p meaning the time-differentiator, α and β unknown operators, A and B unknown time-functions.

Specialise the source to be h at y. This makes $\mathrm{V}_1=\mathrm{V}_2$, and $h=\mathrm{C}_2-\mathrm{C}_1$ at y. Applying these conditions to (27), using the reciprocal property (26), we produce

$$\mathrm{V}_1=\frac{(u_x-\alpha w_x)(u_y-\beta w_y)}{m(\alpha-\beta)}h, \tag{28}$$

$$\mathrm{V}_2=\frac{(u_x-\beta w_x)(u_y-\alpha w_y)}{m(\alpha-\beta)}h, \tag{29}$$

which are explicit when α and β are known.

When the source is e at y, which makes $\mathrm{C}_1=\mathrm{C}_2$ and $e=\mathrm{V}_2-\mathrm{V}_1$ at y, we similarly produce the results

$$\mathrm{V}_1=\frac{(u_x-\alpha w_x)(u'_y-\beta w'_y)}{m\rho(\alpha-\beta)}e, \tag{30}$$

$$\mathrm{V}_2=\frac{(u_x-\beta w_x)(u'_y-\alpha w'_y)}{m\rho(\alpha-\beta)}e. \tag{31}$$

The value of the constant m depends upon the standardisation of the functions u, w. It can be found as soon as they are given, by inserting them in the reciprocity equation. Only the commencement of the series need be used.

The operator α is determined by V/C at any point on the left of the source, and β similarly by V/C at any point on the right. Say $\mathrm{V/C}=-\mathrm{Z}_0$ at λ, and $=\mathrm{Z}_l$ at l, then

$$\alpha=\frac{u_\lambda-(\mathrm{Z}_0/\rho)u'_\lambda}{w_\lambda-(\mathrm{Z}_0/\rho)w'_\lambda}, \qquad \beta=\frac{u_l+(\mathrm{Z}_l/\rho)u'_l}{w_l+(\mathrm{Z}_l/\rho)w'_l} \tag{32}$$

By means of Z_0 and Z_l, we allow for the action of all the parts of the electrical system beyond the limits upon the part between them. That is to say, the operational solutions are complete for the region between λ and l, so far as the source e or h is concerned. The conversion to series of normal solutions is to be done in the usual way, and initial states of potential and current by $e=p\mathrm{P}$, $h=p\mathrm{Q}$, as before described.

Comparing the present investigation with that in § 330, we see that u is represented by $\mathrm{I}_0(qx)$ and w by $\mathrm{K}_0(qx)$, and that the constant m is $2/\pi\mathrm{Z}$. It is constant as regards x. It contains p (or may do so).

§ 333. Returning to the Bessel investigation of § 330, which contains most of the fundamental formulæ involving the zeroth Bessel functions of both kinds, by means of certain equivalent transformations we can develop the whole body of results, ordinary and extraordinary. But before doing that, it is desirable to point out that the formulæ are not merely those concerned in the theory of a telegraph line of a variable nature, of no practical use, but belong to cylindrical electromagnetic waves in general. Moreover, they do not do so by mere analogy, but, by proper interpretation of symbols, the two theories may be seen to be one and the same essentially.

Thus, I have shown in § 206, Vol. I., how, in the transmission of plane electromagnetic waves through a conducting dielectric, any tube of energy flux may be isolated from the rest and made independent, by enclosing it in a conducting tube made of two materials. The electric displacement in the tube must terminate perpendicularly upon perfect electric conductors forming two sides of the tube, and the magnetic induction upon perfect magnetic conductors forming the other two sides of the tube. Also, the electric force is tangential to the two magnetic conductors, and the magnetic force to the two electric conductors, whilst the two forces cross one another perpendicularly within the tube. Under these circumstances the internal plane waves are made self-supporting, guided by the tube. The internal state is like a beam of light, with lateral spreading prevented.

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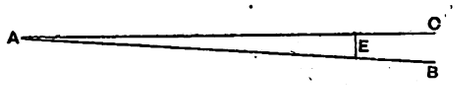
We may conveniently take the tube to be of square section for plane waves. Then the lines of force are straight. But in the present application, the tube must be imagined to be of the shape of a wedge. It increases in section regularly as we pass along it, but two of its flat sides remain equidistant, whilst the other two separate. Looking at the tube in section along its length, A B and A C represent the traces of the separating sides, to be called the top and bottom, whilst the others are parallel to the plane of the paper, and may be called simply the sides.



Now let straight lines of **H** join the sides, or be perpendicular to the plane of the paper. The **E** lines must then join the top and bottom, and be circular, centred at A, as at E in the diagram. Also, let E and H, the intensities of **E** and **H**, be the same at the same distance from A. Under these circumstances we shall have propagation of electromagnetic waves in the tube according to the formulæ given.

For, consider how the inductance and permittance of the tube vary. The current C is the same as H × depth of tube, being the transverse gaussage. The "potential" V, with an enlarged meaning of potential, is E × by length of arc concerned, or the transverse voltage. The inductance (per unit length of tube) varies directly as x, the distance from A, because the section of the tube of induction belonging to unit length of the tube of energy flux varies as x, whilst its length is constant. On the other hand, the permittance varies inversely as x, because the section of the corresponding tube of displacement is constant, whilst its length varies as x. The circuital equations are therefore

$$-\frac{dV}{dx} = Lxp C, \qquad -\frac{dC}{dx} = \frac{S}{x} pV, \tag{33}$$

if Lx and S/x are the inductance and permittance per unit length of tube, L and S being constants, the values of the same at $x=1$. The above makes no allowance for any conductivity within the tube, which is itself merely a guide.

Next, let the medium in the tube be uniformly conducting, both electrically and magnetically. Then the magnetic conductance will vary like L, that is, as x; and the electric conductance will vary like S, or as x^{-1}. We shall therefore make the circuital equations take the form

$$-\frac{dV}{dx} = (R + Lp)xC, \qquad -\frac{dC}{dx} = (K + Sp)\frac{1}{x}V, \tag{34}$$

if Rx and K/x are the magnetic and electric conductances per unit length of tube. So far is an exact theory. The reader should study Chapter IV., or the part relating to the transformation of the circuital equations in general to the special forms for plane waves along wires, and the interpretation of the quantity called magnetic conductivity. It is the same theory now, only applied to a tube of energy flux of variable section.

If we remove R from the inside of the tube, and substitute equivalent electric resistance in its top and bottom, the equations remain approximately true when the angle of the wedge is small, and the distance x not too great. It is now the theory of waves along a pair of finitely resisting electric conductors through an electrically conducting dielectric medium. If we remove K too, we must substitute equivalent magnetic resistance in the other pair of conductors, the side pair. But since K expresses a really existent property, it is no use doing that. Therefore retain K within the tube.

The depth of the wedge is immaterial. Make it infinite, and do away with the side magnetic conductors altogether. The wedge now consists of two planes (top and bottom) inclined at an angle. The magnetic flux is endless, which is equivalent to being circuital. If, now, in addition R is zero, the angle of the wedge becomes immaterial. This is also the case when R is not zero, provided it be in the tube of energy flux, and not at top and bottom. Increase the angle until it becomes 360deg. We may then remove the top and bottom plates altogether. The result is complete cylindrical waves in a conducting dielectric, the conductivity being of either kind or of both kinds, as we please. The voltage V is now circuital, and finite. The measure of C, on the other hand, is infinite. We need only, however, deal with a finite depth along the axis, when C will be finite too.

But in § 330 the resistance of the wires varied as x^{-1}, and the permittance as x. To obtain this case, we have merely to interchange the electric and magnetic forces in the above. The magnetic force must be in the plane of the paper in the figure, and parallel thereto, and be circular. The electric force must be straight and perpendicular to the paper. So, to begin with, the sides of the tube must be perfect electric conductors, and the top and bottom perfect magnetic conductors. Then, if the medium in the tube is uniformly conducting in both ways, the quantities K and S will vary as x, and the quantities R and L as x^{-1}.

The same substitutions of resistance in the bounding conductors for the internal conductance may be made as before, allowing for the change in position of the electric and magnetic forces. Also, the bounding conductors may be wholly removed, leaving complete cylindrical waves in a homogeneous dielectric, conducting in either or both ways. The gaussage C is now reckoned once round the circle of magnetic force. To make V finite we may consider only a finite depth along the axis.

We see that the problem of a telegraph circuit has real application to electromagnetic waves of much greater generality than plane waves, by letting the "constants" of the circuit be variable. The process employed is not confined in its application to cylindrical waves. Spherical waves may be similarly treated, by employing a tube whose section varies as x^2, both pairs of sides separating. Both **E** and **H** will be along arcs of circles, centred at the axis. In fact, the theory of this case is much simpler than the other, but we must not run away from the matter immediately in hand.

§ 334. After the enlargement of ideas of the last section, we may partially discuss some of the operational results. Notice first that the results for ρ in § 330 are produced from those for h, by substituting $eqy(d/dqy)$ for Zh. We may keep at present to the h set. Thus, take equation (14), or

$$V_1 = \tfrac{1}{2}\pi Zh\,\frac{(I_{0x} - \alpha K_{0x})(I_{0y} - \beta K_{0y})}{\alpha - \beta}, \tag{35}$$

giving V_1 at $x<y$ due to h at y. Interchange x and y when V_2 is wanted.

If l is infinity, K_{0l} is zero, and β is infinite, by (12). This reduces (35) to

$$V_1 = \tfrac{1}{2}\pi Zh(I_{0x} - \alpha K_{0x})K_{0y}. \tag{36}$$

We see that the terminal condition at l becomes impotent, and disappears.

Again, if $\lambda = 0$, $K_{0\lambda}$ is infinite, and $\alpha = 0$, by (12). So

$$V_1 = \tfrac{1}{2}\pi Zh I_{0x}\left(K_{0y} - \frac{I_{0y}}{\beta}\right). \tag{37}$$

Thus the terminal condition at λ becomes impotent and disappears by shifting it to the origin. Also note that in the region reaching to the origin, K_{0x} does not appear. It is usual to consider that we cannot have the K_0 function in solutions extending to the origin (the axis of the cylinder in cylindrical waves), unless there is a source at the origin, because to do so would make V infinite there. That this reason is inadequate and unsatisfactory will be evident if it be allowed that V can be infinite at the origin without having a source there, of which I will give examples. That is, we obtain infinite results at the origin without using K_{0x}. Nevertheless, there is no doubt that the K_0 function is excluded unless there is a source at the origin, as we saw above, unless there can be something very peculiar about the Z_0 operator, making α, which is given by

$$\alpha = \frac{I_{0\lambda} - (q\lambda Z_0/Z)I_{1\lambda}}{K_{0\lambda} - (q\lambda Z_0/Z)K_{1\lambda}}, \tag{38}$$

be finite when $\lambda = 0$.

[Equation (12) contains misprints. α is as just written, and β is got by changing λ to l and $-Z_0$ to Z_1.]

If both $\lambda = 0$ and $l = \infty$, then $\alpha = 0$, $\beta = \infty$. Both terminal conditions are impotent, and

$$V_1 = \tfrac{1}{2}\pi Zh I_{0x}K_{0y}, \qquad V_2 = \tfrac{1}{2}\pi Zh I_{0y}K_{0x}, \tag{39}$$

which represent an important fundamental solution.

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If $y=\lambda$, we have only the V_2 solution under control, and

$$V_2=\tfrac{1}{2}\pi Zh\frac{I_{0x}-\beta K_{0x}}{\alpha-\beta}(I_{0\lambda}-\alpha K_{0\lambda}). \quad (40)$$

If $y=\lambda=0$, we reduce the last to

$$V=\tfrac{1}{2}\pi Zh(K_{0x}-\frac{I_{0x}}{\beta}) \quad (41)$$

The source is at the origin, and the Z_0 condition is impotent.

Finally, if $l=\infty$, $\beta=\infty$, and (41) reduces to

$$V=\tfrac{1}{2}\pi Zh K_{0x}. \quad (42)$$

Thus, with the source at the origin, we have the K_0 function alone if there is no reflection, but the I_0 function as well when there is reflection at a finite distance, as in (41).

Similarly as regards e. By (9),

$$l=\infty \text{ makes } V_1=\tfrac{1}{2}\pi qye(I_{0x}-\alpha K_{0x})K_{1y}, \quad (43)$$

$$\lambda=0 \text{ makes } V_1=\tfrac{1}{2}\pi qye I_{0x}(K_{1y}-\beta^{-1}I_{1y}), \quad (44)$$

$$l=\infty\ \lambda=0 \text{ make } V_1=\tfrac{1}{2}\pi qye I_{0x}K_{1y}, \quad (45)$$

$$y=\lambda=0 \text{ make } V_2=0. \quad (46)$$

In the last case the finite e produces no disturbance beyond the origin, because of the vanishing conductance there. In (42), on the other hand, h is given to be finite. That it needs infinite impressed voltage is immaterial.

§ 335. The above results are usually operational. But they are strictly numerical results in certain cases, without change of form, or perhaps with only nominal change. Thus when the source gives rise to a steady state we can use the above at once. Putting $p=0$ makes $q^2=RK$, which is constant. Then I_{0x}, &c., are all algebraical functions and are numerical when x is given. So, knowing the general nature of the curves I_0 and K_0, we can see by inspection in some cases the nature of the steady states on both sides of the source. We have, of course, when α and β are concerned, to make Z_0 and Z_l represent the steady resistances terminally at λ and l.

In these direct numerical applications, use the formulæ (4) when qx is small. But they are quite unsuitable when qx is big. Then use the approximate formulæ

$$I_0(qx)=\frac{\epsilon^{qx}}{(2\pi qx)^{\frac{1}{2}}}, \qquad K_{0x}=\left(\frac{2}{\pi qx}\right)^{\frac{1}{2}}\epsilon^{-qx}, \quad (47)$$

which show plainly how the functions behave ultimately. The quantity $8qx$ should be several times unity to make (47) be practically true. More generally, use the formulæ

$$I_0(qx)=\frac{\epsilon^{qx}}{(2\pi qx)^{\frac{1}{2}}}\left(1+\frac{1^2}{8qx}+\frac{1^2 3^2}{\lfloor 2(8qx)^2}+\frac{1^2 3^2 5^2}{\lfloor 3(8qx)^3}+\ldots\right), \quad (48)$$

$$K_0(qx)=\frac{\epsilon^{-qx}}{(\frac{1}{2}\pi qx)^{\frac{1}{2}}}\left(1-\frac{1^2}{8xq}+\frac{1^2 3^2}{\lfloor 2(8qx)^2}-\frac{1^2 3^2 5^2}{\lfloor 3(8qx)^3}+\ldots\right). \quad (49)$$

The first terms represent (47). These are divergent formulæ, and, to obtain the proper values, stop when you reach the bottom, and ignore the rest. That is, seek the point of convergence of the series you are calculating, or the place where the smallest term occurs. The error is limited by the size of the smallest term, and may be far less, especially if half the smallest term is counted. The above are the practical formulæ except when qx is so small that the smallest term may be big enough to introduce a large error. Even when qx is as small as 1, the error is not very great. It is when the point of convergence, which is at a distance along the series when qx is big, comes to the beginning of the series, that we are obliged to go to the convergent formulæ (4). The difference between the divergent and convergent series is, for numerical calculation, only one of degree, and the degree varies. In the convergent series, the point of convergence is always at the end of the series, which cannot be reached. But the terms at the end tend to zero in size, so that by taking enough trouble we may reduce the error to be smaller than any quantity that can be named. But then, when qx is big, a very large number of terms must be counted before we come to the convergent region, so the convergent formulæ are unpractical. On the other hand, if $8qx$ is greater than 1, the divergent formulæ are convergent from the very beginning, and allow of rapid calculation with an accuracy which is practically unexceptionable when qx is a large number, and of fair approximativeness so long as the point of convergence is not too near the first term. It is a question of practice which formulæ to use. The connections between the convergent and divergent formulæ will be given in Chapter VII., as well as their connections with other formulæ. There is a table of the I_0 and I_1 functions (and others) in Gray and Mathew's work on Bessel functions, p. 282, going up to $qx=5{\cdot}1$. After that (48) may be used, or even (47), noting that I_1 is the derivative of I_0. But I cannot find any table of the important K_0 function, and therefore use (49) myself, or else (4), to get rough values.

Since, as has been said, the above formulæ become numerical where steady states are concerned, it is not necessary to rewrite them, with $\sqrt{RK}$ substituted for q, to indicate the special results. Observe, however, that should either R or K vanish, or both vanish, the formulæ simplify considerably, when steady states are concerned, and it will not be a bad thing for the reader to look into a few cases in detail, both with q finite first, and then with $q=0$, by the vanishing of R or K.

Look at (39) for example. The constant impressed current h at y produces V as there given, with $q^2=RK$ in the I_0 and K_0 functions, and $Z=R$. Now, if R is zero, V is zero on both sides. The corresponding current is $C_1=0$, on the left, and $C_2=h$, on the right side of the source. That is, when $Z=Lp$ and $Y=Sp$, representing the case of no waste of energy by resistance, h all goes to the right ultimately, and there is no electrification. The absence of electrification is the striking point. It is really a case of statics, or of motional statics. The setting up of the steady state involves electromagnetic waves, of course, but they all disappear ultimately.

(To be continued.)

THEORY AND CALCULATIONS OF ASYNCHRONOUS ALTERNATE CURRENT MOTORS.

BY A. HEYLAND (BUDAPEST).

(*Continued from page 508*).

III.—A. *Normal Load.*

We have defined as *normal load* the case, when the difference of phase ϕ between the primary current I_1 and the primary tension K is a minimum, ϕ_{min}, and further, for this case, $\cos(\phi_{min})=(\cos\phi)_{max}$ as *maximum power factor f*.

Let f be given for the design of the motor.

(1) *To determine the coefficient τ from the maximum power factor f.*—Fig. 7 again illustrates the conditions of normal load. A C″ is tangent to the circle described about O_c; C″ A B is ϕ_{min}, so that $\cos C''AB=\cos(\phi_{min})=(\cos\phi)_{max}=f$. Since now O_cC'' is perpendicular to A C″, and O_cA to A B, angles C″ O_c A and C″ A B are equal, and as $OC''A$ is a right angle, we find $\frac{C''O_c}{O_cA}=\cos C''O_cA=\cos C''AB=f$. C″ O_c is as radius equal $\frac{CD}{2}$; A O_c is $AC+CO_c=AC+\frac{CD}{2}$, and therefore, equation (9),

$$f=\frac{\frac{CD}{2}}{AC+\frac{CD}{2}}=\frac{1}{2(1+\tau)^2-1}=\frac{1}{1+4\tau} \quad (10)$$

We thus arrive at the interesting conclusion that the *maximum power factor of a polyphase motor depends simply upon the dimensions of the iron masses, and not upon the resistances of the circuits.*

We further develop

$$\tau=\sqrt{\frac{1+f}{2f}}-1. \quad (11)$$

$$\tau\equiv\frac{1-f}{4f}. \quad (11a)$$

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(2) *To determine the relations between I_1, I_2 and I, f being given.*—For the case of normal load, all the angles may be expressed by ϕ_{min}, as has been done in Fig. 7, from which we derive

$$\frac{AC''}{AC} = \frac{\cos\frac{\phi_{min}}{2}}{\sin\frac{\phi_{min}}{2}} = \sqrt{\frac{1+\cos(\phi_{min})}{1-\cos(\phi_{min})}},$$

that is,

$$\frac{\text{primary current } I_1}{\text{magnetising current } I} = \sqrt{\frac{1+f}{1-f}} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Further,

$$\frac{C''C}{AC} = \frac{\cos(\phi_{min})}{\sin\frac{\phi_{min}}{2}} = \frac{\cos(\phi_{min})}{\sqrt{\frac{1-\cos(\phi_{min})}{2}}},$$

that is,

$$\frac{\text{secondary current } I_2}{\text{magnetising current } I} = \frac{f}{\sqrt{\frac{1-f}{2}}} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

(3) *To determine the dimensions of the motor from τ and f.*—τ has been defined by the equations (3A), (3B), (7),

$$\frac{h_1}{H} = \tau_1\frac{I_1}{I}; \qquad \frac{h_2}{H} = \tau_2\frac{I_2}{I}.$$

Therefore

$$\tau_1 = \frac{\frac{h_1}{I_1}}{\frac{H}{I}} = \frac{\frac{h_1}{H}}{\frac{I_1}{I}}; \qquad \tau_2 = \frac{\frac{h_2}{I_2}}{\frac{H}{I}} = \frac{\frac{h_2}{H}}{\frac{I_2}{I}}; \qquad \tau = \frac{\tau_1+\tau_2}{2}.$$

Referring to one phase of a polyphase system, h_1 signifies the sum of the stray fields per circuit and pair of poles, H the main magnetic field per pair of poles.

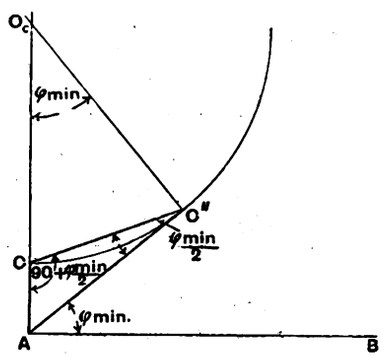

FIG. 7.

Fig. 8 illustrates the winding for one phase of a six-pole triphase motor with drum armature; the other two phases have not been marked. For our stray field h_1 per circuit and pair of poles we can substitute a number of stray fields h_1' h_1' . . . surrounding each groove. If we have z grooves per pair of poles and m phases, there will be to each phase winding $\frac{z}{m}$ grooves and $\frac{z}{m}$ stray fields, h_1' per pair of poles. To each winding we have to reckon two stray fields h_1' connected in parallel. Let there be w turns per phase and pair of poles; let I_1' be the amplitude of the current per phase, and $\rho_{h1'}$ the magnetic resistance of each stray field h_1'; then the *magnetising force* of the turns of a pair of grooves will be

$$\frac{4\pi}{10} \cdot \frac{\frac{w}{z}}{2m} I_1' \quad . \quad . \quad . \quad . \quad . \quad (14$$

and the stray field

$$h_1' = \frac{4\pi}{10} \cdot \frac{\frac{w \cdot 2m}{z}}{\rho_{h1}} \quad . \quad . \quad . \quad . \quad (15)$$

Reckoning to each turn $2h_1'$ in parallel, we have

$$2h_1' = \frac{4\pi}{10} \cdot \frac{\frac{w \cdot 2m}{z}}{\frac{\rho_{h1'}}{z}}$$

These stray fields h_1' h_1' . . . constitute h_1, which is produced by the total ampere-turns of a phase per pair of poles.

Then

$$h_1 = \frac{4\pi}{10} \cdot \frac{w \cdot I_1'}{\frac{\rho_{h1'} \cdot z}{4m}} \quad . \quad . \quad . \quad . \quad (16)$$

The magnetic resistance of this field will be

$$\rho_{h1} = \frac{\rho_{h1'}}{2} \cdot \frac{z}{2m}, \quad . \quad . \quad . \quad . \quad . \quad (17)$$

$$h_1 = \frac{4\pi}{10} \cdot \frac{w \cdot I_1'}{\rho_{h1}} \quad . \quad . \quad . \quad . \quad (18)$$

h_2 will be determined in the same manner.

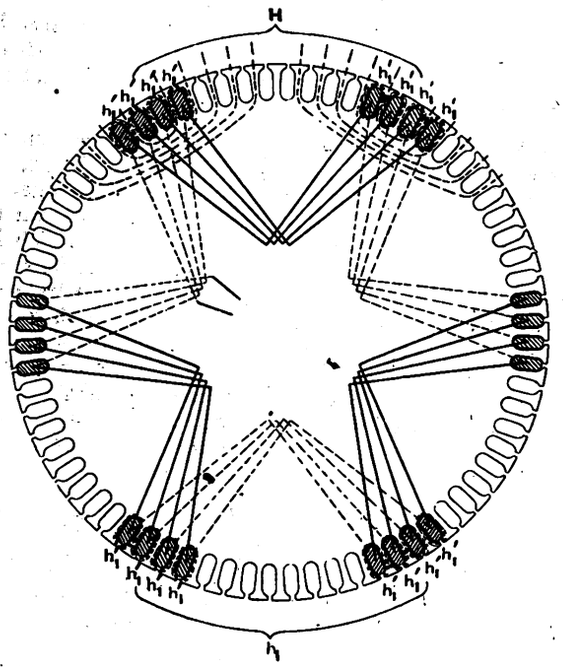

FIG. 8.

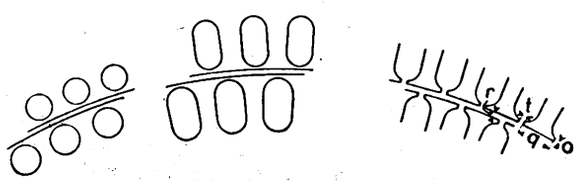

FIG. 8A. FIG 8B. FIG. 8C.

H, the main field, is produced by the combined action of the m phases as represented by the magnetising current of the m phases. Fig. 9 exemplifies, for a three-phase circuit, how these currents are combined. Let I' be the amplitude of the magnetising current, and the current of phase I. be equal to I'; in phases II. and III. it will become $\frac{I'}{2}$. As II. and III. are 120deg. apart, their resultant effect is again $\frac{I'}{2}$, which again acts in the direction I. The total magnetising current will hence be $I' + \frac{I'}{2} = \frac{3}{2}I'$—that is, it will be equal to that of a current $\frac{3}{2}I'$, which is supposed to flow in one phase winding.

The same result has analytically been deduced by E. Arnold; he found, in general, for m phases the equivalent current of one phase equal $\frac{m}{2} \cdot I'$ . . . . . (19)

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The *magnetising force* of this current would be

$$\frac{4\pi}{10} \cdot w \cdot \frac{m}{2} I', \quad \ldots \quad (20)$$

and if ρ_H is the magnetic resistance of the main field per pair of poles, there results

$$H = \frac{4\pi}{10} \cdot \frac{w \frac{m}{2} I'}{\rho_H} \quad \ldots$$

If we substitute the effective primary current I_1 for the amplitudes I_1' and I', and remember that $I_1' = I_1\sqrt{2}$, we obtain from (12)

$$h_1 = \frac{4\pi}{10} \frac{w \cdot I_1\sqrt{2}}{\rho_{h_1}}, \quad \ldots \quad (22)$$

$$H = \frac{4\pi}{10} \frac{\frac{m}{2} I_1\sqrt{2}\sqrt{\frac{1-f}{1+f}}}{\rho_H}. \quad \ldots \quad (23)$$

I_1 can easily be calculated from the power, the losses, the primary tension, and the power factor f. Thus we can also determine

$$I_1' = I_1\sqrt{2},$$

and

$$\frac{m}{2} I' = \frac{m}{2} I_1\sqrt{2}\sqrt{\frac{1-f}{1+f}}.$$

By dividing equation (18) by (21)

$$\frac{h_1}{H} = \frac{\rho_H}{\rho_{h_1} \cdot \frac{m}{2}} \cdot \frac{I_1'}{I'} = \frac{\rho_H}{\rho_{h_1} \frac{m}{2}} \cdot \frac{I_1}{I}.$$

Further, (3A),

$$\frac{h_1}{H} = \tau \frac{I_1}{I},$$

and (11) and (11A)

$$\frac{\rho_H}{\rho_{h_1}} = \tau \cdot \frac{m}{2} = \frac{m}{2}\left(-1 + \sqrt{\frac{1+f}{2f}}\right) \equiv \frac{1-f}{4f} \cdot \frac{m}{2}; \quad (24)$$

and (17),

$$\frac{\rho_H}{\rho_{h_1}'} = \frac{z}{4m} \cdot \tau \cdot \frac{m}{2} = \frac{z}{8}\left(-1 + \sqrt{\frac{1+f}{2f}}\right) = \frac{z}{8} \cdot \frac{1-f}{4f} = \frac{z}{32} \cdot \frac{1-f}{f}$$

$$\frac{\rho_H}{\rho_{h_1}'} = \frac{z}{32} \cdot \frac{1-f}{f}. \quad \ldots \quad (25)$$

ρ_H and ρ_{h_1}' do not depend upon the dimensions of the iron masses alone. They are functions of the dimensions of the

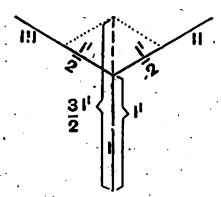


FIG. 9.

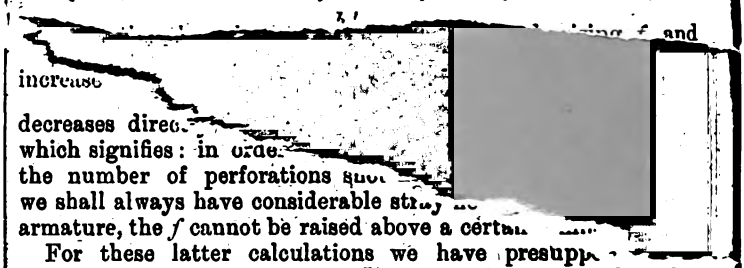
iron and of the air, and of the degree of saturation of the separate fields. The latter factor, the saturation, enters particularly when we have to ascertain the resistance ρ_{h_1}' of the iron-bound stray field in perforated armatures. For such armatures the fields have separately to be determined from the magnetising forces and the dimensions. The main field H must have a certain magnitude, which, as will be explained, depends upon the number of poles, of turns, and of alternations.

From H, the magnetising force, (23),

$$\frac{4\pi}{10} w \cdot \frac{m}{2} I' = \frac{4\pi}{10} w \cdot \frac{m}{2} I_1\sqrt{2}\sqrt{\frac{1-f}{1+f}},$$

and from the admissible density of the lines of force we derive the dimensions of the iron and air for the main field H. The number of perforations, their iron dimensions, and particularly the size of the iron bridge bars which remain on the surface of the armature, can be settled in the following way:—The magnetising forces, (14), $\frac{4\pi}{10} \cdot \frac{w \cdot 2m}{z} \cdot I_1'$ $= \frac{4\pi}{10} \cdot \frac{w \cdot 2m}{z} I_1\sqrt{2}$ produce, per perforation, stray fields h_1', such that, (15) and (16), $h_1' = \frac{h_1}{2}$, in which, (3A), $\frac{h_1}{H} = \tau \frac{I_1}{I}$, and therefore, (11A), (12),

$$\frac{h_1'}{H} = \frac{\tau}{2} \cdot \frac{I_1}{I} = \frac{1-f}{8f}\sqrt{\frac{1+f}{1-f}} = \frac{\sqrt{1-f^2}}{8f} \quad \ldots \quad (26)$$



increase

decreases direc-

which signifies: in orde-

the number of perforations

we shall always have considerable stra-

armature, the f cannot be raised above a certa-

For these latter calculations we have presupp-

$\tau_1 = \tau_2 = \tau$. This hypothesis will in general correspond to the actual conditions, for the two armatures will mostly be of the same type, either both grooved or both perforated. If the construction should be different, τ_1 and τ_2 may separately be deduced from equation (7); for τ we substitute the arithmetical mean $\frac{\tau_1+\tau_2}{2}$.

The grooved armature is easier to deal with than the perforated armature. The iron bridge bar which we notice in Figs. 8A and 8B on the surface of the perforated armature is here replaced by the air space t, Fig. 8C; the saturation of that thin piece of iron does not complicate our calculation.

The resistance of the stray fields is rather chiefly determined by the resistance of the air space of the stray lines of force, and is therefore constant for various loads.

The advantages of this are that with grooved armatures τ remains nearly constant with varying loads, but, above all, that it is much smaller than with perforated armatures.

When the ratio of the dimensions of the teeth and the number of teeth have been ascertained for a certain f, the other dimensions can be found by proceeding as in the case of a transformer.

(4) *Calculation of the motor for normal load.*—Given the work to be done L, the power factor f, and the losses for normal load—namely, electrical waste in the primary coils da_1, electrical waste in the secondary coils da_2, hysteresis and Foucault currents $da_{(H,F)}$, losses through friction da_r. The energy primarily to be supplied is

$$A_1 = L + da_1 + da_2 + da_{(H,F)} + da_r.$$

Each of the phases claims $\frac{A_1}{m}$, which is equal to $K \cdot I_1 f$. The current expended per phase is

$$I_1 = \frac{\frac{A_1}{m}}{K \cdot f}. \quad \ldots \quad (29)$$

The amplitude of the primary current is, per phase,

$$I_1' = I_1\sqrt{2}.$$

The magnetising current, (12):

$$I = I_1\sqrt{\frac{1-f}{1+f}},$$

and its amplitude: $I' = I\sqrt{2}$.

The magnetising force of the m phases, (19): $\frac{m}{2} I'$, the current supposed to be flowing in one phase winding.

The number P of pairs of poles follows from the speed:

$$P = \frac{\text{number of periods}}{\text{number of revolutions}}$$

The calculation can be finished as when dealing with a transformer, if we remember:

The magetising force in the main field H is, (20),

$$\frac{4\pi}{10} w \cdot \frac{m}{2} I',$$

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The magnetising force in the stray field is, (18),

$$\frac{4\pi}{10} w\, I'.$$

The resistances opposed by iron and air are to be chosen such that the E.M.F. induced by H per pair of poles, $\frac{E}{P}$ becomes equal to $\frac{K}{P}$, *i.e*,

$$\frac{K}{P} = 10^{-8} \pi n w H,$$

$$\frac{\text{primary current } I_1}{\text{magnetising current } I} = \sqrt{\frac{1+f}{1-f}} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Further,

$$\frac{C'' C}{A C} = \frac{\cos(\phi_{min})}{\sin \frac{\phi_{min}}{2}} = \frac{\cos(\phi_{min})}{\sqrt{\frac{1-f^2}{8f}}}. \quad . \quad . \quad . \quad (30)$$

that is

The following equations summarise the calculations for a long, with furnace tubes 3ft. 3¾in. diameter. The heating surface is 2,287½ sq. ft., and the grate area 39 sq. ft. The steam was used exclusively for a simple Corliss condensing engine, with cylinder 28in. diameter and 4½ft. stroke, running at 60 revolutions per minute, driving the machinery in a wool-combing mill. The work was arranged so that it should be as nearly as possible equal on the occasion of each test. Owing to an oversight during the test made before the superheater was fixed, the feed was left on while the boilers were being cleaned, the usual custom being to raise the level before cleaning, and then stop the pump. The result was a fall in the steam pressure from 78lb. to 42½lb. per square inch, and the boiler was so fully loaded that it took two hours to recover the normal pressure. The speed of the engine fell to 58 revolutions per minute, although the trips on the Corliss gear ceased to act, and full steam was being taken for nearly an hour; 59 revolutions per minute were made for a further half-hour, before the usual speed was re-established. During the second test the same procedure was intentionally repeated, in order that both tests might be exactly compared; the result was that the steam pressure fell only 3½lb., and the speed was not affected at all. This difference is most striking, and is a forcible proof of the great increase in the capacity of a boiler when fitted with the superheating apparatus. The superheat was measured at the boiler stop-valve, and was almost constant at 56°F.

At Messrs. Henry Bruce and Son's, Kinleith Mills, Currie, Midlothian, five Lancashire boilers are fitted with McPhail's apparatus. Their principal dimensions are 28ft. long by 7½ft. diameter; heating surface 920 sq. ft., grate area 36 sq. ft., working pressure

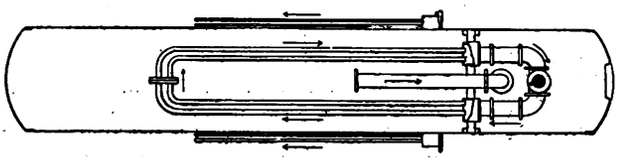

Fig. 6.—McPhail and Simpson Superheater.

about 90lb. absolute per square inch. In Table IV. is shown a test of the complete range of boilers, six without the superheaters against the five fitted with them.

At the works of the Thornliebank Company, Glasgow, a Lancashire boiler is fitted with McPhail's apparatus. Its dimensions

(I.) $$\frac{\rho_H}{\rho h_1'} = \frac{z}{3 2} \frac{1-f}{f}; \quad . \quad . \quad . \quad . \quad . \quad (25)$$

(II.) $$H = \frac{K\sqrt{2}}{10^{-8} \pi n s_1}; \quad . \quad . \quad . \quad . \quad . \quad (30)$$

(III.) $$\frac{2r}{\frac{z}{2} q l} + \frac{R_1}{\mu_1 F_1} + \frac{R_2}{\mu_2 F_2} = \frac{\frac{4\pi}{10} \frac{s_1}{P} \frac{m}{2} I'}{H}; \quad . \quad (20)$$

(IV.) $$I' = I_1 \sqrt{2} \sqrt{\frac{1-f}{1+f}}; \quad . \quad . \quad . \quad . \quad (12)$$

(V.) $$I_1 = \frac{\frac{A_1}{m}}{K \cdot f}, \quad . \quad . \quad . \quad . \quad . \quad (29)$$

s_1 being the total number of turns in one phase $= w P$;
F_1 the mean cross-section of the field in the primary armature;
R_1 the mean length of the field in the primary armature;
μ_1 the permeability of the primary armature;
F_2 the mean cross-section of the field in the secondary armature;
R_2 the mean length of the field in the secondary armature;
μ_2 the permeability of the secondary armature.

The dimensions of the iron masses, F_1, F_2, R_1, R_2, as well as μ_1 and μ_2, must be determined from the admissible losses $d a_{(H,F)}$. We bear in mind that the iron of the secondary armature may be strained to a higher degree, inasmuch as it is exposed to a lesser number of alternations. The number of turns and the current density follow from $d a_1$ and $d a_2$, as in the case of transformers. The ratio of transformation, and the number of phases in the secondary armature may be left to discretion; the conditions will not change in the coils of the short-circuit armature, so long as the *mass of copper* is not changed. The value of the secondary losses determines also the loss in speed or the slip of the motor. We shall demonstrate that slip $= \frac{d a_2}{A_1 - d a_1}$.

(To be continued.)

NOTES ON STEAM SUPERHEATING.*

BY WILLIAM H. PATCHELL.

(Concluded from page 545.)

In its complete form this superheater has been tested and fully reported upon by several engineers in this country, among whom may be mentioned Messrs. Crosland and Michael Longridge. In Tables III. and V. are given the results of some recent tests, one made by M. Armengaud at the works of Messrs. Isaac Holden and Son, Reims, and others at Kinleith and Thornliebank, for which the author is indebted to the manufacturers.

The Reims tests, Table III., were made before and after the apparatus was fixed on a Lancashire boiler 8½ft. diameter and 28ft.

* Paper read before the Institution of Mechanical Engineers.

Table III.—*Boiler Test Without and With McPhail and Simpson's Superheater at Messrs. Isaac Holden and Son's Works, Reims.*

Lancashire boiler 28ft. long and 8½ft. diameter, with two internal flues 3ft. 3¾in. diameter; heating surface 1,012 sq. ft., grate area 39 sq. ft.; supplying steam to a Corless engine. Quality of fuel, Dourges.

Without or With Superheater.	Without.	With.
1. Date 1894	June 20	June 28
2. Duration of trial ..... hours	7·83	8
3. Av. boiler-pressure per sq. in. above atm. ... lb.	73·6	91·5
4. Temp. corresponding with pressure ..... Fahr.	318·7	331·6°
5. Temp. of steam leaving boiler ..... Fahr.	...	388·1°
6. Degrees of superheat ..... Fahr.	...	56·5°
7. Average temperature of feed-water ..... Fahr.	117½°	119°
8. Water evaporated, total during test ..... lb.	49,899	47,096
9. Water evaporated per hour ..... lb.	6,373	5,887
10. Water evaporated per hr. per sq. ft. of grate.. lb.	163·4	151·0
11. Water evaporated per hour per sq. ft. of heating surface ..... lb.	6·29	5·81
12. Coal burnt, total during test ..... lb.	7,364·7	5,435·3
13. ,, ,, per hour ..... lb.	941·0	679·4
14. ,, ,, per hour per sq. ft. of grate..... lb.	24·13	17·42
15. Ash and clinker, total ..... lb.	937	613
16. ,, ,, percentage of coal... per cent.	12·75	11·3
17. Combustible burnt, total..... lb.	6,427·7	4,822·3
18. Water evaporated per lb. of coal..... lb.	6·78	8·66
19. ,, ,, ,, combustible..... lb.	7·76	9·76
20. Average indicated horse-power ..... I.H.P.	328·3	328·5
21. Coal per I.H.P. per hour..... lb.	2·86	2·10
22. Water ,, ,, ... lb.	19·41	18·19
23. Gain in coal per I H.P. ..... per cent.	...	36·2
24. ,, water ,, ... per cent.	...	6·3
25. ,, ,, evaporated per lb. of coal..... p. c.	...	27·7
Equivalent evaporation from and at 212° F. Superheat neglected.		
26. Water per lb. of coal..... lb.	7·69	9·81
27. ,, ,, ,, ... gain per cent.	...	27·5
28. ,, ,, combustible ..... lb.	8·80	11·05
29. ,, ,, ,, ,, ... gain per cent.	...	25·5
Superheat included.		
30. Water per lb. of coal ..... lb.	7·69	10·07
31. ,, ,, ,, ... gain per cent.	...	30·9
32. ,, ,, combustible ..... lb.	8·80	11·35
33. ,, ,, ,, ,, ... gain per cent.	...	28·97

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Table IV.—*Boiler Tests Without and With McPhail and Simpson's Superheaters at Messrs. Henry Bruce and Son's, Kinleith Mills, Currie, Midlothian.*
Lancashire Boilers, each 28ft. long and 7½ft. diameter; heating surface 920 sq. ft., grate area 36 sq. ft. Quality of fuel, local Scotch coal.

Without or with Superheaters.	Without.				With.				Gain due to superheaters.
1. Number of test	1	2	3	Mean.	4	5	6	Mean.	Per cent.
2. Date of test 1895	July 2	July 3	July 4	...	Nov. 28	Dec. 4	Dec. 5	...	...
3. Duration of test hours	9	9·16	9	...	8·75	9	9	...	...
4. Number of boilers under test	6	6	6	...	5	5	5	...	...
5. Average boiler-pressure per square inch above atm.	73·6	78	77·4	76·3	82	84·3	84·5	83·6	...
6. Temperature corresponding with pressure Fahr.	319°	322·5°	321·9°	...	325°	327·9°	327·5°	...	...
7. Temperature of steam leaving boilers Fahr.	...	...	...	...	413°	421°	426°	...	...
8. Degrees of superheat Fahr.	...	...	...	...	88°	93·1°	98·5°	93·2	...
9. Average temperature of feed-water Fahr.	116°	124°	118°	...	112°	106°	106°	...	...
10. Water evaporated, total during test lb.	393,095	345,581	371,640	...	392,410	420,867	413,375	...	...
11. Water evaporated, per hour per boiler lb.	7,280	6,399	6,882	6,853	8,969	9,351	9,186	9,168·6	33·8
12. Water evaporated, per hour per sq. ft. of grate lb.	202	178	191	...	249	259	255	...	...
13. Water evaporated, per hour per sq. ft. of heating surface lb.	7·92	6·96	7·44	7·44	11·70	12·18	11·94	11·94	...
14. Coal burnt, total during test	57,792	53,256	56,817	...	47,462	49,423	47,544	...	...
15. „ „ per hour per boiler lb.	1,067	969	1,052	...	1,084	1,098	1,056	...	...
16. „ „ „ „ per sq. ft. of grate lb.	29·7	26·9	29·2	...	30·1	30·5	29·3	...	...
17. Ash and clinker, total during test lb.	7,071	6,741	7,479	...	5,096	5,520	5,024	...	...
18. Ash and clinker, percentage of coal per cent.	12·23	12·65	13·16	...	10·73	11·16	11·81	...	...
19. Combustible burnt, total lb.	50,721	46,515	49,338	...	42,356	43,903	42,520	...	...
20. Water evaporated, per lb. of coal lb.	6·802	6·489	6·541	6·611	8·269	8·515	8·694	8·493	28·4
21. Water evaporated per lb. of combustible lb.	7·750	7·428	7·532	7·570	9·264	9·586	9·721	9·524	25·8
Equivalent Evaporation from and at 212° F. Superheat neglected.									
22. Water per lb. of coal lb.	7·713	7·306	7·404	7·474	9·418	9·758	9·963	9·713	29·9
23. „ „ combustible lb.	8·788	8·365	8·526	8·559	10·552	10·985	11·140	10·892	27·2
Superheat included.									
24. Water per lb. of coal lb.	...	...	...	...	9·799	10·158	10·406	10·121	35·4
25. „ „ combustible lb.	...	...	...	8·559	10·978	11·436	11·636	11·350	32·6

Table V.—*Boiler Tests Without and With McPhail and Simpson's Superheater, at the Thornliebank Company's Works, Glasgow.*

Number of test	1		2		3		4		5		Av. gain due to superheater.
Date of test 1895	August 28th.		August 29th.		September 5th.		September 6th.		September 10th.		
Duration of test	8 hours.		8 hours.		8 hours.		8 hours.		8·66 hours.		
Fireman	Lowry.		Parker.		Hannah.		Lowry.		Parker.		
No. 6 boiler Without and No. 7 boiler With superheater	Without	With	Without	With	Without	With	Without	With	Without	With	Per cent.
1. Av. boiler pres. per sq. in. above atm. lb.	72	72	72·5	72·5	57	57	58	58	63	63	
2. Temp. corresponding with pres. Fahr.	317·8°	317·8°	318°	318°	304·8°	304·8°	305·7°	305·7°	310°	310°	
3. Temp. of steam leaving boiler Fahr.	309·3°	373°	304°	372°	303·8°	363·9°	300·1°	366·5°	300°	362°	
4. Degrees of superheat Fahr.	...	55·2	...	54°	...	59·1°	—	60·6°	...	52°	
5. Av. temperature of feed-water Fahr.	161°	156°	161·5°	155°	145·6°	151·0°	148·5°	153°	146°	151°	
6. Water evaporated, total during test lb.	58,910	69,586	68,978	76,181	55·890	62,040	55,277	65,600	70,684	75,461	
7. Ditto, gain due to superheater p c.	...	18·1	...	10·4	...	11·0	...	18·6	...	6·75	12·97
8. Water evaporated per hour lb.	7,363	8,698	8,622	9,522	6,986·2	7,754·7	6,909·6	8,200	8,162	8,713	
9. Ditto ditto per sq. ft. of grate lb.	188·8	223·0	221·1	244·2	179·1	198·8	177·2	210·3	209·3	223·4	
10. Ditto ditto per sq. ft. of heating surf. lb.	7·71	9·10	9·02	9·97	7·31	8·12	7·23	8·58	8·57	9·12	
11. Coal burnt, total during test lb.	9,632	9,632	10,976	11,200	9,086	9,171	9,408	9,408	10,752	10,304	
12. Ditto per hour lb.	1,204	1,204	1,372	1,400	1,135·7	1,146·4	1,176	1,176	1,241	1,189	
13. Ditto ditto per sq. ft. of grate lb.	30·4	30·4	34·3	35·0	28·4	28·6	29·4	29·4	31·0	29·7	
14. Ash and clinker, total lb.	1,397	1,596	1,364	1,572	1,252	1,426	1,428	1,521	1,276	1,292	
15. Ditto, percentage of coal per cent.	14·5	16·5	12·4	14·0	13·7	16·2	15·1	16·1	11·8	12·5	
16. Combustible burnt, total lb.	8,235	8,036	9,612	9,628	7,834	7,685	7,980	7,887	9,476	9,012	
17. Water evaporated per lb. of coal lb.	6·11	7·22	6·28	6·80	6·15	6·76	5·87	6·97	6·57	7·32	
18. Ditto, combustible lb.	7·15	8·65	7·17	7·91	7·13	8·07	6·92	8·31	7·45	8·37	
Equivalent evaporation from and at 212° F. Superheat neglected.											
19. Water per lb. of coal lb.	6·63	7·88	6·81	7·42	6·69	7·38	6·42	7·59	7·22	8·00	
20. Ditto, combustible lb.	7·76	9·44	7·77	8·64	7·82	8·81	7·57	9·05	8·18	9·15	
21. Gain due to superheater (on combustible) per cent.	...	21·64	...	11·2	...	12·6	...	19·5	...	11·8	15·35
Superheat included.											
22. Water per lb. of coal lb.	6·63	8·12	6·81	7·72	6·69	7·59	6·42	7·34	7·22	8·24	
23. Ditto, combustible lb.	7·76	9·72	7·77	9·00	7·82	9·06	7·57	9·34	8·18	9·42	
24. Gain due to superheater (on combustible) per cent.	...	25·25	...	15·83	...	15·85	...	23·38	...	15·16	19·08

Lancashire boilers, Nos. 6 and 7, each 28ft. long and 8ft. diameter; heating surface 955 sq. ft, grate area 39 sq. ft. Quality of fuel, Greenfield virgin coal. No. 7 boiler had superheater attached.

No. 7 boiler with superheater did 12·97 per cent. more work, or, in other words, the saving effected was 19·08 per cent. Lowry, being the regular fireman and acquainted with the boilers, obtained the best results.

are 28ft. long and 8ft. diameter; heating surface 955 sq. ft., grate area 39 sq. ft. One of their other boilers was tested against that fitted with the superheater, as shown in Table V. The superheat of the steam leaving the stop-valve of the boiler fitted with the superheater averaged 56·2°F. Since these tests a second boiler has been fitted with the same apparatus, producing steam at 80lb. per square inch above atmosphere and at 558°F., being a superheat of 234°F.

This type of superheater was adopted by the author in 1893 at the Maiden-lane station of the Charing Cross and Strand Electricity Supply Corporation, but had to be considerably modified to suit the Babcock and Wilcox water-tube boiler, as it was found possible to put only one set of superheating tubes in the limited space between the top of the water tubes and the underside of the drum, and only one set of radiating pipes in the drum: so that the arrangement represents only one-half of the complete apparatus as applied to a Lancashire or double-flued boiler. The arrangement is shown in Figs. 6 and 7. The saturated steam is taken from the anti-priming pipe to the upper box of the superheater, whence it passes down through the superheating tubes to the lower box, thence up into the radiating

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pipes in the drum, and through these to the steam stop-valve. The principal dimensions of the Babcock and Wilcox boiler are :—9×9=81 tubes, 18ft. long and 4in. diameter ; total heating surface about 1,827 sq. ft. ; drum 23½ft. long and 4ft. diameter ; width of fire grate 5ft. 6in. ; total grate surface 34·4 sq. ft. The principal dimensions of the superheater are :—75 superheating tubes of 1in. diameter, heating surface 355 sq. ft. ; 12 radiating pipes of 2in. diameter, heating surface 174 sq. ft. ; area through superheating tubes 58 9 sq. in., through radiating pipes 37 7 sq. in., and through steam stop-valve 28·27 sq. in.

Complete tests of one boiler were made by Prof. Kennedy, before and after the superheating apparatus was fixed ; and the principal results are given in Table VI. The dynamos are Edison-Hopkinson continuous-current shunt-wound, driven by Willans engines :

Table VI.—*Boiler Tests Without and With McPhail and Simpson's Superheater.*

	Without.	With.
1. Date of trial 1893	June 20.	Oct. 17.
2. Duration of trial, hours and minutes.....	8-15	8-31
3. Indicated horse-power of engines working at full load ..... I.H.P.	135	135+80
4. Full output of dynamos, amperes × volts	$750a \times 105v$	$\begin{cases} 750a \times 105v \\ 450a \times 105v \end{cases}$
5. Coal burnt, total ....lb.	3,229	4,528
6. „ „ per hour .....lb.	389	532
7. Water pumped into boiler, total .....lb.	28,000	43,655
8. „ „ „ „ per hour ...lb.	3,457	5,125
9. Mean electrical horse-power .....E.H.P.	82·15	129·2
10. Total kilowatt-hours (units)	686·4	824·2
11. Mean kilowatts	61·3	97·0
12. Boiler pressure above atm., per sq. in ....lb.	131·3	140·3
13. Mean temperature of steam on leaving boiler .....Fahr.	355°	377·1°
14. Mean temperature of saturation at boiler pressure ... .Fahr.	355°	361·0°
15. Mean temperature of steam in engine-room steam pipes..... .....Fahr.	...	365·1°
16. Mean temperature of saturation at probable pressure in engine-room steam pipes..... .....Fahr.	...	358·3°
17. Mean temperature of feed-water .....Fahr.	80·4°	79·76°
18. Calorific value of 1lb. of coal .....Th. U.	14,840	14,790
19. Equivalent evaporation per lb. of coal ...lb.	15·36	15·31
20. Carbon value of coal per lb. ..... lb.	1·023	1·020
21. Actual water evaporated per lb. of coal ..lb.	8·89	9·65
22. Evaporation per lb. of coal from and at 212deg. ....lb.	10·50	11·47
23. Evaporation per lb. of carbon value ...lb.	10·30	11·22
24. Coal burnt per hour per sq. ft. of grate .lb.	11·3	15·5
25. „ „ „ per E.H.P. .....lb.	4·74	4·12
26. Water per hour per E.H.P. .....lb.	42 1	39·7
27. Coal per kilowatt-hour .....lb.	6·35	5·5
28. Water „ „ .....lb.	56·4	52·3
29. Efficiency of boiler, 100 × line 22 ÷ line 19 .....per cent.	68·4	74·9
30. Temperature of gases leaving boiler...Fahr.	309°	376°
31. Mean chimney draught, inch of water.. inch.	0·3	0·4

The great increase in the capacity of the boiler will be noted in line 8 ; the steaming was much easier and steadier, and at the same time the efficiency of the boiler improved from 68·4 per cent. to 74·9 per cent. (line 29), and this with cold feed. Practically the whole of the superheat was lost in the range of steam pipes between the boiler and engine. The slight difference in water used per kilowatt-hour may be accounted for by the engine not being in such good order in the second test as in the first. It had been thoroughly overhauled immediately before the June trial, and had been in daily use from that date until the October trial, so that both valve and piston rings would be somewhat slacker in October than in June. The same cause would affect the coal consumption, which nevertheless shows a saving of 13·5 per cent.

The increased capacity and ease in working of the boiler have been as marked in its subsequent use with the superheating apparatus ; in regular work it is evaporating about 50 per cent. more than heretofore. At first the author had some misgivings as to incrustation forming in the superheating tubes from the priming water ; but from examining them closely on several occasions after a run of 4,000 hours and more, and finding them perfectly clean, he is satisfied on this point. The top box, by its increase in area over the steam pipe, gives a period of comparative rest in the flow of the steam, and acts as an efficient separator for the water or scum carried over. A steam trap fitted to the box discharges any such accumulation regularly, thus preventing its being carried into the superheating tubes. The bottom box is also fitted with a trap to intercept any leakage from the steam stop-valve when the boiler is shut in.

The first apparatus proved so satisfactory that a second was applied to the companion boiler in 1894, when the effect of the superheated steam in the pipes began to be marked by a decrease in the discharge from the drains and in the leakage from joints. There are altogether seven boilers, of which five or six are in general use on a common steam main. The figures in Table VII. show this effect clearly.

Table VII.—*Steam Tests Without and With McPhail and Simpson's Superheaters.*

Without and With Superheaters.	Without.		With.		
Boiler pressure, absolute lbs. per square inch	166	168	157	162	162
Corresponding temperature of saturated steam .....Fahr.	366·5	367·0	362·0	364·5	364·5
Temperature in main steam pipe in engine room .....Fahr.	359	361	371	375	373
Fall or rise in temperature of steam, degrees Fahr.	−7·5	−6·0	+9·0	+10·5	+8·5

Induced Draught.—The duty of the boilers having been increased to the above extent, and the priming difficulty being quite overcome,

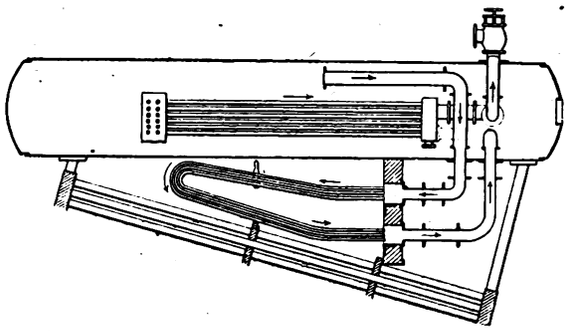

FIG. 7.—McPhail and Simpson Superheater.

the only limit to the evaporation was the chimney draught. As the two boilers were fitted with an independent flue and chimney, they lent themselves readily to an experiment in this direction. Having considered several schemes of forced and induced draught as an auxiliary, the author finally decided on putting the fan in the flue at the back of the boilers. As there was no space available for any

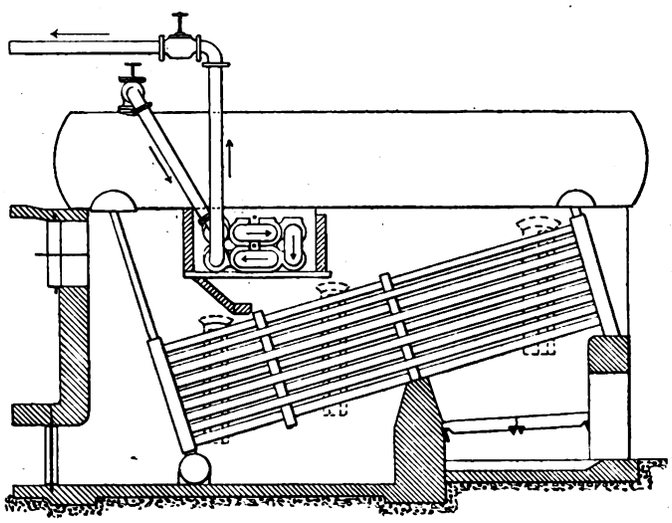

FIG. 8.—Schwoerer Superheater

form of economiser between the boilers and the fan, no attempt could be made to diminish the loss from heat in the waste gases. The gain sought for was in the direction of increasing the capacity of the existing boilers, so as to render steaming independent of the natural effects of foggy or heavy weather, and by working the boilers at a higher rate to diminish the proportion of radiation losses, which are practically constant at all loads.

The fan selected is a 72in. single inlet, made by Messrs. G. E. Belliss and Co., and driven direct by one of their tandem compound self-lubricating engines, having cylinders 3½in. and 6in. diameter, and 4½in. stroke, working at 150lb. boiler pressure and running at 300 revolutions per minute. The engine and fan were put in somewhat large for the estimated work, in order to secure slow speed and quiet running, with the result that within a few feet of the fan it is impossible to tell by the sound whether it is running or not ; this is a marked improvement on many fan engines. A draught in

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the flue at the fan inlet equal to a 2in. water gauge has been easily maintained. The usual method of working is to work the boilers on natural draught at times of light load, and then, as the load increases, to start the fan, close the by-pass in the flue, and work steadily at 1in. water gauge. With this draught the superheater tubes are continually bathed in incandescent gases, but not the slightest trouble has been experienced with them. In order to test the thorough reliability of the tubes, and in view of the fact that trouble was most likely to arise, if at all, when getting up steam, one of the boilers was shut in, and the steam let down day after day for some weeks, and then raised again with the induced draught, and there was an entire absence of any signs of irregularity or trouble.

When the boiler is steaming freely an iron bar inserted through the brickwork to a point near the ends of the tubes soon becomes red hot, and the temperature as taken by a platinum coil pyrometer at this point is about 900°F. At this temperature it appears to be of little importance whether the cooling agent is water or steam, so long as the circulation is kept up. This circumstance is most interesting in view of Mr. Durston's Devonport experiments, reported in his presidential address to the Institute of Marine Engineers,* as to the permissible limit of temperature in a tube or tube plate, which he places at about 750°F.; and in view also of the grave doubts that are frequently expressed as to the safety of steel tubes exposed to furnace temperatures without a perfect circulation of water on the other side of the metal. What temperature the tubes actually reach the author is unable to state; but the steam coming out of them is over 600°F. The tube plates would be lower in temperature than the outer ends of the tubes, because the gases are drawn downwards and away from the plates by the draught. No trace of leakage at any one of the tube ends yet appeared.

A further test of the boiler with the induced draught was made on January 2, 1896. It was not possible to shut off part of the steam ring main, and to use the steam on certain steam dynamos only, measuring the electrical output from them, as had been done in the two former tests; an evaporative test only was therefore arranged for. The stop-valve temperature was measured about 5ft. from the stop-valve at the boiler, on a branch pipe about 10ft. long, connecting the boiler with the main ring. A mercury thermometer in a mercury cup let into the steam pipe was used in this position. Being anxious to get the temperature of the steam between the superheater and the radiating pipes in the drum, the author had tried mercury thermometers, which failed. The difficulties due to the high pressure and temperature were successfully overcome, however, by Mr. F. W. Burstall, to whose ingenuity and kindness in co-operation the author is indebted in this matter. With a temperature of 1,058deg. around the superheating tubes, steam entering at 362deg. left them at 650deg., and after passing through the radiating pipes in the drum left the boiler at 403°F. The principal results are given in Table VIII., the boiler being fired with Welsh steam coal. It will be noted that the application of the superheater, together with a stronger draught, has increased the capacity of the boiler by 140 per cent., or raised the evaporation from 3,457lb. per hour (Table VI.) to 8,293lb. without increasing the space occupied: which is a most important gain, and a saving both in capital and in rent. In comparing the temperature here given of the gases leaving the boiler with those given in Table VI., it should be noted that in Table VIII. the temperatures were taken between the back tubes and the wall in which is situated the damper communicating with the flue. In Table VI. the temperatures were taken in the flue, where the gases are cooled by the influx of cold air through the damper slots, and by any leakage through the other boiler, which was shut off at the time.

Table VIII.—*Test of Babcock and Wilcox Boiler fitted with McPhail and Simpson's Superheater.*

Date of Trial 1896	Jan. 2
Duration of Trial ..... hours	8
Coal burnt, total ..... lb.	8,050
,, ,, per hour ..... lb.	1·006·25
Ash and Clinker, dry ..... lb.	476
Water evaporated, total ..... lb.	66,350
,, ,, per hour ..... lb.	8,293·75
Boiler Pressure above atm. per square inch ..... lb.	148·3
Temperature corresponding with pressure ..... Fahr.	365°
Mean Temperature of steam at stop-valve ..... Fahr.	396·6°
Degrees of Superheat ..... Fahr.	31·6°
Mean Temperature of Feed Water ..... Fahr.	48°
Actual Water evaporated per lb. of coal ..... lb.	8·24
,, ,, ,, ,, ,, combustible..... lb.	8·76
Water evaporated per lb. of coal from and at 212°F. ..... lb.	10·16
,, ,, ,, ,, combustible ,, ,, ... lb.	10·80
Coal burnt per sq. ft. of grate per hour ..... lb.	29·3
Water evaporated per sq ft. of heating surface per hour ..... lb	4·37
Temperature of gases leaving boiler ..... Fahr.	655°
Mean chimney draught, inches of water ..... inch.	1·11

* *Engineering*, October 4, 1895, p. 437.

Schwoerer's Superheater.—The superheater illustrated in Figs. 8 to 10 is the invention of Mr. Emile Schwoerer, of Colmar, Alsace, who was for some time private secretary to the late Mr. G. A. Hirn. It was Mr. Hirn who first took up superheating seriously; and it is due to his energy that so much has been done with it in practical working in Alsace. Mr. Schwoerer's improvements were in the direction of reducing the space occupied by the apparatus; and he attained this end by employing a coil of pipes with gills on them both inside and outside, thus getting large surfaces in a small bulk. Regulation of the superheat by deflecting the hot gases away from the tubes, rather

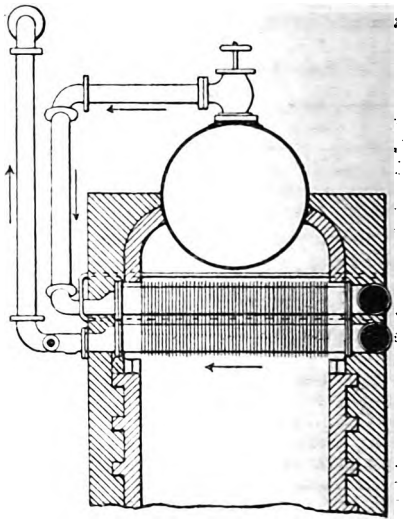

Fig. 9.—Schwoerer Superheater.

than by varying the proportion of the total steam passing through the tubes, is due to Mr. Schwoerer, though this regulation does not appear to have been generally carried out. By the courtesy of Prof. W. Cawthorne Unwin the author is enabled to give the tests in Table IX. of Schwoerer superheaters in Alsace, some of which were carried out by himself and others by Mr. Walther Meunier, Engineer-in-Chief of the Alsatian Association of Steam Users. It will be noted that in tests 1, 3, 5, 9, one more boiler was required to do the work when saturated steam was being used at the engine. The boilers were of the elephant kind, with Green's economisers.

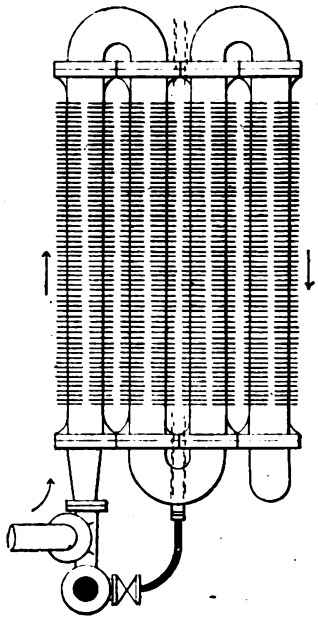

Fig. 10.—Schwoerer Superheater.

An application of the Schwoerer superheater has been made by Messrs. James Simpson and Co. to a Babcock and Wilcox water-tube boiler at the Grand Junction Waterworks, Kew.* The arrangement is shown in Figs. 8 to 10. The boiler is of the same size as those fitted by the author with McPhail's apparatus at Maiden Lane. Full details of the trials unfortunately cannot be obtained; but the saving effected is satisfactory. Tests were conducted by Mr. Osbert

* *Engineering*, March 29, 1895, p. 403.

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Table IX.—*Boiler Tests Without and With Schwoerer's Superheaters.*

Tests made by	Mr. Walther Meunier.								Professor Unwin.			
No. of test	1	2	3	4	5	6	7	8	9	10	11	12
With or without superheaters	Without	With	Without	With	Without	With	Without	With	Without	With	With	With
Number of boilers in use	3	2	4	3	4	3	1	1	4	3	3	3
Duration of trial, hours and minutes	11-10	11-0	10-24	10-19	11-30	11-30	11-30	11-30	6-0	5-0	6-0	5-0
Mean indicated horse-power	278	276	554	564	310	309	116	119	475	491	501·4	502·3
Steam per I.H.P. per hour ..... lb.	19·8	17·1	21·87	17·44	19·00	15·70	21·6	19·2	19·75	15·63	17·06	15·61
Coal „ „ „ „ ..... lb.	3·16	2·37	3·78	3·01	2·98	2·33	3·45	2·64	3·15	2·59	2·56	2·51
Boiler pressure above atm. per sq. in. ..... lb.	...	...	86·7	86·7	68	65	...	...	95·72	99·05	93·74	94·00
Degrees of superheat Fahr. at valve chest	...	115°	...	102°	...	118°	...	...	...	118·3°	119·2°	126·9°
Economy in coal ..... per cent	...	25	...	20	...	20·7	...	23·5	...	17·6	18·5	20·1
„ steam .... per cent	...	14	...	20	..	17·4	...	11·0	...	20·9	13·6	20·9

Chadwick before and after the superheater was fixed, with the following results (Table X.):—

Table X.—*Boiler Tests Without and With Schwoerer's Superheater.*

Date	Jan. 21, '93.	Dec. 20, '93.	Feb. 22, '94.	Mar. 13, '94.
Degree of superheat, Fahr.	0°	57·7°	109·5°	57·0°
Steam per pump, H.P. per hour ..... lb.	20·98	19·71	18·75	19·48
Saving effected...per cent.	...	6·05	10·63	6·75

A test was also conducted by Mr. Goodman, the Superintending Engineer at the pumping station, under ordinary working conditions from December 8, 1894, to January 5, 1895, the engine and boiler being kept continually at work. The fuel used was 86·98 per cent. anthracite peas and 13·02 per cent. breeze, the draught being assisted by a Meldrum blower. The results then obtained were:—

Duration of trial	723½ hours.
Feed water per hour	3223lb.
Fuel per hour	471lb.
Steam per pump horse-power per hour	17·74lb.
Fuel „ „ „	2·58lb.
Mean superheat	121°Fahr.

These results showed a saving of about 15 per cent. on what had been obtained before the Schwoerer superheater was fixed.

This type of superheater is also made by Messrs. Fraser and Chalmers, Erith, who have one in constant use at their works.

Sinclair's Superheater.—Another form of superheater is shown in Fig. 11, which is due to Mr. George Sinclair, of Leith. There is

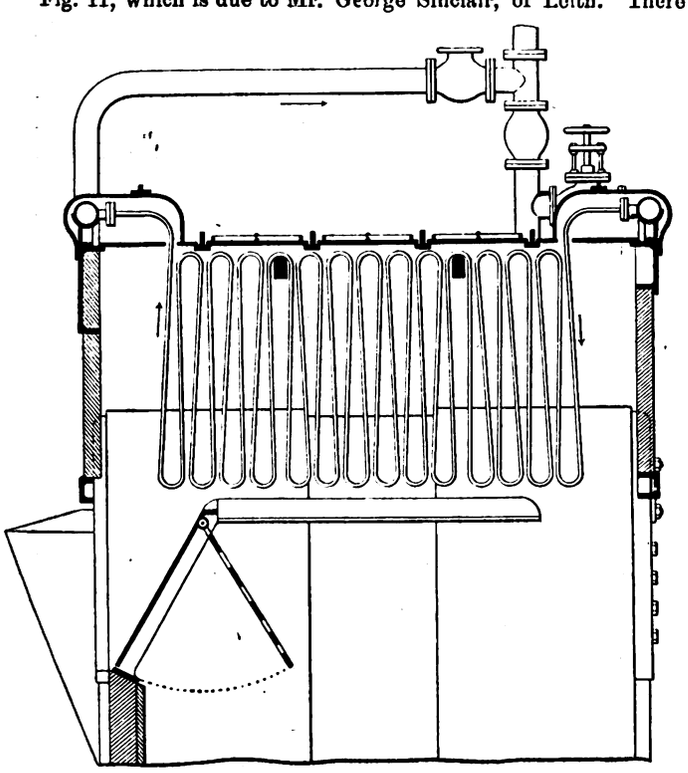

Fig. 11.—Sinclair Superheater.

here a departure from the usual method of securing the tubes, which in this apparatus are flanged and bolted to the cross inlet and outlet pipes, instead of being expanded into them. In such positions an expanded joint is generally considered desirable; but here the joints are removed from the action of the hot gases, and a bolted joint gives much greater facilities for removing a tube in order to examine or clean it. In Fig. 11 the apparatus is shown in conjunction with a marine dry-back boiler, as fitted by Prof. Kennedy at the Edinburgh Electric Lighting Station. The arrangement is very compact, and should prove highly economical. The hot gases from the smoke box at the front are led to the back over the top of the boiler, passing among the superheating tubes; thence down the sides of the boiler to the centre flue underneath it. The apparatus was described in Mr. Burstall's Paper read at the last meeting (October, 1895).

It is much to be regretted that so little has been done as yet with superheated steam at the engine. In nearly every instance the superheat appears to be gone, if not at the steam chest, at any rate immediately on admission to the cylinder. But even under these circumstances the advantage of superheating is manifest from many of the tests given above; and it must be recognised that, although the steam may be cooled down again to the temperature corresponding with the pressure, it is still dry steam, and is a better working gas than the saturated solution of water dust supplied by an ordinary boiler. The desirable amount of superheat has been generally considered to be the equivalent of the heat lost by initial condensation; but this does not obtain in practice. The amount of heat lost in initial condensation is generally from 20 to 25 per cent. of the total heat of the steam above boiling point. Tests with superheated steam show a saving of 20 per cent. with only 5 per cent. extra heat in the steam. This point has been brought out clearly by Mr. W. H. Booth in his Paper on cylinder condensation, read to the Manchester Association of Engineers a few months ago, wherein it was shown that the amount of superheat is but little in excess of that necessary to supply the heat required for making good the latent heat which disappears as work during expansion.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, February 28th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read: (1) "Experiments with Incandescent Lamps," by Sir D. Salomons. (2) "On the Alternating Current Arc," by Dr. Fleming and Mr. Petavel.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Concert (Ladies' Night) at the St. James's Hall Restaurant.

SATURDAY, February 29th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Light," by the Right Hon. Lord Rayleigh, F.R.S.

MONDAY, March 2nd.

SOCIETY OF ENGINEERS.

7:30 p.m. Ordinary Meeting at the Royal United Service Institution, Whitehall. Paper to be read: "The Mechanics of Horse Haulage," by T. H. Brigg.

CHEMICAL SOCIETY.

8 p.m. Meeting at Burlington House.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture III.: "The Chemistry of Certain Metals and their Compounds used in Building, and the Changes produced in them by Air, Moisture, and Noxious Gases, &c.," by Prof. J. M. Thomson.

TUESDAY, March 3rd.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "On Littoral Drift in Relation to River Outfalls and to Harbour Entrances," by W. H. Wheeler. At this meeting the monthly ballot for members will be taken.

WEDNESDAY, March 4th.

INSTITUTION OF ELECTRICAL ENGINEERS.

6 p.m. Students' visit to the Central Stations of the St. Pancras Vestry. Meeting at Stanhope-street Central Station, near Gower-street or Portland-road Stations.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "Röntgen's Photography of the Invisible," by A. A. C. Swinton.

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THE PROLONGATION OF PATENTS.

An invention is at the best somewhat of a speculation. As hardened inventors know full well, it is not enough to be inspired with a good idea and to be possessed of a patent purporting to cover it. A "good" patent is worth more than a good idea, and plenty of capital is better than either. The gentle system of trial by fire must have yielded some curious results in its day, but as a device for awarding approximate justice we are not at all disposed to admit that it was decisively inferior to the ordeal to which we subject a patentee in this year of grace. No doubt if Dr. JOHN HOPKINSON, on the morning of Wednesday, November 2, 1892, when the action of "Hopkinson *v.* the St. James' and Pall Mall Electric Lighting Company (Limited)" came on for hearing before Mr. Justice ROMER, had been given the choice of walking blindfolded and barefooted over 9ft. of ploughshares warmed to the equable temperature of, say, 800°C., or of undergoing the more modern substitute for this painful process, he would have availed himself of the latter alternative with alacrity. Possibly, however, if comparative statistics were available, it would be found that the chance of a miscarriage of justice by the ploughshare test was not appreciably greater, and the method was certainly shorter and less of an elaborate and expensive deception. The element of luck entering, therefore, to such an extent into the business of inventing and patenting, it would seem desirable not to add to it unnecessarily. But this, to our mind, is precisely the tendency of the present system of extending the term of a patent when it can be proved to the satisfaction of the Judicial Committee of the Privy Council that a patentee or his assignee has been inadequately remunerated. If careful inquiry were to show that as a rule it was not possible for patentees to reap their due reward in 14 years, that would be a reason for extending the term of *all* patents. As it is, an industry

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frequently acquiesces in the payment of tribute to the owners of a patent, not because it is regarded as a good one, legally or ethically, but because it has only a few more years to run. Then, just as the moment of expiry arrives, the royalty receivers announce their intention of applying for a prolongation, and the whole basis upon which a peaceful submission to their claims was made is swept away. It is true that in most instances the life of a patent is not prolonged for many years, and that its prolongation is often accompanied by conditions tending to mitigate any hardship inflicted on an industry, but it may be extended by another seven years, and in exceptional cases by another 14 years. Hence not only is it a chance whether or no a patent will be kept alive beyond its normal age, but the amount of the added increment is also problematical. Surely this is an altogether unnecessary and undesirable addition to the notorious uncertainty of patent law—some of which is, of course, inherent to all mundane transactions, but most of which is merely due to the intricate, illogical and inchoate state of the law, a condition easily remediable by a broad-minded public-spirited lawyer, endowed with a strong will and given a free hand. The more the element of pure chance is imported into any class of transaction the more do these transactions tend to degenerate into a mere gamble—an exciting pursuit we doubt not, but never encouraged with impunity by the State. As matters stand at present a patentee neither knows, nor, humanly speaking, can know, whether he has been genuinely anticipated; whether, notwithstanding the care taken by his legal adviser in drawing up the specification, the impish ingenuity of another gentleman of the robe may not discover a fatal technical flaw or unearth from Limbo a plausible "prior user." And to legal difficulties are superadded doubts as to whether a public want is filled by the invention and as to whether the idea will commend itself to the omnipotent but not omniscient capitalist. Finally, to make sure that the venture shall lack every single element of certitude, the term of a patent, if the patent should, by a rare concatenation of favourable circumstances, survive the many "ifs" and "ands" that beset its path, is not a fixed invariable quantity, as it might well be, but anything from 14 to 28 years.

The patent system, notwithstanding all its defects, artificial and natural, is incomparably superior to the secrecy of trade guilds and the like, and the fundamental idea underlying it is an exceedingly obvious one. In return for a full disclosure of a method or process, the public grants a legal monopoly of it to the individual for a limited term. The nation's fund of technical knowledge is thereby increased, and technical progress is stimulated. If the monopoly grant too often proves a snare and a delusion, or if its term is too short, the inventive minds of the nation will assuredly revert to the baneful secrecy of ancient times; baneful to the inventor, because it is not in the long run as profitable by reason of the expense and trouble entailed by maintenance of secrecy; baneful to the nation, because trade secrets are very liable to become extinct, and close-rings do not tend to improvements in methods. On the other hand, the public is a loser if the term of these legal monopolies be unduly prolonged, or if patentees be allowed to evade a full disclosure. The main advantage that accrues to the patentee under the patent system is, or should be, certitude. How far this great desideratum is attained, when even the duration of a patent is a matter of judicial caprice, we leave our readers to judge.

But, taking things as they are, and not as they ought to be, what chance of prolongation into the twentieth century, may we ask, has the famous three-wire patent, No. 3,576, of July, 1882? The only ground upon which the term of a patent may be extended is the inadequate remuneration of the patentee or his assignee; and a case of inadequate return having been made out, the patentee then has to show that his invention is of unusual merit, and that it is through no fault of his own that he has not made enough money out of it. In 1892 the Westinghouse Company endeavoured to use the three-wire patent as a means of extracting royalties from the St. James' and Pall Mall Company; a lawsuit was the natural result. In November the case occupied the Courts for ten days, and on January 14, 1893, Mr. Justice Romer vindicated the aspersed validity of the patent. As no appeal was made, and as royalties were subsequently paid by the defeated parties and by others, we may assume that the patent is, legally speaking, a tolerably good one. So much for the validity of the patent. As to its intrinsic worth, no disinterested electrical engineer would, we think, venture to question its "unusual merit." Again, since it was impossible, owing to the practical non-existence of three-wire systems of distribution in England prior to 1890, to put the patent into force until more than half of its normal life had passed, and since Mr. Justice Romer's judgment was not actually delivered until the beginning of 1893, that is to say, until within 3½ years of the expiry of the patent, there can be no gainsaying the fact that the patentee or his assignee had but little time in which to reap a fair reward. However, if a field be fertile and the tiller industrious and acute, a large profit may be made in a short while. Has this been the case with Patent No. 3,576 of 1882? The levy of £2. 10s. per annum per ton of copper laid was certainly not extortionate, and municipalities and companies who have not seen their way to pay even this modest tribute do not appear to have been harried. In short, no burdensome or vexatious hindrance has been imposed upon the progress of the electric supply industry by the owners of the three-wire patent. Nevertheless, the aggregate tribute received will have to be disclosed to the last cent, and the Judicial Committee of the Privy Council may very well deem it adequate, especially if the municipalities show as much fight as they threaten to. On the whole, however, we should not be surprised if the three-wire patent were prolonged, and we do not see that its prolongation should give cause for serious regret.

REVIEWS.

The Electrical Transmission of Energy. By Arthur Vaughan Abbott. (New York: D. Van Nostrand Company. London: Sampson Low, Marston and Co.)

Lest readers of the above title should imagine that this book deals with a subject which already has been treated in many excellent works, we may at once add the sub-title, "A Manual for the Design of Electrical Circuits." And a most valuable manual it is, for large as is the amount of information on this subject scattered up and down among *Proceedings* and *Journals*, there is no work to compare with this in the thoroughness with which the subject is dealt with. The author states in his preface that the work has been prepared as "an endeavour to collect and arrange in an accessible form the data necessary for the scientific designing and proportioning of electric circuits, . . . a subject so aptly and untranslatably termed by the French *canalisation*." After an introduction on "Distribution" in its varied methods —series, parallel, mixed, and indirect—followed by a useful chapter on the mechanical and electrical properties of wire, we have valuable chapters on aerial lines for general work and electric railway circuits. Seeing that the author is an

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American, and bearing in mind the general character of American overhead constructions, we can only say that after reading these chapters American constructors will sin wilfully, not of ignorance. To English engineers it is only necessary to call particular attention, as the author does, to the difference of climate in different countries as necessitating differences of material for insulators, and differences of treatment for timber and other constructional material. Then underground circuits, cables and conduit systems of all sorts are described and copiously illustrated with notes of their practical working. After a chapter on electrical measurement, the laws of continuous-current circuits and of alternating-current circuits are dealt with. Chapter VIII., on the latter subject, is probably the most lucid exposition of the method of calculating the constants for combined series and parallel resistances, inductances and capacities which has been put before students at any time. All these chapters, occupying half the book, bring the subject to the point of the actual design of conducting systems for any given conditions. Perhaps few scientific rules have had more laid upon them which they were not intended originally to carry than what has been named Sir William Thomson's law for economy in conductors. The fact is, this law only considers a conducting system from one point of view, and, as the writer of this book points out, there are at all events eight. In addition to the economic point of view, mechanical considerations, *possible* capital outlays on stations and generating plant, good and regular service to customers, maximum possible income with minimum outlay on station, are all points of great practical importance which Thomson's law does not, and was not intended to include. It cannot be overlooked that many electric undertakings never would have come into existence if the capital outlay demanded by Thomson's law had been adopted. These points the author deals with in detail, and as they involve questions of cost of conductors of various kinds, of machinery, of stations, of coal and water and of units and watts, all these items are illustrated by tables and diagrams of a very valuable nature. It is impossible within the scope of a short review to deal with a fraction of the contents of this book. In subject useful, in matter most painstaking and lucid, illustrated by 289 figures, each of which conveys what pages of words would not, with 74 tables embodying an enormous amount of information, with nine large folding plates for graphical solution of problems (these latter in a neat pocket, forming the back cover of the volume), it forms a book which completely covers this branch of engineering. And not the least valuable parts of its make up are the table with which it commences, giving the symbols used throughout and their meaning, so as to avoid endless repetition, (or what is worse, the use of the same symbol for different things in different parts of the book); and the copious index with which it ends, containing on an average about three references to each of the nearly 600 pages which it comprises.

Elementary Treatise on Electricity and Magnetism. Founded on Joubert's "Traité Elémentaire d'Electricité." By G. C. Foster, F.R.S., and E. Atkinson, Ph.D. (London: Longmans, Green and Co. 1896.)

The va'ue of any given educational work depends upon the time and place of its use. An otherwise excellent work may cease to possess any educational value whatever, and may be useful only to the antiquarian or the collector when translated from its native place or proper age into a foreign region or a later period of time. These trite reflections naturally suggest themselves when the idea of a translation into English of Joubert's "Traité Elémentaire d'Electricité" is proposed. For, though in the continental school of electricians of a few years ago such a work as the one by Joubert just named represented orthodox theories in clear and lucid language, the same work done into the language and used by the countrymen of Maxwell must conflict with views which have long taken firm root in the soil of English science. Doubtless considerations such as these influenced Profs. Foster and Atkinson in deciding to abandon the scheme of a simple translation of Joubert and to weave instead upon the skeleton of Jobert's treatise a modernised and Maxwellian presentment of the elements of electrical science. The result has been the work before us; and in it we find that but little that was Joubert's has remained, and much has been introduced by the adapters which is essentially based upon the hypothesis of action within a medium, as opposed to the notion of action at a distance, which latter view was adopted by Joubert. Thus, for example, the phenomena of electrostatics are considered in relation to the condition of the dielectric, and not as being inherently due to the charged conductors. In fairness to M. Joubert, however, we should say that he professed to attempt little more than a statement of the bare facts of electricity and magnetism, without reference to what, at the time and place of its writing, would have been regarded as debateable hypothesis; while his adapters have carried their work into a much more advanced and philosophic stage, having analysed the bases of the phenomena and sought to connect them upon the Maxwellian hypothesis. This extension of the scope has inevitably resulted in the introduction of a more mathematical treatment than that employed by Joubert.

While a considerable amount of technical matter is discussed, especially in the later chapters, this book appeals more to the student of theory than of practice. It is a book rather for the physicist than for the engineer. The interlinking chain of electrostatic and magnetic phenomena is entered at the same point as that selected by Maxwell—namely, at the time-honoured subject of "electrification by friction." The electrostatic is made the basis of the reader's ultimate conception of the interdependent phenomena of electricity and magnetism. This has been, with but one or two notable exceptions, the starting point for the theorist and the physical student, though, as has recently been pointed out by Dr. John Hopkinson, it is often to the advantage of the practical student to commence with the phenomena of the electric current. Yet, while ignoring the antiquated action-at-a-distance idea of electrostatics, the adapters have retained the system of units which has its sole basis in that obsolete conception. Not the Heaviside units, not any rational system of units, but the irrational—though unfortunately fashionable—C.G.S. units are used throughout this treatise. Surely a treatise which omits all reference to Heaviside from its pages, and all mention of the rational system from the chapter on "Units," cannot justly claim to be modernised, however Maxwellian it may be.

Regarded from the standpoint adopted by the writers, and upon the lines selected by them, this work is worthy of the serious attention of students of elementary electrical science. By its careful perusal they will obtain an accurate insight into the more important phenomena of the science, their logical connection and their bearing upon the principal branches of electrotechnics and electrical engineering. Its language is terse and clear; its mathematics are not beyond the stage at which everyone who seeks the end in view should have arrived; and its numerous illustrations are well executed and are to the purpose. It should prove a useful introductory to higher studies in electrical science.

Mesures Electriques. By Eric Gerard. (Paris: Gauthier-Villars et Fils.)

The measurement of electrical and other physical quantities with which the electrician and the electrical engineer are concerned forms the greater part of the curriculum of electrical laboratories, whether they are devoted to pure science or to technical applications. Indeed, one of the main points of difference between the college-trained worker and the so-called "practical man" is that the one knows more or less what is meant by accurate measurement, and understands how to get the best work out of his instruments, while the other uses them with a simple faith in the maker, and prefers direct methods and direct-reading scales.

Prof. Gerard's treatise on Electrical Measurements will be of considerable assistance not only to those engaged in teaching and their students, but also to the managers of testing and standardising departments in works and electric supply stations. In a large book of over 400 pages he gives descriptions and investigates the measurement of all quantities likely to be dealt with in an electrical laboratory. Commencing with an excellent chapter on the theory of measurements and errors, including some

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good advice on the method of reporting results, he follows with an account of photometry and photometric instruments. About one-half of the book is devoted to measuring instruments, galvanometers, standard units and other apparatus, with methods of measurement of current, E.M.F., resistance, capacity, self and mutual induction, power, magnetic measurement of iron and terrestrial magnetism. Special applications, including the resistance insulation and capacity of telegraph and electric light systems and the determination of faults, the testing of primary and secondary batteries, and of continuous and alternating-current dynamos motors and transformers, occupy the rest of the book. At the end there are some useful tables of resistances of metals and liquids, with temperature corrections, and a brief set of instructions on the use of the slide rule.

Such a wide field obviously renders impossible an exhaustive treatment of each branch, and the book will not give much new information to an expert in his particular subject. Moreover, the proportion of space allotted to each part may not receive the approval of some specialists. In fact the discussion of dynamo, motor and transformer testing is perhaps the least valuable part of the book, being hardly more than a short *résumé* of some of the methods in vogue, and the descriptions are not sufficiently full to admit of this portion of the book being used by inexperienced workers. A similar paucity of information may be observed in the chapters on commercial measuring instruments and switches. The few that are mentioned are not altogether representative, and more information would be obtained by a student from a few makers' catalogues than from these chapters. The illustrations, in some instances, are merely pictures of the outside case of the instrument, and convey no useful information. In spite of these blemishes, the greater part of the book contains a large amount of well-arranged and useful information, with very few sins either of omission or commission. In the chapter on Photometry the Methven screen is not mentioned among the standards, perhaps with some justice. The multitudinous methods of measurement of resistance, capacity, E.M.F. and the like are carefully and clearly given, and a feature of the book is an investigation of the probable error in each case and the conditions of maximum accuracy. It is surprising that Carey Foster's adaptation of the Wheatstone's bridge is not mentioned in any of its forms, and there is apparently room for improvement in the potentiometer methods in vogue at Liège, since the arrangements described in the book are unnecessarily complex.

It is to be regretted that references to original Papers are not more frequent. If this had been conscientiously carried out, a short description would have amply sufficed to indicate the suitability of a method, but without such reference the student is put to very great trouble. Again, a criticism of alternative methods, and a few words as to the accuracy and limiting conditions of each, would from the hands of an expert be of extreme value. We note, for instance, that Frisch's method of determining faults in installations by means of a single voltmeter is given without a word of caution, whereas, as a matter of fact, it is useless unless there is only one fault, and the insulation of therest of the circuit is indefinitely high, conditions which are not likely to occur in practice.

Nevertheless, the book is well up to date, the language is simple and straightforward, the mathematics clear and free from unnecessary complications, and the diagrams are plentiful and admirably executed. In all electrical laboratories it deserves a place.

ELECTRIC TRACTION BY POLYPHASE CURRENTS.

What we believe to be the first application of polyphase currents directly to electric traction is now being made by Messrs. Brown, Boveri and Co., at Lugano, in Switzerland. At this place an electric railway is being equipped with polyphase plant, and will, it is hoped, shortly be ready to start work. Preliminary trials have already been made with successful results.

The power for this railway is derived from a waterfall, where a power house has been installed with a 300 H.P. turbine, driving two 150 H.P. three-phase alternators. The power is generated at 5,000 volts, and a portion of it is used by a chocolate factory near the power house. The three-phase generators are of a special type, in which the only moving parts are the iron star-shaped pole cores. Both the field coils and the armatures are stationary.

Three-phase current for the railway is conveyed at 5,000 volts, overhead, over a distance of 12 kilometres (7½ miles) to Lugano, where it is transformed down to 400 volts by ordinary transformers. The power is there distributed to the cars by means of two aerial or trolley lines, the third conductor being supplied by the rails. Three-phase motors on the cars receive power through a double trolley-wheel apparatus; and a special form of controller is used when varying the speed or reversing the car. The motors are designed to give a normal speed of 15 kilometres (9⅜ miles) per hour.

The advantages which attend the use of polyphase currents for electric traction are, principally, in enabling power to be derived from a distant source, and in allowing of the use of motors which require no commutator, collector, nor bare electrical conductor upon them. On the other hand, a double trolley line and the duplication of the trolley collector wheels are rendered necessary. Of the modifications in the controller which are involved, we cannot now speak particularly; though it seems probable that a more complicated construction than where the current is continuous would be essential, this need not, however, necessitate additional complexity in the manipulation of the controller. The use of two overhead conductors must also present a disadvantage, from the increased risk of breakdown due to a telegraph or telephone wire falling across them.

We are indebted to S. Giovanni Giorgi, of Rome, for the foregoing particulars of the Lugano electric railway, the further development of which will be watched with interest by electrical engineers.

THE LESSING DRY CELL.*

During the last few years the advantages of the so-called dry cells, as compared with other forms of primary batteries, have become and more recognised by users of small electric currents, especially when employed intermittently, as in telegraphy, telephony, medicine, ringing electric bells, &c. These advantages have been discussed and admitted generally in the technical Press, and it is, therefore, unnecessary in this preliminary note to refer to them in detail.

Dr. Lessing's cells belong to the well-known type of modified Leclanché cells, the depolariser being black oxide of manganese and the exciting fluid sal-ammoniac. Each cell is contained in a neat porcelain outer cylinder or jar, highly glazed, and is securely sealed up; lugs on the carbon and zinc plates project through the seal and are provided with convenient binding screws for making connections. The height of each cell is 6·3in., and its external diameter 3·1in., whilst the weight averages about 3lb. 2oz. The arrangements for so sealing the cell that the moisture cannot creep or escape, and the necessary vent for the gases that may be set free, appear to be admirably adapted to the objects in view, and have responded very well to the preliminary tests. Further tests designed to break down these arrangements will try them still more severely.

The following tests were made upon three cells taken at random from a large parcel. The electromotive force (E.M.F.) of each cell as compared with a Latimer Clark standard cell by methods which need not be here described was found to be 1·470 volts, the variations on the different cells being inappreciable. This is fully equal to the E.M.F. that can be expected from this type of cell. The resistances of the cells were next ascertained under very severe conditions, viz., when generating heavy currents, varying from 2·25 to as much as 3·75 amperes. Notwithstanding the severity of the test the resistances were found to have the following very low values for the above size of cell: No. I. cell=0·222 ohm; No. II. cell=0·166 ohm; No. III. cell=0·121. Each resistance given is the mean of four measurements taken with currents varying within the above-named limits.

The cells were then discharged in series through a constant external resistance for 45 hours continuously, the currents given

* Preliminary and further reports by Dr. R. Mullineux Walmsley.

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varying from 113 milliamperes at the start to 36 milliamperes at the end of the test. These currents are much larger than the cells would ordinarily be called upon to give in any of the cases cited above, and the fact that they were maintained for such a long period without the cells being allowed to recuperate by intervals of rest augurs well for the practical use of the cells. Measurements of E.M.F. and resistance were made at intervals during the discharge. The details need not be given in this preliminary note, but it may be stated that at the end the E.M.F.'s were 76·2, 78·7 and 74·7 per cent. of their respective values at the beginning of the test, whilst the average resistance had only risen to a little over 0·4 ohm per cell. The cells were next allowed to rest for five days, during which the E.M.F.'s returned to 99·0, 99·4 and 92·9 per cent. respectively of the before-named initial values. On discharging continuously for a further period of 24 hours through the same resistance as before, the current fell from 108 milliamperes at the start to 80 milliamperes at the end of the time. Simultaneously the E.M.F.'s had fallen to 72·3, 74·0 and 68·8 per cent. respectively of the value at the commencement of the first test.

It may be remarked, in passing, that the variations in the fluctuations noted in the values of the E.M.F.'s show how very necessary it is in tests of this nature to discharge more than one cell under precisely similar conditions if reliable deductions are to be made of the general behaviour of the cells. Experiments, such as are sometimes made, on single cells may give very misleading results, owing to the particular cell experimented upon being either above or below the average, for it is impossible for any manufacturer to ensure absolute uniformity.

The above tests, which are merely preliminary, show that Dr. Lessing's cells compare very favourably indeed with other forms of dry cells as shown by published tests. Further tests are now being made under varying conditions on all the principal points which are of importance in connection with the use of primary batteries as current generators for small currents.

The following report is a continuation of a preliminary one dated October 31, 1895, to which reference should be made for various descriptive details which will be found therein. The further tests, which will be dealt with presently, were designed chiefly to try the behaviour of the cells as current generators under different and varied conditions, and were all completed before Christmas, but private circumstances have prevented the writer from making his report until now. It will be unnecessary to repeat generally what has been already said in the preliminary report, but perhaps attention may again be drawn to the importance of not making deductions from the behaviour of a single cell. All the subsequent experiments emphasise strongly the remarks previously made on this point, and in these experiments *three* cells were always discharged simultaneously under precisely similar conditions, and measurements were taken on each cell separately. The only doubt regarding the advisability of this course is as to whether *more* than three cells ought not to be used to get fair measurements of the average behaviour of the type of cell under test. The E.M.F.'s were obtained by comparison with a standard Latimer Clark's cell by means of a condenser and sensitive ballistic galvanometer. Both charge and discharge readings were taken, and the usual well-known precautions were adopted, the actual E.M.F. at the moment of breaking circuit being obtained by taking timed readings and plotting the results on curved paper. The resistances were obtained by measuring the P.D. just before breaking the circuit and calculating in the usual way. Some remarks will be made on this subject later on. For convenience, the tests may be referred to in two groups, namely, those in which the current was kept on continuously and those in which the currents taken were intermittent. The former will be described first.

Continuous-Current Tests.

In these tests, unless otherwise mentioned, the current was kept on continuously day and night, except that the circuit was broken occasionally for about a minute at a time to enable readings of E.M.F. to be obtained. It will, perhaps, be sufficient to mention three sets of tests.

In the first set three cells were discharged through a constant external resistance, which was such that the current at starting was nearly 500 milliamperes or 0·5 ampere (more exactly, 435 milliamperes), a very large current to take from cells of this size. Notwithstanding this, the cells maintained the current fairly well for rather more than six hours, during which time the fall of the current was less than 7 per cent. Shortly afterwards the cells fell off very rapidly, but their resistance at the end of the six hours was less than 0·2 ohm per cell.

In the next set three fresh cells were discharged through a larger constant external resistance such that the value of the current, after the cells had been at work a few minutes, was 42·5 milliamperes, a value approximating to the currents usually required from cells of this kind. At 27·2 hours from the commencement of the test the current had fallen to 39·4 milliamperes (92·7 per cent. of the above starting value); at 48·7 hours it was still 39·4 milliamperes; at 71·1 hours it had fallen to 37·3 (87·7 per cent.); and at 95·5 hours to 27·6 milliamperes. This last low value was due to the fact that one of the cells had become exhausted. This cell was therefore now cut out of circuit and the external resistance reduced to two-thirds of its value for the three cells. The current from the two cells then rose to 37·6 milliamperes (88·5 per cent. of the first value) and only fell to 26 milliamperes at 178 hours from the start. The two cells were now practically equal in E.M.F. and resistance, and though the discharge was continued for nearly 22 hours longer it is unnecessary to quote further measurements, as for all practical purposes the cells were exhausted.

The E.M.F.'s of the cells were 1·455, 1·470, and 1·466 volts before closing the circuit, and these fell off in much the same percentage manner as the current, though there were variations between the cells. It is not necessary to cumber the report with the detailed figures, but as an example it may be mentioned that at 71·1 hours the E.M.F.'s were 1·280, 1·297 and 1·308 volts respectively, or 88·0, 88·3 and 89·2 per cent. respectively of their original values. The current had fallen off rather more because the resistance of the cell, which was eventually cut out 24 hours later, had already begun to rise. When this cell was cut out its E.M.F. had fallen to 33·4 per cent. of its original value, but the other two cells had only fallen in E.M.F. to 62·0 and 62·5 per cent. of their initial values 74·5 hours later, or 170 hours from the start.

The behaviour of the cells with regard to resistance during these tests with small currents was not easy to examine. To measure the resistances very accurately would have necessitated the taking of much larger currents from the cells for short periods. To this course there are two objections: first, that it destroys the value of the tests for the particular currents under investigation, and secondly, as was ascertained by actual experiment, the passage of these large currents affected quite irregularly the very resistance to be measured, which was sometimes diminished and sometimes increased. The resistance measurements for small currents are, therefore, only approximate. In the set of tests now being described the resistance was less than 0·2 ohm for each cell at starting and remained at that value for over 24 hours. It then began to rise irregularly and in different ways in each cell till at the end of 48 hours it was about 0·5 ohm per cell. At the end of 72 hours it had fallen in two cells, but had risen to over 1 ohm in the third, which was the cell cut out 24 hours later. In a general way it may be said that the resistance fluctuated about the value 0·5 ohm per cell until the cells were exhausted, and that the rise of resistance was a sign of approaching exhaustion more marked at first than the fall of E.M.F.

The next set of tests need not, perhaps, be referred to in such detail. In these a still larger external resistance was employed, such that the value of the current after the first few minutes was 28·4 milliamperes, a current quite large enough for many purposes. After 48 hours the current was still 27·6 milliamperes, and at 70 hours was 26·7. At this time the circuit was accidentally broken for 1½ hours, so that the cells had a short period of rest. The discharge was then resumed, and the current fell off gradually till at 163·5 hours it stood at 21·8. This low value, as in the preceding experiments, was chiefly due to the exhaustion of one cell only. On cutting this cell out and reducing the external resistance proportionately, the current rose to 25·6 and fluctuated between 26·0 and 25·4 milliamperes, until the discharge had continued for 242·7 hours. At 266 hours the current was still 25 milliamperes, but 22 hours later it had fallen considerably and the cells were both exhausted. The E.M.F. and resistance, allowance being made for the more extended periods of discharge, followed the same general course as in the experiments last described.

Two sum up briefly, the tests show that with cells in good condition, currents of from 25 to 28 milliamperes may be taken continuously and without breaking circuit for 260 hours or longer, a result which may certainly be regarded as very satisfactory.

Intermittent-current Tests.

But one of the chief uses of this type of battery is not for the supply of continuous currents but for generating intermittent currents, and it was therefore considered desirable to examine the behaviour of the cells when supplying such currents, but still under conditions more rigorous than would probably be exacted in actual practice. A piece of simple apparatus driven by clockwork, but which it is unnecessary to describe in detail, was therefore constructed, by which the circuit of a battery could be kept closed for 4min. and then opened for the 6 following minutes, to be again closed for 4min. and opened for 6min., and so on for as long as was considered desirable. In this way the whole time of a test was broken up into intervals of 10min., and in each interval the current flowed without interruption for 4min., and during the remaining 6min. the battery was allowed to rest and recuperate.

Two such series of tests will be here referred to. In both cases, for reasons already given, three cells were joined up in series, and the tests made on the three cells of each group simultaneously. In the first series the cells were allowed to discharge through a constant external resistance, such that the current at the end of the second 4min. was 258 milliamperes—a heavy current

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to take from such a battery for any extended period. The tests were continued for 96 hours. Before any current had been taken from the cells their E.M.F.'s were 1·505, 1·490, and 1·476 volts respectively, and the resistances after the above current had flowed for a few minutes were 0·54, 0·49, and 0·10 ohm respectively. It would thus seem that the first two cells for some reason had both a higher E.M.F. and higher resistance than most of the cells experimented upon, and perhaps on that account may be regarded as somewhat abnormal. At the end of 49 hours the E.M.F.'s had fallen to 79·8, 78·8, and 83·0 per cent. of their initial values, whilst the resistances had increased some 50 per cent.; at the end of the 96 hours the E.M.F.'s were 1·067, 0·935, and 0·766, or 71·0, 62·7, and 52 per cent. of their initial values. It is evident that at this time the battery was practically exhausted for this method of working. Nevertheless, the discharge was continued 50 hours longer, and then the battery allowed a complete rest of 23 hours. At the end of this period the E.M.F.'s had returned to 67, 70, and 62 per cent. of their initial values, but the resistances of the two first cells (the apparently abnormal ones) had permanently risen to the high value of over 2 ohms, whilst that of the third was now only 0·3 ohm. These tests show that a rest of 6min. is not sufficient to allow the cells to recuperate after supplying such a very heavy current for 4min. continuously.

The next tests to be quoted show that with a smaller current of a magnitude more likely to be demanded in actual practice the relative times allowed for rest and work were more nearly suited to the capabilities of the cells. In these tests, using the same clock-work apparatus as before for making and breaking the circuit, three new cells were taken and caused to discharge through a much larger constant external resistance. The resistance, which was not changed throughout the experiments, was such that the commencing current was 27·6 milliamperes. At the end of 167½ hours, throughout which currents of 4min. duration were followed by rest intervals of 6min., the current had only fallen to 26·4 milliamperes. The cells were next allowed to rest for some days, and were then again discharged through the same resistance. The current started at 27·2 milliamperes, and, at the end of 213·4 hours further work, had only fallen to 25·0 milliamperes. Thus, after 380 hours of intermittent working, the current from the three cells through a constant resistance had only fallen 9·6 per cent. of its initial value. How much longer the battery would have maintained approximately the same current was not ascertained, as the experiments were interrupted by the intervention of the Christmas holidays.

Comparing, however, with the corresponding continuous-current tests, we find that about the same percentage fall of current occurred after 308 hours' intermittent working as after 70 hours' continuous working. In 308 hours the current is actually on for 123 hours. Now, in the "continuous" tests the cells continued to give a good current for about 280 hours or 4 × 70. If we assume the proportion to hold, it would have taken 1,200 consecutive hours to exhaust the cells by the intermittent working. The calculation, though on a probable basis, must only be taken as approximate. Returning to the "intermittent" tests, it was found that the percentage fall of E.M.F. was fractionally (but very slightly) greater than the fall of current, because of the falling off in resistance referred to below.

The remarks previously made on measurement of resistance for small currents apply to these tests and should be borne in mind. At starting, the resistance of the first cell was less than 0·25 ohm, of the second was 0·3 ohm, whilst the resistance of the third was as high as 2·6 ohms. The resistances of the first two cells varied between less than 0·25 ohm and 0·5 ohm throughout the tests, whilst that of the last gradually diminished till it fell to about 0·3 ohm at the middle of the tests and afterwards showed much the same fluctuations as the other cells. The passage of successive currents through this cell therefore had the effect in time of breaking down its high resistance, and the tests show that each cell had a working resistance of 0·5 ohm to 0·25 ohm or less for currents of about 27 milliamperes, a result which may be regarded as very satisfactory. In the preceding tests with heavier currents, where it was easier to make the resistance measurements, the fluctuations were wider and extended from 0·1 ohm to 0·79 ohm until the cells began to get exhausted, when the resistance in two cases rose rapidly, and in the third fell to below the mean value.

The above tests show conclusively that these cells are admirably adapted for generating intermittent currents of the magnitude usually required for many purposes, such as telegraphy, telephony, ringing electric bells, and for medical and other uses. The cells, for their size, have, as a rule, a very low internal resistance and consequently a high efficiency, since only a small proportion of the electric energy is lost in working against the internal resistance. They also have good recuperative power, and if the outside be kept dry the terminals are very well insulated. The so-called test of trying how long a cell would ring an electric bell was not considered necessary, for, at the best, it is unscientific, and can only yield ambiguous results. This is at once evident when we consider that the current required to ring a given electric bell depends largely on the construction of the bell; moreover, much also depends on whether the current is kept at the minimum required to ring the bell or is allowed haphazard to be of any greater magnitude.

One other important property of Dr. Lessing's cells may be referred to in conclusion. Throughout the tests, even when the heaviest continuous currents were being taken, in no instance did a cell show any sign of bursting or of mechanical leakage. In this respect they compare favourably with some similar cells on the market which the writer has seen burst open by the expansion of the materials caused by the heat generated by heavy currents.

The cordial thanks of the writer are due to three of his students, Messrs. J. H. Hughes, C. A. Henderson, and M. Thomson, at the Heriott Watt College, for the care taken in making the experiments, and to the two first-named for constructing the special apparatus required for the intermittent tests.

DIELECTRIC STRENGTH OF OILS UNDER ALTERNATING POTENTIALS.*

BY PROF. ELIHU THOMSON.

In the course of tests made under the direction of the writer some two or three years ago, the interesting fact was noticed that the striking distances of high potentials in insulating oils were in some way variable with the frequency of the current or potential waves, or upon the time during which electric stresses existed in a given direction through the medium. This relation has been confirmed by other and later experiments. The general effect was found to be that discharges at low frequencies are capable of puncturing mineral oil layers up to from one-third to one-half the thickness of an air layer required to just resist puncture by the same discharges, while with high frequencies of equal striking distance in air an oil layer of one-thirtieth to one-sixtieth of the thickness of the air layer was sufficient to prevent discharges. At frequencies such as 125 per second, a potential which would give one-half of an inch spark in air, may puncture from one-third to one-fourth of an inch of oil between the electrodes, while at frequencies of 50,000 to 100,000 a layer of oil of one-fourth of an inch may resist puncture when the spark in air is as much as 8in. The high frequencies experimented with were such as are given by condenser discharges over an air gap, including a primary of a few turns, with a secondary of a single layer of some hundreds of turns immersed in oil. The discharges, in such cases, are not continuous waves, but a rapid succession of oscillatory discharges with dead intervals or periods of inactivity intervening.

The effect of carefully drying an oil was found to increase its insulating power. This was also true to a marked extent when careful filtering was resorted to, a decided decrease of striking distance through the oil with the lower frequencies being observed. It follows from this that all oil used in insulating for high potentials with low frequencies should be kept clean and homogeneous, and free from floating particles.

Variations of temperature of oil did not, in the experiments made, greatly affect the striking distances for a given potential. The general fact, however, that with high frequencies the insulating power of oil layers is, as measured by the striking distance in air relatively to that in the oil, far in excess of such insulating power for low frequencies, seems to be unaffected by the dryness, clearness or temperature of the oil used.

It appears probable, also, that with partially conducting liquids like alcohol and water, the behaviour with high frequencies is more like that of a true dielectric insulator than with low frequencies. As an interesting fact in this connection it may be noted that a high-potential high-frequency coil capable of yielding spark torrents over 30in. of air gap between its terminals, still maintains its discharges even when shunted by a glass tube 1½in. in diameter containing ordinary water, and long enough to bridge the gap.

It is difficult to account for the differences in the effects obtained with high frequencies from those with low-frequency alternating waves. A time lag in the establishment of the full dielectric stress or full electrostatic field in the oil might account for the phenomena. According to this hypothesis if two electrodes under oil, separated a certain distance, instantly acquire a difference of potential, this potential would not with equal rapidity strain the oil to the full extent. It might be assumed that the polarisation of the oil molecules requires time; or, it may be that only such part of the electrostatic field as is due to the ether is first established after electrification and that the increase of such field, due to the molecules of the substance, such as interposed oil, is subsequent to the former. If this were so, the establishment of an electrostatic field at high rates in oils would present analogies with the case of magnetic fields in iron or metals. It would also follow, if the sup-

* From the *Electrical Engineer* of New York, February 12th.

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position of a lag as above be true, that in condensers such as those using oil as a dielectric, the capacity would be less the higher the frequency. Again, if any such lag as is assumed exists, it would probably vary with different insulating media, and it may depend upon the molecular state, as viscosity, for example. Observations of the oil space between the immersed electrodes by polarised light could probably be used with certain media to detect any differences in time of establishment of electrostatic stress with different frequencies, it being well known that under high stresses certain insulating liquids become strongly affected in their optical properties, with rotation of polarised beams of light traversing them. If the optical effect noticed should be less in the case of high frequencies than with low rates it would indicate a probable lag of the kind assumed. Similar studies, using solid dielectrics like glass, mica, &c., would also be desirable. Should the results be negative it would be necessary to attack the problem in some other way. M. P. Janet, about a year or more ago, in a communication to the Paris Academy of Sciences, gave the results of his investigation of the properties of mica. He found that it did possess, with rapid oscillations, what might be termed a dielectric hysteresis. Such a property may exist to a more marked degree in oils.

In the tests of the power of oil layers to withstand puncturing by high potentials, a curious effect was noticed, which was that discharges under oil passed far more readily between balls than between sharp points. In other words, with any given difference of potential between the immersed electrodes, as measured by the air spark obtainable, pointed electrodes could be brought much nearer than balls without provoking puncture. With balls of half an inch diameter as terminals and with low frequency (125), potential differences ranging from 100,000 to 150,000 volts, the space between the points could be one-quarter that between the balls. The ratio between the length of spark in air and between sharp points in oil was 10 to 1 at 10,000 volts and 8 to 1 at 15,000, while with balls these ratios fell to 2·4 to 1 and 2 to 1 respectively. When flat plates were substituted for the balls the striking distance in oil was still further increased as compared with the distance with points. The seemingly anomalous action of points under oil, so different from their action in gases or air, is certainly curious, and the usual injunction to avoid points and edges as conducive to electric discharge does not seem to apply in such media as oil, at least when the potentials are alternating and at ordinary frequencies.

In experimenting with discharges in oil uniform results are only to be obtained by using carefully-filtered oil, as ordinarily they contain suspended particles, fibres, &c., which appear to bridge the space between the electrodes and provoke a breakdown due to the non-homogeneous character of the dielectric. It is also necessary to discard oil after arcing has once occurred through it, as it will have become much weaker, owing doubtless to the fine carbon particles set free, and which remain floating ready to be drawn into the space between the electrodes, thus giving rise to loss of homogeneity of the medium.

THE ELECTRIC RAILWAY SYSTEM OF MONTREAL, CANADA.

At the ordinary meeting of the Institution of Civil Engineers on Tuesday, the 18th inst., Sir Benjamin Baker, the President, in the Chair, a Paper was read on "The Electric Street-Railway System of Montreal, Canada," by Mr. G. C. Cuningham, M.Inst.C.E.

The author traced the rapid development in Canada and the United States of the application of electricity to street railways. In the United States in 1888 there were about twenty electrical roads in operation, having a total of 80 miles of track, and working ninety motor-cars, while there were now 10,363 miles of track, on which were operated over 40,000 motor-cars. While this had been the progress in the United States, Canada had not been slow to adopt a system that was manifestly so convenient for the public. Montreal, Toronto, Hamilton, Ottawa, Winnipeg, Brantford Niagara Falls and other places had their electric systems either complete or in process of construction. Almost all the lines were constructed on the overhead trolley-wire system.

In Montreal the electric street railways comprised 74 miles of single line, laid on 41½ miles of streets. A daily service of 140 motor cars, and about 50 trail cars, was now running. The gradients were in many cases very severe. On the streets running at right angles to the St. Lawrence River, there was a continuous rise in most instances, and short sections had gradients of 1 in 10, and even 1 in 8. These gradients were a severe test for the motor cars, but they were overcome successfully, and caused little difficulty.

The ordinary rail adopted was $6_{\frac{7}{16}}$in. in height, and weighed 72lb. per yard. The rails were laid on a foundation of concrete, or imbedded in it, according as block pavement or asphalt was used for the roads. The rails were constructed in complete electrical continuity, and where they passed the power station they were directly connected by copper wiring to the generators. Bond wires were riveted into the web at each joint. To still further improve the return circuit, track return wires of the same size, 0·460in. in diameter, as the line feeders, were riveted into the web at various points and carried back to the generators directly by overhead insulated copper wires. At first earth returns had been used, the rails being connected by copper wire to cast-iron car wheels buried between 7ft. and 8ft. in the soil; but considerable electrolytic action was found to be set up between the earth and gas or water pipes. It was determined not to use the ground for this purpose and to construct a complete metallic return.

The trolley wire used throughout the system was of bare copper, 0·365in. in diameter, carrying a safe currrent of about 440 amperes It was suspended from poles between 110ft. and 120ft. apart at the curb line on either side of the street, at a height of between 18ft. and 20ft. over the centre of each track. In some instances the trolley wire was carried by a central line of posts placed between the double tracks. The current had been at first supplied to the trolley wires connected in one continuous system; but this was now divided into various independent sections, so that trouble on any one was felt there only, and did not affect the others. Each section was fed directly from the power station by feed wires, and had its own system of return wires. The feed wire and return wire mostly used was 0·460in. in diameter, but within a ¾-mile radius of the power station heavier insulated cables were inserted, about 1in. in diameter, carrying a safe current of about 600 amperes. Ten such wires led from the power station, and ten others of same size acted as return-wires, allowing for a total output from the power station of 6,000 amperes. The difference of potential maintained at the generators was 550 volts.

The boiler house and engine room were placed fairly centrally to the system, and near to the Lachine Canal, whence water was obtained for condensing purposes, and to the coal wharves. There were fifteen Lancashire boilers, each 28ft. long by 7ft. in diameter, with double furnaces. They developed each 300 H.P., and carried a working pressure of 125lb. per square inch. The gases from the furnaces, after passing through the boiler flues, returned under the boilers and along their sides to the main flue. They then passed, at a temperature of between 439°F. and 480°F., into Green economisers placed on each side of the chimney, which heated the feed water to about 260°F. The temperature of the gases entering the chimney was between 225°F. and 250°F. The feed water was obtained from the condensing water, and entered the economisers at an average temperature of 90°F. The fuel used was bituminous coal from the Cape Breton mines, of an evaporative power of 6½lb. of water per pound of coal.

The engine and dynamo room was 235ft. long by 89ft. wide. There were six horizontal cross-compound condensing engines developing 600 H.P. each, with a boiler pressure of 125lb. per square inch. The cylinders were 24in. and 48in. in diameter, and steam jacketed, with Corliss valves. The diameter of driving wheel was 22ft., its peripheral velocity at 70 revolutions per minute being nearly 4,900ft. per minute. The total weight of each engine was 85 tons. The engines were placed in a row next to the boiler house, 26ft. from centre to centre, on foundations of cement concrete and brick in cement. Each of the first three engines drove four Edison generators, developing 200 kilowatts apiece. The driving wheels were double crowned, and carried two pairs of belts, driving 41in. pulleys, fixed on the armature shaft of the generator. The three remaining engines drove each a pair of multipolar generators by one 52in. belt on one pulley, 48in. in diameter. The two generators were mounted on the same bedplate, with the pulley between them. The armature shaft and the pulley shaft were in alignment, and were connected by two friction clutches. By this means the generators could be driven together or separately. The generators were supported on a continuous length of foundation wall built in brick and cement, and sufficiently massive to be free from vibration.

The rolling-stock equipment in the summer amounted to 163 motor cars; in winter it was 145 closed cars with double motors, and 14 snow sweepers with triple motors. There were besides, 53 open trail cars and 60 closed trail cars belonging to the former horse system.

The motors developed 25 H.P. or 30 H.P. each, and were all of the single-reduction type, the ratio of the pinion to the gear wheel being generally about 4 to 1. The average speed of the cars was about 7½ miles per hour. Electric snow sweepers, 18ft. long, carried on two pairs of 33in. wheels, were used. To each axle was geared a 30 H.P. motor, a third motor being placed in the car to drive the rotatory brooms.

The cost of working for July, 1895, was almost exactly 3¾d. per car-mile, and that of the power was less than ½d. per car-mile. For the year ending September, 1895, the cost was 5⅓d. per car-mile, the average cost of power being slightly under ¾d. per car-mile.

In an Appendix particulars were given as to the amount of coal consumed and electrical energy developed at the William-street power station, with details of the operation of the system during the past four years.

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ON THE GENERATION OF LONGITUDINAL WAVES IN ETHER.*

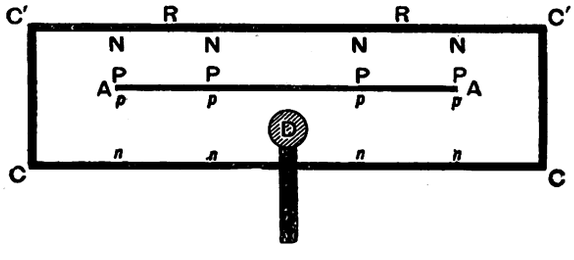
BY LORD KELVIN, F.R.S.

In a short note published in last week's *Nature*, of which a copy is appended, I suggested an arrangement of four insulated and electrified spherical conductors with their centres in one line, giving rise to ethereal waves in the surrounding atmosphere, of which the disturbance in the line of centres is essentially longitudinal. But at any finite distance from this line there must be laminar or distortional waves of the kind expressed in Maxwell's equations. The object of my present communication is to show an arrangement by which a large space of air is traversed by pressural disturbance, or by waves essentially longitudinal, or by condensational-rarefactional vibrations; with but a very small proportion, practically evanescent, of laminar waves.

Let A A be a plane circular metal plate insulated within a metal case, C C C′ C′, as indicated in the drawing. Let D be a discharger which can be pushed in so as to make contact with A.

Let A be charged to begin with, positively for instance, as indicated by the letters P P *p p*, N N *n n* showing negative electricity induced by it. Let now the discharger be pushed in till a spark passes. The result, as regards the space between A A and the roof R R over it, will be either an instantaneous transmission of commencement of annulment of electrostatic force or a set of electric waves of almost purely longitudinal displacement, according as ether is incompressible or compressible.

Hence, if the theory of longitudinal waves, suggested by Röntgen as the explanation of his discovery (for the consideration of which he has given strong reasons), be true, it would seem probable that a sensitive photographic plate in the space between A A and R R should be acted on, as sensitive plates are, by Röntgen rays. Either a Wimshurst electrical machine or an induction coil, adapted to keep incessantly charging A A with great rapidity so as



to cause an exceedingly rapid succession of sparks between D and A, might give a practical result. In trying for it the light of the sparks at D must be carefully screened to prevent general illumination of the interior of the case and ordinary photographic action on the sensitive plate.

The arrangement may be varied by making the roof of sheet aluminium, perhaps about a millimetre thick, and placing the sensitive photographic plate, or phosphorescent substance, on the outside of this roof, or in any convenient position above it. When a photographic plate is used there must, of course, be an outer cover of metal or of wood, to shut out all ordinary light from above. This arrangement will allow the spark gap at D to be made wider and wider, until in preference the sparks pass between A A and the aluminium roof above it. The transparency of the aluminium for Röntgen light will allow the photographic plate to be marked, if enough of this kind of light is produced in the space between the roof and A A, whether with or without sparks.

The new photography has hitherto, so far as generally known, been performed only by light obtained from electric action in vacuum; but that vacuum is not essential for the generation of the Röntgen light seems demonstrated by an experiment by Lord Blythswood, which he described at a meeting of the Glasgow Philosophical Society last Wednesday (February 5th). As a result he exhibited a glass photographic dry plate with splendidly clear marking which had been produced on it when placed inside its dark slide, wrapped round many times in black velvet cloth, and held in front of the space between the main electrodes of his powerful Wimshurst electrical machine, but not in the direct line of the discharge. He also exhibited photographic results obtained from the same arrangement with only the difference that the dark slide, wrapped in black velvet, was held in the direct line of the discharge. In this case the photographic result was due, perhaps wholly, and certainly in part, to electric sparks or brushes inside the enclosing box, which was, as usual, made of mahogany with metal hinges and interior metal mountings. I have suggested to him to repeat his experiments with a thoroughly well closed aluminium box, instead of the ordinary photographic dark slide which he used, and without any black cloth wrapped round outside. The complete metallic enclosure will be a perfect guarantee against any sparks or brushes inside.

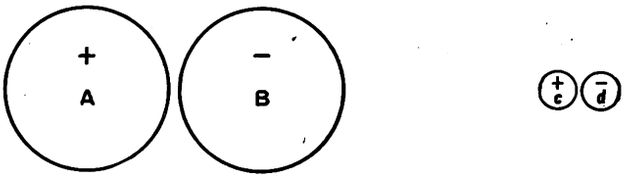
If the arrangement which I now suggest, with no sparks or brushes between A A and the roof, gives a satisfactory photographic result, or if it shows a visible glow on phosphorescent material placed anywhere in the space between A A and the roof above it, or above the aluminium roof, it would prove the truth of Röntgen's hypothesis. But failure to obtain any such results would not disprove this hypothesis. The electric action, even with the place of the spark so close to the field of the action sought for as it is at D, in the suggested arrangement, may not be sudden enough or violent enough to produce enough of longitudinal waves, or of condensational-rarefactional vibrations, to act sensibly on a photographic plate, or to produce a visible glow on a phosphorescent substance.

(Extract from *Nature*, referred to above.)

"*Velocity of Propagation of Electrostatic Force.*

"Dr. Bottomley's note, published in *Nature* of January 23rd, quotes an extract from my Baltimore Lectures of October, 1884, in which this subject is spoken of, with an illustration consisting of two metal spheres at a great distance asunder, having periodically varying opposite electrifications maintained in them by a wire connecting them through on alternate-current dynamo.

"For an illustration absolutely freed from connecting wire and all complications, consider four metal spheres, A, B, *c*, *d*, with their centres all in one straight line;—their relative magnitudes and positions being such as shown in the accompanying diagram. Let each of the four be initially electrified, A and *c* positively, B and *d* negatively. Let the charges on *c* and *d* be so strong that a spark is only just prevented from passing between them by the influence of B and A. Let A be gradually brought nearer to B till a spark passes between them. Will the consequent spark between *c* and *d* take place at the same instant or a little later? It is not easy to see how this question could be answered experimentally; but remembering the wonderful ingenuity shown by Hertz in finding how to answer questions related to it, we need not, perhaps, despair to see *it* also answered by experiment.



"The elastic solid theory restricted to the supposition of incompressibility (which is expressed by Maxwell's formulas) makes the difference of times between the two sparks infinitely small. The unrestricted elastic solid theory gives for the difference of times the amount calculated according to the velocity of the condensational-rarefactional wave.

"But I feel that it is an abuse of words to speak of the 'elastic solid theory of electricity and magnetism' when no one hitherto has shown how to find in an elastic solid anything analogous to the attraction between rubbed sealing-wax and a little fragment of paper; or between a loadstone or steel magnet and a piece of iron; or between two wires conveying electric currents. Elastic solid, however, we must have, or a definite mechanical analogue of it, for the undulatory theory of light and of magnetic waves and of electric waves. And consideration of the definite knowledge we have of the properties of a real elastic solid, which we have learned from observation and experiment, aided by mathematics, is exceedingly valuable in suggesting and guiding ideas towards a general theory which shall include light (old and new), old and new knowledge of electricity, and the whole of electro-magnetism.

"KELVIN."

* Paper read before the Royal Society.

PHYSICAL SOCIETY.

At the annual general meeting of the Physical Society, held on February 14th, Captain W. de W. Abney, President in the chair, the CHAIRMAN after referring to the position of the Society, called upon the treasurer to read the balance sheet. After a discussion on the financial status of the Society, in which a number of members took part, the ballot was held for the election of a President and Council for the ensuing year. The following gentlemen were declared duly elected:—President, Captain W. de W. Abney; Vice-Presidents, Shelford Bidwell, Major-General E. R. Festing, Prof. Perry, G. Johnstone Stoney; Secretaries, T. H. Blakesley and H. M. Elder; Treasurer, Dr. E. Atkinson; Demonstrator, C. Vernon Boys; other members of Council, Walter Bailey, C. V.

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Burton, L. Fletcher, R. T. Glazebrook, Prof. A. Gray, G. Griffith, Prof. G. M. Minchin, Prof. W. Ramsay, Prof. S. P. Thompson, and Prof. S. Young.

The CHAIRMAN read an obituary notice of the late Rt. Hon. T. H. Huxley.

A vote of thanks to the auditors was proposed by Prof. CAREY FOSTER, seconded by Mr. ENRIGHT, and carried unanimously.

A vote of thanks to the officers was proposed by Prof. A. GRAY, seconded by Mr. RHODES, and carried unanimously.

A vote of thanks to the Chemical Society for the use of their rooms was proposed by the CHAIRMAN and carried by acclamation.

The meeting was then resolved into an ordinary science meeting, and a Paper on

The Determination of High Temperatures by the Meldometer,

by Prof. RAMSAY and Mr. EUMORFOPOULOS, was read by the latter.

The meldometer, an instrument invented by Dr. Joly, of Dublin, consists essentially of a thin platinum strip which can be heated by the passage of an electric current. Small fragments of a solid substance are placed on the platinum strip, and the temperature at which they melt is deduced from the length of the platinum strip, which has been previously calibrated by means of solids of known melting point. The authors have used gold for the purpose of calibrating the strip, and have assumed Violle's value, 1,045°C., for the melting point of gold. A number of measurements have been made of the melting point of salts of sodium, lithium, strontium, barium, calcium and lead. The results obtained, however, differ considerably from those of Haycock and Neville, and the authors have not been able to account for these differences.

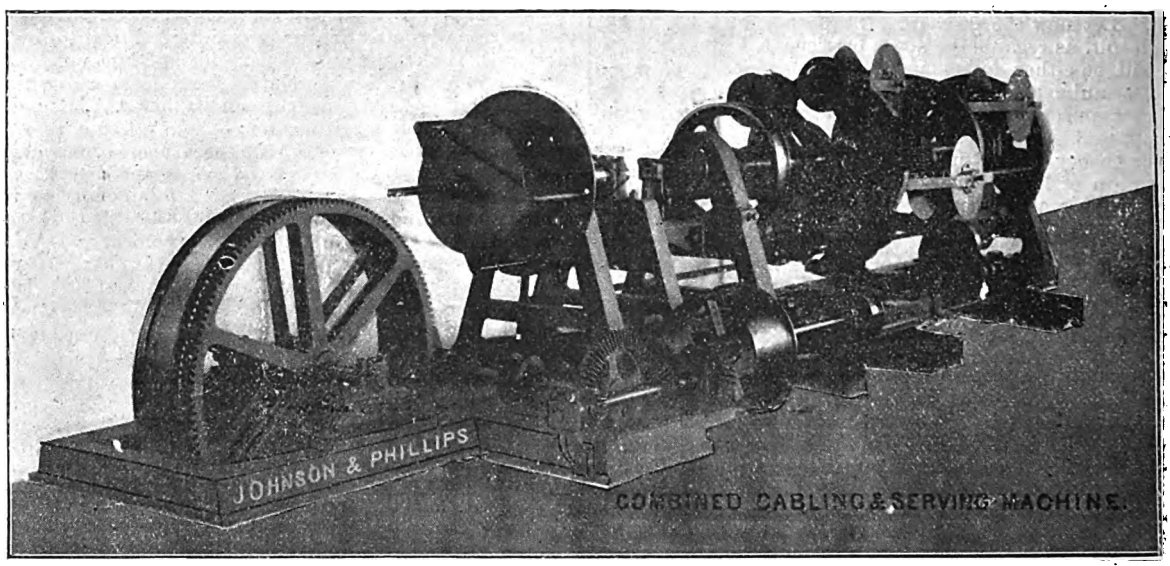
Prof. RAMSAY said the chief advantage of the meldometer was that only a very minute fragment of the substance was required for the measurement, so that extreme purity of the sample could be secured. There was the disadvantage, however, that many substances undergo some change when heated in air. In reply to a question from Mr. Blakesley, Prof. Ramsay said that the property of the platinum which was used to measure the temperature was its expansion.

Mr. CAMPBELL asked whether the zero of the instrument was found to be constant. In Cardew voltmeters it often took several hours for the needle to come back to zero after heating.

Mr. EUMORFOPOULOS, in reply, said that the zero was constant to within a quarter of a degree.

COMBINED CABLING AND SERVING MACHINE.

The machine which we illustrate this week is made by Messrs. Johnson and Phillips, and is arranged for cabling seven wires, *i.e.* laying six wires round one, and at the same time laying a yarn in the recess formed between each pair of wires, so that when the cable is taped it forms a more perfect round. The machine is erected on a strong cast-iron bedplate, and the six wire bobbins (arranged in two bays) are carried on forged wrought-iron flyers between three discs, the third disc also carrying the six yarn bobbins. The central hollow steel shaft runs in a large gun-metal stepped bearing at one end, and the "lay-head" end and the centre disc run on anti-friction rollers. The draw-gear is driven from the "lay-head" end of this shaft by means of a belt driving on to a countershaft carried from the bedplate of the machine. The motion is transmitted to the draw-through drum by means of a spur and bevil gearing, change wheels being provided to give the requisite length of "lay" for the different sizes of wires. The taping head is designed to serve various widths of tapes, and for that purpose is driven by means of coned pulleys, which allow the "lay" and "lap" of the tape to be adjusted very minutely. The bobbin of tape, as will be seen, is arranged concentrically with the cable, the tape being led from the bobbin by means of a series of rollers, &c., down through a slotted guide on to the cable. The wire bobbins are each arranged to hold one mile of gutta-percha covered wire, and the yarn and tape bobbins respectively hold sufficient tape to "worm" and "serve" this length of cable. The diameter of the tape bobbin is 21in., the radius described by taping head, measured over the guide rollers, is 16in., and the speed of this head is about 500 revolutions per minute. The central hollow shaft is 3in. diameter and runs in large gun-metal stepped plummer blocks, having bearings two and a-half diameters long. All the bobbins are provided with means for adjusting the tension on the various wires, yarns, &c., as may be desired. The finished cable is led from the draw-through drum on to a receiving drum placed a few feet distant from the cabling machine, from which it is driven by means of a belt. This apparatus is provided with an automatic guiding-on and flaking gear, which is not shown in the illustration.



PARLIAMENTARY INTELLIGENCE.

LIGHT RAILWAYS BILL.

On Thursday evening last week a Light Railways Bill was introduced by Mr. Ritchie and read a first time.

Mr. RITCHIE said the question of greater facilities in railway communication was before the House last Session, when he believed there was a general expression of opinion that Parliament ought to endeavour to supply some less costly means than the existing law allowed for providing more extensive railway accommodation. The Government did not put forward their proposals as a panacea for the evils of agricultural depression. But it was the duty of the Government to do all in their power to remove any impediments which they thought interfered with the development of agriculture, and it was with that view they proposed to introduce the Light Railways Bill. If they could do anything to bring consumer and producer more closely together—if they could make more easy the distribution of agricultural produce—they would have done much to help both the producer and the consumer. The Agricultural Department had had for some time past under their charge the production of maps of various counties containing large tracts of country without adequate means of communication. He found that in one county there were 324,000 acres of cultivated land which had no railway within three miles. In another county there were 286,000 acres, in another 128,000 acres, and so on. When Mr. Bryce introduced his Bill last year the complaint which was made of the absence of any provision for help from the State was by no means confined to the right hon. gentleman's opponents. The present Government's view was that in a great number of districts, at any rate, where the railways were most needed they would not be made except with some aid both from the locality and from Parliament. Believing that a little personal investigation and experience would be a very valuable aid in dealing with this question, he, together with Lord Dudley and Sir Courtenay

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Boyle, went to France and Belgium last year with a view to seeing the nature of the light railways there—how they were made and worked, and how their finance was conducted. In France the light railways were to all purposes secondary railways. In Belgium the system would be more properly described as a great system of steam tramways. The main roads were used for the lines, although occasionally a strip of land by the side of the road was taken, or a short cut across country was made, to avoid a difficulty. They had very few signals and hardly any stations. The branches leading to particular farms or centres of industry which had to be served were simple and inexpensive, and the loading and unloading of trucks was carried on in simple sidings on the roadside, where the farmers' carts and waggons were drawn up. The Bill of the Government would, of course, provide for either of these two plans being adopted. In Belgium these railways were made at an average cost of about £3,000 a mile, including rolling stock. He found that in Belgium the light railways travelled with the greatest ease up gradients of one in 22 and round the sharpest curves. The development of this system in Belgium had been very great. Within the last ten years over 1,000 miles of railways had been completed and were in working order; and he was told that projects were now under consideration for another 1,000 miles, which would probably be approved and in operation in a short time. In Belgium the money for the light railways was provided by the State, the province, the commune, and outside subscribers in conjunction. In 1894 the average profit was 2·91 per cent. In England the main difficulties hitherto had been two—first, the unwillingness of Parliament to authorise the compulsory acquisition of land otherwise than by a scheme directly approved by Parliament itself, and the cost of obtaining that approval. The second difficulty had been the expense of the requirements for the public safety enforced by the Board of Trade. As regards the requirements for the public safety, the public must make up their minds that, if they desired to have these railways, they must of themselves exercise an amount of caution, and not insist upon those elaborate precautions which, on trunk lines, where trains were run at great speed, might be necessary. The Government also proposed not to require the sanction of Parliament to the compulsory acquisition of land for the purpose of these light railways. Under this Bill a Light Railway Commission, consisting of three persons, two of whom it was hoped would consent to serve without pay, was to be set up. The Government desired to have on the Commission gentlemen who would act with considerable knowledge of the whole subject in the interests of the community. It was not intended that this Commission should be a mere formal department of the Board of Trade. What would be the mode of working of the Commission when a scheme was presented to them? They would have to satisfy themselves that all persons interested had been consulted; they would determine the expediency of the application, elaborate its details, and after consideration of all objections laid before them they would reject the scheme or submit a draft order for the confirmation of the Board of Trade. As to the action of the Board, they would give notice of the effect of the order, consider any objections lodged with them, and confirm the order with or without modification; and the order when confirmed would have the same effect as if enacted by Parliament. They hoped that in the bulk of cases there would be no necessity for more than one local inquiry, but they did not shut out the possibility. The Bill guarded against any attempt to apply the machinery of the Bill to the promotion of great lines of railway. It also provided against lines being made on a cheap and easy system which would unreasonably and improperly compete with existing lines, which had been formed and built under much more costly conditions. The Lands Clauses Consolidation Acts would be incorporated in the order, but, instead of the difficult and expensive process of deciding as to value under the Lands Clauses Consolidation Acts, all matters in connection with them would be determined by a single arbitrator appointed by the Board of Trade. With regard to finance, it was provided in the Bill that local authorities might themselves construct and work light railways either alone or jointly with other local authorities. The Government believed that Parliament might and ought in many cases to join with local authorities in giving financial aid. The Government rejected the systems of State guarantees and State ownership. They proposed to devote to the objects of the Bill £1,000,000 sterling, which would be available in two different ways. One portion would be available for special advances under special circumstances, another would be available for the granting of loans to facilitate the making of these lines. The Bill proposed that an existing railway company should undertake the construction and working of the line. The total amount contributed by the Treasury must not exceed 25 per cent. of the whole capital required for the making of the line. Two conditions were necessary before the State gave its aid—namely, that 50 per cent. of the capital required should be subscribed by way of share capital, and that 25 per cent. of that capital should be subscribed outside any public authority. The Government must be satisfied that all parties interested in the matter were becoming partners in the undertaking. He hoped and believed that the existing railway companies would be large factors in the success of their proposal, and would recognise that the light railways would become feeders of their own lines. They hoped for co-operation from the road authorities. The interests of the landowners would be adequately safeguarded, and their private rights would not be infringed, nor would these rights, he hoped, be unduly pushed, because if these light railways were a success there was no one who would derive greater benefit from them than the existing landowners. The Government, therefore, expected their co-operation, and also that of the public, who, he trusted, would consent to some relaxation of the precautions hitherto taken.

Mr. BRYCE said this Bill differed from the Bill of last year in three points—(1) In the creation of a Light Railway Commission; (2) in the power given to local authorities; and (3) the giving of a subsidy from national sources. He did not feel any objection to allowing the local authorities to subsidise the lines provided proper safeguards were taken. Then, as to the Imperial subsidy, those who came forward with a gift always had an indulgent House, and therefore he should not be surprised if this proposal was received with favour. They must remember, however, that they were inaugurating a perfectly new policy. An appeal was sometimes made to the practice of Continental countries, but in all countries of the Continent the State had always taken a much more active part in railway construction than it had done here, and in many instances it was the owner of the railways. One of the causes of the greatness of our railway system was that we had relied so much on private enterprise. Our railways, made at immense cost, were at present enjoying great prosperity, and therefore he thought we ought to be loath to embark on the new policy of State railways. He hoped before this proposal was approved by the House—if it was ever approved—these considerations would be very carefully weighed and set against those temporary temptations which were no doubt strongly felt by a good many of his friends. Besides our hereditary policy in the matter there was another point worth attention, and that was that the entry of the State would necessarily be a check to voluntary action. Last year when the late Government introduced their Bill they had every reason to believe that the great railway companies were prepared to make these lines without any subsidy. It was quite plain that now no company would make a line without getting a subsidy if they saw the slightest chance of getting one, and therefore, so far, this plan would operate actually as a discouragement to the action which railway companies would otherwise have taken of their own accord.

Mr. MURDOCH doubted the wisdom of having a different gauge for the light railways. He believed such a course would add to the cost of the carriage of agricultural produce.

Mr. CHANNING congratulated the President of the Board of Trade upon the general construction of the Bill. He thought the suggestion of a Light Railway Commission an exceedingly happy one. It should be an essential part of the scheme that any company starting a light railway should have the right of obtaining access to existing railways. It was in his opinion of great importance that where money was advanced by the Treasury for local objects the local authority should be brought into the operation in some form of guarantee. The policy of spending this money in the form of gifts without any conditions whatever should be looked upon, after Irish experience, with caution and reserve.

Mr. RADCLIFFE COOKE wanted to know, however, whether there would be any provisions in the Bill which would enable an existing railway which did not pay to reduce itself to the condition of a light railway, and, if not, whether the President of the Board of Trade would favourably consider an amendment which would give effect to this proposal.

Mr. LUTTRELL said it was useless for the House to expect that light railways could be made without being a burden on either the local rates or the Imperial Exchequer. He believed the railways would do good to agriculture, and he, therefore, welcomed the Bill of the Government, but they should not let the people suppose that agriculture could be relieved in this way without costing anybody anything. The experience of France, Italy and Germany was that light railways were not a financial success.

Mr. RITCHIE, by leave of the House, brought in a Bill, and it was read a first time.

CORRESPONDENCE.

THE ELECTRICAL ENGINEERS AND MILITARY SERVICE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There is much discussion going on at present as to the actual value of the services of electrical engineers to the nation in time of war; unquestionably, if he is suitably trained for military service, in addition to his electrical experience, he would be a valuable acquisition to our defences; for, generally speaking, the most valuable application of electrical science and mechanical skill to military and naval purposes is one of defence. It must not be forgotten, however, that a most necessary thing for him to understand in the first instance is how to obey. The slightest hitch caused by any neglect of the word of command would probably cause absolute disaster instead of success. He must, therefore, be a soldier as well as an engineer, and thus it requires something more than an engineer to conduct operations of any magnitude. Let us split up our enthusiasts into groups.

1. Cable companies' engineers and their men and assistants. These would be valuable indeed to the Navy and to the submarine mining departments of the Royal Engineers—their practical knowledge of the actual conditions of working at sea would soon enable officers commanding to appreciate them.

2. Telegraph engineers (land). Here again we must see at a glance their utility in the corps of Telegraph Engineers—perhaps one of the finest organisations of the Army, or at least it is one of the greatest usefulness; and we must not exclude telegraphists from this group, who are operators only, and cannot be considered to rank as electricians or electrical engineers.

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3. Electric light and general electrical engineers, especially those of seaport towns, who are engaged in marine work, could very soon be converted into useful units for submarine mining purposes, their constant contact with nautical men and the knowledge of nautical terms thus acquired, and their readiness in the handling of ropes, how to tie a knot, or make a splice, without an argument being necessary, making them a welcome addition to the submarine mining department. Divers also are required for this work. There is, in fact, a use for every branch of electrical knowledge in submarine mining, but each individual should be able to keep his sea legs on also.

The three general classifications are drawn up merely to point out the direction in which the services of an engineer could be turned to useful account most readily, and no doubt this is the actual object of the Institution of Electrical Engineers in bringing forward this matter. The question of decorations and military honours forms no part of it, being a secondary consideration only, and hardly worthy the consideration of men on whose efforts the success or failure of a defence may depend.

The Telegraph Corps of the Royal Engineers is an excellent one, and has done good service to the Army as an auxiliary, and no engineer whose lifetime has been spent in this class of work should think of joining the submarine mining branch without some special reason for so doing. On the other hand, every type of electrical engineer would be of value for submarine work after a course of training. Nor must we neglect mechanical engineers also. The demands of this department (submarine mining) may be classed as follows :—

Marine engineers, for the rapid and efficient working of the steamers used, or miners as they are called.

Cable engineers, for the laying and under-running of cables and for completing the necessary repairs; this includes all the necessary men such as divers, splicers, &c.

We then come to the land-service departments, where the search lightsare to be dealt with, the testing station and test rooms to be designed and attended to, &c.

Now, to be an officer in any work such as above mentioned the person who offers himself as such must be thoroughly acquainted with the details of the work in hand, and this can only be acquired by a proper course of study. Clearly, then, the most useful effect would be produced by our electricians not forming a body in themselves, but by being attached to one or other of the above.

No doubt the War Department would be very pleased to welcome them in their proper stations. The officer must, however, do something more than this; he must seek out from the men in his employ, or with whom he may become associated in any way, those most fitted to form a useful addition to the rank and file, for in this, as in everything else, the men form no small part in the consideration of ultimate success. It has a pleasant ring to it, when speaking of an appointment classing one as an officer; but in submarine mining work the officer must be a man also, and not be ashamed of lending a hand when hauling in a muddy cable, or in laying out a new one, the latter operation being a decidedly uncomfortable one on a hot day, when the composition protecting the armoured cable has a habit of finding its way to the eyes and face of the operator, and requiring a very stout heart to cease from grumbling at cables in general, and the composition in particular after the work is finished for the day or night, as the case may be. Our electrical engineers would probably open their eyes very wide if they knew the truly scientific method carried on in all submarine mining work in England. It is not flattery to say that it is the finest in the world, and further, it is conducted with a skill only brought about by the most careful study and training. No doubt the uninitiated might regard the failure of a mine, which occasionally occurs, as a thing he would soon put right when he brings his skill to bear upon it, but only those acquainted with the work know the many little difficulties which may occur, tending to upset previous calculations or plans so nicely laid out on shore, and which often require the greatest coolness and knowledge of circumstances to surmount. It is probable that our engineers might with credit to themselves become pupils of the Submarine Corps of Engineers, and those who aspire to be in charge of the electricians and their work will find plenty of scope for their energy and abilities. Let our engineers, therefore, search the records of the Corps of Royal Engineers, and they will be surprised at the skill already existing even in the rank and file of a body of men whose officers have in the past, and probably still contain, some of our best electricians, who further combine a wide knowledge of human nature with their scientific education, and of the kind necessary for military and naval operations.—Yours, &c.,

W. H. Preece.

Bedford.

THE DISCOVERY OF THE ELECTRIC ARC.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In No. 925 of your esteemed journal we found a letter by Mr. W. Perren Maycock, in which he states that the electric arc was discovered by H. Davy. Without desiring to diminish the high authority of this celebrated English physicist, we cannot abstain from informing him that in the year 1802 a Russian professor, W. Petroff, of the Medical Academy of St. Petersburg, discovered the so-named voltaic arc, using a battery of 4,200 volta cells, which discovery he described in his work "Galvani-Volta Researches," &c. Many experiments of this able explorer, amongst others the electrolysis of water by means of copper electrodes and volta cells, have been repeated by Prof. N. Egoroff, of St. Petersburg, at the meeting of the Russian Physical-Chemical Society.*—Yours, &c.,

A. Smirnoff,

February 19, 1896. Editor of *Electrischestwo*.

[Without in the slightest degree disputing the great merits of Prof. Petroff, or the importance of the researches he made in 1802 (and which were published in Russian in 1803), it suffices to remark that Davy's experiments on the arc began in 1800 (as witness his Papers in *Nicholson's Journal* and in the *Philosophical Magazine* of 1801). In 1802 Davy had already shown the arc light in the theatre of the Royal Institution, using a battery of 150 pairs of plates.—Ed. *E.*]

LEGAL INTELLIGENCE.

Lazare, Weiller, and Co. v. Bolton and Sons.

This case, which was reported in *The Electrician* for February 7th and 14th, came again before the Court on Friday last for the assessment of damages. It will be remembered that Mr. Justice Mathew held that there had been a breach of contract on the part of the defendants, and, further, that the plaintiffs had repudiated the obligations imposed upon them by a collateral agreement.

For the plaintiffs Mr. WALTON, Q.C., now urged that the actual net profit which the plaintiffs would have made upon the contract was £5 per ton. Since June, 1895, the date of the breach of contract, the plaintiffs had only sold 83 tons per month, at a loss of £2 per ton. In five years that would be £9,960. Then there was a loss of £5 per ton upon the balance unsold—namely, 7,220 tons, and a loss of profit of £35,100. That was the basis upon which he estimated the damages.

Sir E. CLARKE, for the defendants, said that the bargain was that the plaintiffs were to make some concession in order to beat down foreign competition, and they had not done so. The contract, therefore, came to an end. There were matters of principle to be decided before elaborate inquiry as to damages were gone into.

Mr. Justice MATHEW said the question of damages must be reserved until the questions of principle had been decided in the Appeal Court, and this course was agreed to.

Walter and others v. the Central News.

In the Court of Appeal, on Monday, the Master of the Rolls and Lords Justices Lopes and Rigby were asked to grant leave to appeal against certain interrogatories being insisted upon. As our readers are aware, the main action is of considerable public interest, and has been brought by the proprietors of *The Times* against the Central News (Limited), an organisation which supplies items of information to the Press, in respect of certain telegrams which the latter had sent the former for publication in that journal. The telegrams in question purported to have been sent to the defendants by their special correspondent at the seat of the Japanese Chinese war, and the ground of complaint by the plaintiffs was that the telegrams supplied to them by the defendants were not the actual telegrams that the latter received from their correspondent, but were amplifications and concoctions of the original telegrams. The plaintiffs

* See *Journal* of this Society for 1894.

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had administered some 20 interrogatories to the defendants, about 18 of which had been allowed by Mr. Justice Cave.

On the part of the defendants, leave to appeal against the learned judge's decision was asked, on the ground that the interrogatories were administered by competitors for news, who were seeking to obtain information as to the way in which the defendants conducted their business.

Their Lordships refused to give leave to appeal, and said it was only in very strong cases, involving evident injustice, that they would interfere.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d., abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations issued February 6th.

NEW BOOKS AND EDITIONS.

The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices:—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

'THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.), Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables. 30s., post free.

"COMPREHENSIVE INTERNATIONAL WIRE TABLES FOR ELECTRIC CONDUCTORS."—By W. S. Boult, price 5s., post free.

TENDERS INVITED.—The Corporation of Sunderland invite tenders for steam engines, continuous-current dynamos, water-tube boilers, fuel economiser, water-softening plant, and cast-iron tank. Specifications, &c., can be obtained at the office of the Borough Electrical Engineer, the Electric Supply Station, Sunderland, and tenders must be sent to Mr. Fras. M. Bowey, Town Clerk, not later than 5 p.m. on Friday, the 13th March. Further particulars are given in our advertisement columns.

——— The Corporation of Bangor require tenders for the construction, supply and laying down of the necessary plant and mains for the installation and supply of electric current within the borough. The contracts are split up into two sections, and plans and specifications may be obtained from Mr. F. Hastings Medhurst, M.I.E.E., Westminster-chambers, 13, Victoria-street, London, S.W., after Monday next. Tenders must be sent in to Mr. W. H. Pritchard, Town Clerk, Bangor, by March 18th. Our advertisement columns contain further particulars.

TENDERS INVITED.—The London County Council require tenders for the supply of electric lighting sundries to Claybury Asylum for one year. Tenders to the Asylums Committee, 21, Whitehall-place, S.W., by Wednesday next.

——— Tenders are requested by Mr. George White-Fraser, consulting electrical engineer, of 18, Imperial Loan Building, Toronto, Canada, for generators and motors to a total capacity of about 1,000 H.P. of each, in various sizes. The machinery is to be installed in a large paper mill in Canada. Our advertisement columns contain further particulars, and tenders should be forwarded promptly.

——— *Extension of Time.*—The time for sending in tenders for the public lighting of Chesterton has been extended to March 31st. Tenders to Mr. J. Spearing, 15, Sidney-street, Cambridge.

——— The Manchester, Sheffield and Lincolnshire Railway Company invite tenders for the supply, during the twelve months ending April 30, 1897, of various stores, including telegraph materials, wire, signal stores, fog signals, screws, rivets, asbestos packing, &c., &c. Patterns can be seen on and after March 9th, on application to Mr. A. W. Longden (storekeeper) at Junction-street Mills, off Ducie-street, London-road, Manchester, and specifications, with forms of tender, may be obtained on and after the same date from the Secretary (Mr. Oliver S. Holt), London-road Station, Manchester, to whom tenders must be sent in by 10 a.m. on Tuesday, March 17th. Further particulars appear in our advertisement columns.

——— The Chelsea Guardians require tenders for supplying and fixing telephones, &c., at their infirmary, Cale-street. Tenders to the Clerk (Mr. W. Miller), 250, King's-road, Chelsea, by March 10th.

——— Tenders are invited for the supply of 12,450 telegraph poles and 15 lots of paper-insulated electric cable for the Direction Générale des Postes et des Telegraphes, 103, Rue de Grenelle, Paris. Tenders must be sent in by March 10th.

——— The Norwegian State Railway Authorities require tenders for the supply of Morse telegraph instruments, Morse keys, lightning conductors, galvanometers, signal bells, &c. Tenders to the Expeditions Contor, Eisenbahn Verwaltung, Jernbanctoret 8-9, Christiania, by March 11th.

——— The Netherlands Minister of Waterways, Commerce and Industry requires tenders for the supply of telegraph poles to the Telegraph Department during 1897. Tenders to be sent to the Minister, The Hague, by March 6th.

——— Tenders are required for the concession for the electric lighting of the city of Lima. Tenders to La Legation de Perou, 8, Avenue Hoche, Paris, by June 1st.

——— The Royal Portuguese Railways Company invite tenders for the supply of electrical apparatus for alarm bells. Particulars from the Company, 28, Rue de Chateaudun, Paris, and tenders to the Ingenieur-in-Chef du Service des Magasins, Compagnie Royale des Chemins de Fer Portugais, Santa Apolonia, Lisbon, by March 11th.

TENDERS ACCEPTED.—The Cuckfield (Sussex) Guardians have accepted the tender of the Private Wire and Telephone Installation Company for providing and erecting telephones in the workhouse premises.

PATENT SPECIFICATIONS.—Particulars will be found in our advertisement columns of an application to be made for leave to amend the specification of Letters Patent No. 4,572 of 1894, granted to Mr. Charles Adams-Randall for "Improvements in Telephonic Transmitters."

PREMISES TO LET.—Our advertisement columns contain particulars of eligible premises to let, suitable for electrical engineering works or supply station, in the Rochdale district.

APPOINTMENTS VACANT.—All whom it may concern are reminded that the applications for the post of electrical engineer to the Queensland (Australia) Government have to be sent in by Monday next. All necessary information can be obtained from the Agent General for the Colony, 1, Victoria-street, Westminster, London, S.W., to whom applications have to be sent in.

DISSOLUTION OF PARTNERSHIP.—The partnership business of electrical engineers and contractors, hitherto carried on under the style of Cooper and Pannett, at Newman-street, Oxford-street, W., and Gray's Inn-road, W.C., London, has been dissolved.

PERSONAL.—Mr. Haydn T. Harrison, M.I.E.E., has resigned his position as manager of the Nalder and Harrison Construction Syndicate (Limited), in order to devote his whole time to his consulting and testing practice. Mr. Harrison's address is now Albany Buildings, 47, Victoria-street, Westminster, S.W.

BUSINESS CHANGES.—In our last issue we called attention to the retirement of Mr. J. D. F. Andrews from the firm bearing his name, and his starting in business on his own account at Putney. We are asked to state that the goodwill, patents, stock-in-trade, fixtures,

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&c., of the old firm have been purchased outright by the Safety Concentric Wiring Company, and that the business will be carried on by that Company at the old addresses, 15, Marsham-street and (temporarily) 34, Victoria-street, S.W., Mr. J. D. F. Andrews having no longer any connection of any kind with the firm, Mr. E. Jesse Piper is manager to the Company.

LIQUIDATIONS.—A petition has been presented by the Bank of Liverpool for the compulsory winding-up of the Morecambe Electric Light and Power Company (Limited), and will be heard at the County Court, Preston, on March 10th. Messrs. Bolton and Bolton, 14, Kent-street, Kendal, are solicitors for the petitioners.

——— A meeting is to be held at the offices of Messrs. Price, Waterhouse and Co., 44, Gresham-street, E.C., on March 24th, at 3 p.m., for the purpose of receiving an account of the winding-up of the Edison Electric Light Company, Limited.

BANKRUPTCY.—A sequestration order has been made against the estate of William Gray, jun., electric light engineer and contractor and ironmonger, also trading as the Scottish Electrical Engineering Company and Gray and Son (of which the bankrupt is sole partner). Claims to Mr. A. Campbell, agent, Albany-street, Edinburgh, by June 21st. The examination takes place at the Court House, Edinburgh, on March 10th.

FAILURE.—In the failure of P. B. Steele and Co., electrical engineers, of 43, Commercial-street, Dundee, the following list of creditors is published :—

J. H. Holmes and Co.	£76	1	0
Crompton and Co.	69	11	7
Siemens Brothers and Co.	50	18	5
John Harling and Sons	33	13	0
Körting and Mathiesen	31	2	6
Edison and Swan United Electric Light Company	30	10	8
Electrical Company (Limited)	30	3	5
W. T. Henley's Works Co.	25	5	1
Ross and Co.	24	7	4
Bell and Sime (Limited)	20	0	2
Munro's Electrical Manufacturing Company	15	1	8
B. Verity and Sons	11	17	11
Zurich Incandescence Lamp Company	11	2	1
Beanland, Perkin and Co.	10	8	7
General Electric Company	7	1	3
Sunbeam Lamp Company	6	2	1
G. Braulik	5	0	11

The liabilities are £519. 14s. 2d., and assets (after deducting the preferential claims), £64. 4s., equal to a dividend of 2s. 5½d. subject to realisation. The debtors are stated to be offering a composition of 2s. 6d. in the £.

PATENT BEAD RAY DIFFUSERS.—Messrs. D. H. Bonnella and Son, of Mortimer-street, Cavendish-square, London, W., inform us that they have acquired (in succession to Messrs. Bashall and Overton) the sole agency for the United Kingdom for these well-known diffusers.

POLE-FINDING PAPER.—Mr. A. H. Avery, of Tenterden, Kent, sends a sample of his pole-finding paper, which he claims is an advance on anything of the kind previously brought out. The paper is stated to be non-poisonous.

CATALOGUE.—Messrs. Doulton and Co., of Lambeth, have recently brought out a revised edition of their catalogue of stoneware conduits and accessories for underground electric mains. The publication gives numerous illustrations of the Doulton conduit systems in use in London, Manchester, Portsmouth and numerous other cities, and it is interesting to notice how extensively stoneware conduits have been adopted, and to how many systems of electrical distribution they have been applied.

——— A handy pocket price list of continuous current machinery is issued by Messrs. Thomas Parker (Limited) of Wolverhampton. Useful information is given as to the construction of the machines and their efficiency. The list also contains prices and information regarding multiple contact switches and resistance coils, motor-starting switches, &c.

ELECTRO-HARMONIC SOCIETY.—A "Ladies' Night" of this Society is to be held at the St. James's Restaurant, Regent-street, London, W., this (Friday) evening at eight o'clock. An excellent programme is, as usual, provided.

BERMONDSEY (LONDON).—The Vestry have decided to appoint a special committee to consider and report upon the question of applying to the Board of Trade for a Provisional Order.

BIRMINGHAM.—At the meeting of the Markets and Fairs Committee of the Corporation on Friday last, the subject of the lighting of the new Meat Market was under discussion. A suggestion had been made that the incandescent gas light should be adopted ; but after the Committee had received and considered a communication from the Gas Committee, it was decided to adhere to the original resolution to light the market electrically, and to advertise for the necessary tenders. The *Birmingham Daily Post* states that incandescent gas burners were recently tried for outdoor lighting in some of the lamps in front of the Council House, but the result was very unsatisfactory ; the strong air currents and vibration of the lanterns proved most destructive to the incandescent mantles.

BRIGHTON.—At the last meeting of the Lighting Committee it was decided to recommend the Town Council to join the other Corporations in opposition to the application by the Westinghouse Electric Company for an extension of time for the three-wire patent.

BRISTOL.—At the meeting of the Town Council last week the report of the Sanitary Committee on the application of the Bristol Tramways Company for a Provisional Order authorising the construction of tramways in the City of Bristol and Kingswood was discussed. An abstract of this report, and also of the report of the Electrical Committee, appeared in our last issue. Mr. Alderman Cope-Proctor moved the adoption of the Sanitary Committee's report, and Mr. George Pearson proposed an amendment that the consent of the Corporation be refused unless the Company accepted the condition that every future extension must be upon the principle of the electrical energy being supplied by the Corporation. After a long discussion Mr. Pearson decided to remodel his amendment as follows :—"That a committee, consisting of the Sanitary and Electrical Committees, be appointed to consider, and report upon, the desirability of introducing the overhead trolley system in the city, and, if such system should in their opinion be sanctioned, to report upon the terms on which such sanction should be given." The Sanitary Committee's report was then adopted.

CABLE MESSAGES BY TELEPHONE.—The Liverpool Chamber of Commerce has succeeded in obtaining permission for cable messages to be transmitted by telephone after 6 p.m. to private addresses. The arrangements come into operation on Monday next.

CHURCH LIGHTING.—The Augustine Church, Edinburgh, has just been fitted up for the electric light. The installation has been carried out by Messrs. Lowdon Bros., of Dundee.

COUNTRY HOUSE LIGHTING.—Messrs. Drake and Gorham have obtained a contract for the electric lighting of Bidborough Court, the residence of Mr. Henry J. Wood.

DOUGLAS (ISLE OF MAN).—In reference to the electric lighting of this town we have received a further letter from Mr. Gillmore, who assures us that he never intended to convey the impression that the electric light was three times the cost of gas in all cases. When using this comparison he was referring to the lighting of the Promenade only, and the coefficient 3 would, he thinks, fairly fit the facts in this instance, because the small plant required for this single job could not be worked economically, and because the Gas Company of Douglas light the Promenade at a specially low rate. We trust we have now made Mr. Gillmore's contention clear. We have also received a letter from Mr. Berry, who takes exception to Mr. Gillmore's contention regarding the cost of the electric light, and puts it that no such limitation was connected with the original assertion that electricity costs three times the price of gas. Feeling runs high at Douglas on this electric lighting question, and it is very cogently pointed out by Mr. Berry that remarks signed "G. Gillmore, Electrician," would be taken up by opponents of electric lighting and made the most of. After the elections the subject will doubtless have more dispassionate consideration.

EALING.—Owing to the increasing demand for electric current the District Council has decided to put in additional plant at their electricity station. The number of lamps connected is 5,627, while there are applications for 531 additional in hand.

EDINBURGH.—At the last meeting of the Edinburgh and Leith Gas Commission, Bailie Anderson, in moving the adoption of the minutes of the Works Committee, which recommended an outlay of £13,000 for laying a new gas main to the south side of the city, said that the supply on the south side was very defective, and unless they were prepared to supply the gas which was required they would be playing into the hands of the promoters of electric lighting. Mr. Eunson thought the matter should be delayed, because there was a very strong desire in the district to introduce the electric light. Lord Provost M'Donald (the Chairman of the Commission) said he lived in the district, and acknowledged that the supply of gas was so bad that he was compelled to keep three burners alight in his dining room, but he only got the light of one burner from the three ! He would say they should not be at all afraid of the electric light !

Mr. E. Monkhouse, the Corporation's electrical engineer, read a Paper before the Royal Scottish Society of Arts on Monday, the subject being "The Distribution of Electricity in Edinburgh." He stated that ten miles of low-tension and seven miles of high-tension mains had been laid, and that out of 250 arcs used for street lighting, 61 only were on the high-tension system. On the advice of their consulting engineer, Prof. Kennedy, the Corpora-

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tion had adopted the Ferranti and the Kelvin electricity meters, and found these worked very well. He attributed the low price at which current was supplied to the fact that the policy of the Corporation had been to adopt all the latest means for saving steam and water in the station, the superheater having contributed to a saving of about 15 per cent. of coal; they had cheap and good coals; and the system had been extended in all directions, enabling the station to keep up a fair load all night. Mr. Councillor Mackenzie, who was present on the occasion, said an important factor had been overlooked by Mr. Monkhouse, and that was that the Corporation had taken care to select a good consulting engineer, and a clever, practical man as resident engineer, and had left the work of the station to be done by those gentlemen without themselves meddling in the matter. They had trusted their engineers, and the proof of the wisdom of this course was shown in the success of the undertaking. Lord Kingsburgh was also present, and made the statement that by the exercise of discipline and economy in his own house his bill for electric lighting was, comparing one quarter with another, less than his gas bill had been.

ELECTRICITY IN MINING.—The *Mining Journal* (Perth, Western Australia) states that the Government are in receipt of information from London showing that the Electric Power Company, which is represented in West Australia by Mr. Edmund Mitchell, has lodged the necessary deposit, and that the work of erecting generating plant and cables is to be proceeded with forthwith.

FAREHAM.—The Local Government Board have sanctioned the borrowing of £6,681 by the District Council for electric lighting purposes. This sum includes £4,886 for the purchase of the Fareham Company's undertaking, and the balance is to be expended in providing additional machinery for the station.

GATESHEAD.—A firm of electrical engineers recently applied to the Town Council for liberty to supply electric current within the borough, and this application was discussed at Wednesday's meeting of the Parliamentary Committee. It was decided to instruct the Town Clerk to obtain information from other towns where the electric light had been introduced.

GLASGOW.—The City Council were engaged in the discussion of electric lighting matters at their meeting on Thursday last. The minutes of the Committee on Electric Lighting recommended that the Waterloo-street station should be extended at an estimated cost of about £6,000. The minutes of the Special Lighting Sub-Committee contained a report by Messrs. W. Foulis (manager of the electric light and gas departments) and W. Arnot (city electrical engineer), which stated that they had considered the saving that might be effected by transferring the arc lighting from John-street to the Waterloo-street station, and supplying the lamps from the low-tension mains used for private lighting. This would necessitate new lamps being procured, and the estimated cost of these with the necessary connections was put at £1,300. From the higher efficiency of the plant at Waterloo-street, and also from the fact that the additional current may be generated without extra cost for labour, they anticipated making a total saving of £688, viz., cost of fuel £257, and wages £431. Additional capital would be required for plant at Waterloo-street, but the sum realised from the sale of the building and plant at John-street would probably meet this charge. If these recommendations were adopted the cost per lamp per annum would be reduced to £22. 10s. 1d. The same sub-committee also recommended that it be remitted to them to consider and submit an exhaustive report as to the supply of current for public and private lighting and motive power purposes. After a long discussion the minutes were referred back. ——At a joint meeting of the Sub-committees on Tuesday it was resolved, by way of experiment, to alter eight arc lamps at the Charing Cross end of Sauchiehall-street, and to hang the lamps on overhanging arms, similar to those at present employed at Edinburgh. The Sub-committees are also engaged in preparing a plan for the electric lighting of the main streets of the city. ——At the last meeting of the Tramways Committee it was decided to send a small deputation (including Mr. Young, the tramways manager) to the Continent, for the purpose of visiting various cities where electric traction is employed. This step has been taken in order to obtain information for the guidance of the Committee, and with the ultimate view of adopting an improved system of motive power for the city tramways.

HALIFAX.—The Finance Committee are greatly exercised as to the best means of preserving the elaborate and costly decorations at the Town Hall. As a means to this desirable end the Committee have decided to dispense with the use of gas and to introduce the electric light throughout the building. A sub-committee has been appointed to prepare estimates, &c.

HUDDERSFIELD.—The Town Council, at their last meeting, approved a report as to the lighting of the Market Hall.

HULL.—At the last meeting of the Electric Lighting Committee the Chairman said they had a good many orders for current coming in, and assuming the increase to go on at the present rate they would reach the utmost capacity of their present plant by the end of the current year. A sub-committee was appointed to consider the question of extensions. The engineer presented a report on the suggested reduction in the price of current, and on his recommendation it was decided to make no change at present.

LECTURES.—A lecture was given at the Highbury Quadrant, London, N., on Monday last, by Mr. Percival P. Kipping, traffic superintendent of the National Telephone Company, on the subject of "Some of the latest Marvels of Electricity." The electrophone, phonograph, telautograph, and column-printing telegraph, telephones and a small telephone exchange illustrated Mr. Kipping's remarks.

MULLINGAR.—The electric light is making considerable progress in this town. Numerous isolated electric lighting plants have already been put down by tradesmen, and to keep pace with the times Messrs. Willis Bros. and Co., building contractors, have had a very complete installation put in at their extensive premises. The engines of the firm are utilised for the purpose of generating current, and a battery of accumulators has been put in. The work has been carried out by Messrs. Tuck and Co. (Limited), Aston's Quay, Dublin, under the supervision of Mr. D. M'D. Grosart, electrical engineer.

NEWCASTLE-ON-TYNE.—A poll of the ratepayers on the proposed Tramways Bill of the Corporation was taken last week, the result being adverse to the Bill by 9,656 votes to 9,363.

NOTTINGHAM.—The report of the Electric Lighting Committee, to be presented at the meeting of the Town Council on Monday next, states that, owing to the demand for electric current having greatly exceeded their anticipations, it is absolutely necessary that the generating station should be enlarged, and orders placed for additional plant at once. Several large buildings in the town are being wired, and a supply of current will be required by the autumn, in addition to which there is a steady increase in the number of ordinary customers. The present plant is capable of supplying current to an equivalent of 11,000 8 c.p. lamps, and there are applications for 16,240 8 c.p. lamps. The Committee therefore recommend the Council to put down plant capable of supplying an additional 12,000 8 c.p. lamps. The capital expenditure to date is £50,200, and it is recommended that an additional £40,000 be borrowed, this sum to be expended as follows: Capital already expended but not raised, £5,200; extensions of buildings, £5,430; additional machinery, £13,000; meters, &c., £2,800; extension of mains, £12,570.

PEMBROKE DOCK.—The gas supplied by the Pembroke Dock Gas Company is so unsatisfactory, both as regards quality and price, that the Town Council are seriously contemplating the introduction of the electric light. At a special meeting of the Council on Tuesday a letter was read from the gas company, agreeing to reduce the price from 4s. 2d. to 3s. 11d. per thousand. The question of applying for a Provisional Electric Lighting Order was, owing to this concession, postponed for six months.

RATHMINES (DUBLIN).—At a special meeting of the Town Commissioners on Saturday last it was decided to consent to the proposal of the Dublin Southern District Tramway Company to construct electric trams in the district. The townships of Dalkey, Kingstown, Blackrock, Pembroke, Drumcondra and Clontarf have already agreed to the principle of electric traction.

SMOKE NUISANCE.—At the Westminster Police Court, on Tuesday, Mr. W. R. Renshaw, manager of the Queen Anne's-mansions Lighting and Heating Company, was summoned for allowing smoke to issue from a chimney shaft on the Company's premises. Mr. P. Gye prosecuted on behalf of the Westminster Vestry, and, in defence, Mr. Renshaw said that he had done everything possible to abate the nuisance. He thought it should be taken into account that the furnaces were used for domestic purposes, and saved about 113 ordinary kitchen ranges. The aggregate volume of smoke from these ranges would be greater than that from the shaft. Mr. de Rutzen, however, imposed a fine of £20, and £5 costs.

STAPLETON (BRISTOL).—At the last meeting of the District Council it was reported that the Great Western Electric Light and Power Company had withdrawn their application for a Provisional Order for the district.

STOKE-ON-TRENT.—At the last meeting of the Town Council it was decided to approve the draft agreement with the local tramway Company as to the electrical equipment of the old tramways. It was also decided to offer no objection to the proposed Potteries Extension Tramways Order, provided the promoters agreed to the modifications suggested by the Town Clerk.

SWANSEA.—The Town Council intend to abandon their Tramways Bill and their dust destructor scheme. It is reported that Mr. J. C. Howell has made an offer to purchase the Council's Provisional Order in case Mr. Manville's electric lighting scheme should also be abandoned.

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WANDSWORTH (LONDON).—The District Board last week again dealt with the question of the opening up of Manor-street and Little Manor-street by Mr. P. E. Singer, without notice having been given to the Board. Complaint was originally made by the County of London and Brush Provincial Company, who have a Provisional Order for the district. The Company pointed out the injustice, after having been put to great expense in obtaining the Provisional Order, and in conforming to the conditions laid down by the Board of Trade and the local authorities, in having to contend against competition of this kind. After discussing the matter for some time, the members ultimately voted in favour of Mr. Singer being allowed to put down a new cable. Mr. Singer's action was described as "local enterprise."

WEST AUSTRALIAN TELEGRAPHS.—The West Australian Government land lines have been out of working order for some days, the breakdown being caused by storms and gales. This accounts for some delay in the receipt of telegrams from the interior.

BOOKS RECEIVED.

"Die Ankerwicklungen und Ankerkonstruktionen der Gleichstrom-Dynamomaschinen." By E. Arnold. Berlin : Julius Springer. Second edition. Price, 12 marks.

"Applied Magnetism." By J. A. Kingdon. (London : H. Alabaster, Gatehouse and Co.) Price 7s. 6d.

Journal of the Institution of Electrical Engineers, No. 119, Vol. XXIV. Edited by F. H. Webb. (London : E. and F. N. Spon.)

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

February 10, 1896.

2,944. H. W. SULLIVAN. London. Improvements in electromagnetic instruments.

2,964. A. C. QUIN. Brighton. An improved system of wiring for electric installations.

3,022. H. H. LAKE. London. Improvements in and relating to the electrodes of secondary batteries. (H. J. Tudor, Belgium.)

3,032. H. O. KRAPF. London. New or improved self-acting electrical signalling apparatus for preventing collisions on railways.*

February 11th, 1896.

3,071. G. E. DORMAN. Stafford. Improvements in and relating to dynamo-electric generator and motor collecting brushes.

3,082. A. L. CUSHMAN. London. Improvement in armatures for induction motors.*

3,083. R. W. BRAHAM. London. An improved ceiling rose and attachment therefor, chiefly applicable for electrical purposes.

3,091. R. LINDE. London. Improvements relating to the composition of the filling paste of accumulator batteries.*

3,092. J. DEVONSHIRE. London. Improvements in controllers for electric motors. (W. B. Potter, U.S.A.)*

3,093. J. DEVONSHIRE. London. Improvements in controllers for dynamo-electric machines. (W. H. Knight and J. W. Darley, jun., U.S.A.)*

3,094. J. DEVONSHIRE. London. Improvements in regulating phase relation of alternating currents. (E. J. Berg, U.S.A.)*

3,096. J. IMRAY. London. Improvements in apparatus for regulating the tension of alternating electric currents. (La Société Anonyme pour la Transmission de la Force par l'Electricité, France.)

3,133. J. WIESNER and A. WITZEL. Liverpool. Improvements in and relating to electric clocks.*

February 12, 1896.

3,151. A. T. SCHMIDT and F. T. SCHMIDT. Birmingham. Improvements in arc lamps.

3,213. J. H. DOUGLAS-WILLAN and F. E. W. BOWEN. London. Improvements relating to treating or flashing filaments for electric incandescent lamps.

3,224. W. H. SCOTT. London. Improvements in or connected with culverts or conduits and insulators for carrying electric conductors, more especially intended for carrying underground bare electric conductors.

February 13, 1896.

3,235. E. G. FIEGEHEN. Bedford. Improvements in electric cranes.

3,256. G. H. NISBETT. Liverpool. Improvements in electric cables.

3,322. J. FUCHS and L. THIEMANN. London. Improvements in electric batteries.

February 14, 1896.

3,350. K. RUDOLPH. London. Improvements in coin-freed apparatus for administering electricity.

3,359. E. BAILEY and J. DUNN. Glasgow. Improvements in electrical furnaces for volatilising metallic and other ores.

3,361. J. KIRKWOOD. Edinburgh. The electro-plating of iron and other metals and alloys, and the electro-reduction of metallic iron.

3,375. T. S. PAYNTER and G. C. WALKER. London. Improvements in electrical contact devices for clocks and the like.

3,394. G. WEBB, Jun., and R. J. UNDERWOOD. London. Improvements in electric glow lamps.

3,409. A. WRIGHT. London. Improvements in or connected with recording electric meters.

February 15, 1896.

3,441. J. H. BENNET. Liverpool. Improvements in or connected with or to be used with telephones.

3,478. W. J. DAVY. London. Improvements in switches for controlling glow or incandescent electric lamps when used in conjunction with arc lamps.

3,481. S. Z. DE FERRANTI. London. Improvements in dynamo-electric machines.

February 17, 1896.

3,535. W. R. H. INGLIS. Doncaster. The automatic electric self-registering long-distance signalling apparatus.

3,550. E. W. SMITH and THE NEW PHONOPHORE TELEPHONE COMPANY (LIMITED). Improvements in simultaneous telephony and telegraphy.

February 18, 1896.

3,627. W. H. RUSSELL, G. E. RUSSELL, F. M. NEALE and H. CONNETT. Wolverhampton. Improvements in telephones.*

3,628. F. E. ELMORE. Leeds. A new or improved dynamo brush.

3,633. F. G. THOMAS and J. THORNTON. Manchester. Improvements in and connected with electric alarms and indicators.

3,658. G. SHULTZ. London. Improvements in joints for the conduits of electric mains.

3,682. SIEMENS BROS. AND CO. (LIMITED) and KINGDON. London. An improvement in multiple contact circular electric switches.*

3,690. A. C. SHUTTLEWORTH. London. Electromagnetic induction system of propulsion.*

3,705. V. A. FYNN. London. Improvements in dynamo-electric machines.

3,712. F. MOUTERDE, C. CHAVANT and J. GEORGE. London. Improvements in electric accumulators.

February 19, 1896.

3,736. T. PARKER. Wolverhampton. Improvements in electrical accumulators.

3,761. G. H. SKEE. Bishop Auckland. Eight-day and above electric alarm.

3,796. C. W. ATKINSON. London. Improvements in electrically-driven machinery for cutting coal or other minerals.

3,809. J. F. C. SNELL, A. H. M. FRANCIS and R. S. J. SPILSBURY. London. Improvements in sockets and holders for incandescent electric lamps.

February 20, 1896.

3,823. L. P. FOSTER. Halifax. Improvements in electrical lamps.

3,841. F. M. LEWIS. Leeds. Improvements in and in connection with arc lamps.

3,842. H. BERRY. Leeds. Improvements in cranes, especially applicable to electrically-driven cranes.*

3,846. T. HARDEN and S. GLOVER. St. Helens. Improvements in electrical generators.

3,847. T. HARDEN and S. GLOVER. St. Helens. Apparatus for reversing the flow of electrical currents.

3,864. C. D. BARKER. London. Electrical thermometers.

3,908. A. E. BUTCHER. London. Improvements in electrical dial-indicating and communicating apparatus.

3,910. F. KLOSTERMANN. London. An improved magnetic regulator for the carbons of arc lamps.

February 22, 1896.

4,028. T. J. BAKER. Erdington. An improvement in the construction of ammeters and voltmeters.

4,033. J. A. SINCLAIR. London. Improvements in diffusing and colouring the light from incandescent electric lamps.

4,076. W. P. THOMPSON. Liverpool. An improved holder for electric incandescent lamps. (Porzellanfabrik Kahla Filiale ; Hermsdorf-Klosterlausnitz, Germany.)*

4,082. W. ACKROYD and W. BEST. London. Improvements in or connected with apparatus for electrically igniting miners' safety lamps.

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SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1895.

1,698. NIEWERTH, H. and R. Electric current regulators.
2,064. HOPKINSON. Electric switches.
2,182. ATTREE. Incandescent electric lamps.
2,218. HUMMEL. Counters for electric currents.
3,055. KING. Electric steering apparatus.
3,076. LAKE (SHEA and ANOTHER). Telephone and telegraph systems.
4,154. COWPER-COLES GALVANISING SYNDICATE (LIMITED) and COWPER-COLES. Electro-deposition.
4,352. ATKINSON. Dynamo electric machines and motors.
5,875. MUIRHEAD. Electric conduits.
6,043. BOLLÉ (Jeffersen). Electrical insulation.
6,075. DAVY. Electric switches.
6,177. ESSON. Alternating-current dynamos.
6,545. DAVENPORT. Arc lamps.
6,657. LYONS and BEVIS. Incandescence electric lamp holders.
13,670. COOPER. Electric incandescent lamps.
19,032. KINDERMANN and OTHERS. Incandescent lamps.
24,098. DE PUYDT and PONCIN. Motor dynamos.
24,354. DORMAN and OTHERS. Electric switches.
24,514. HACKING and BENNETT. Holding electric lamps.
24,516. EPSTEIN. Voltaic batteries.
24,710. DEVONSHIRE (Potter). Lightning arresters.

COMPANIES' MEETINGS AND REPORTS.

City of London Electric Lighting Company (Limited).

The sixth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, E.C., on Friday last, Sir David L. Salomons, Chairman of the Company, presiding.

The MANAGER and SECRETARY (Mr. J. Cecil Bull) read the notice calling the meeting.

The CHAIRMAN said: Gentlemen, I would remind you that it was in Sept., 1892, that this Company actually commenced operations. In August, 1891, we took over the Pioneer Company, with all its assets and surplus funds to continue the work which that Company had not at the time completed. We came in, therefore, to this legacy with a few street lamps erected in Queen Victoria-street and other parts of the City—no private lights were being supplied. You will see by the report that by the end of that year there were a certain number of private lamps connected—something like 20,000, I think. That was done with the Pioneer Company's machinery. During the first two years there was naturally very great difficulty in coping with the demand for current, which increased more rapidly than would have been imagined from the criticisms which appeared in the Press about that time, which were to the effect that the demand in the City for current would be comparatively small, and might not even pay, on account of the light not being required much in the evenings in offices and other places of business. All such predictions have been totally falsified. The demand became so great that there was an enormous difficulty on our part to meet it. We were also confronted with another difficulty—that of having to learn the peculiarities of the district we supply. That, of course, is not singular to the City, but has to be overcome in every district. People in one locality have totally different requirements from those in another, and the electric lighting companies have to discover for themselves what the requirements of their customers are. That experience has been gained by us, and we now know exactly from hour to hour what is likely to be the demand made on our machinery. The third year—last year—found us in a very different position from that of the two previous years. It is true the whole of the machinery was not at work, and if the applications continue to come in week after week as they do at the present time, of course we shall always be requiring more machinery. At the same time, I would point out that our main building was practically completed last year. Instead of working under a temporary roof with an unfinished building, and amid the dust and dirt inseparable from such a state of things (which is not favourable for running machinery), we were able to turn our attention to more important matters. We have now under one roof, I think, the largest installation that exists anywhere. We yet require further time to finish the machinery in course of erection, and with an engineer such as we now possess in Mr. Bailey I am sure we may have every confidence that when the work in hand is completed there will be no cause whatever to complain. At the present time (Feb. 12th) we had connected the equivalent of 202,045 8 c.p. lamps. The applications have reached 213,224, but we cannot connect up directly we receive an application. Out of applications for 213,000 odd lights only 11,000 are waiting to be connected, and the number is being reduced day by day. The period of what I may call constructional anxiety may now be said to have come to an end, and there is scarcely a doubt that, owing to the great support which has been given to the Company by the public in the City, it will succeed. We may regard the City of London Electric Lighting Company as on a thoroughly sound and permanent basis. To prove this point I should like to refer to a point in the accounts to which some critics might make objection.

You will observe that we have again trenched—if I may use the expression—on the premiums to increase the depreciation fund. It might be said that we shall not be able to do this every year, as in course of time the premiums will become exhausted. But here is the strength of our position. If matters go on in 1896 as they have during 1895, and seeing that for only a portion of the past year were we earning money on the whole of the 200,000 lamps, it can easily be calculated that with this number of lamps bringing us in revenue for the whole of the current year there will be sufficient income not only to cover any amount that may have to be placed to the Parliamentary and other depreciation funds, but there may possibly be a surplus. On this point I should not like to make any prophecies, however, although we may express hopes. At least, we may take it that, accidents apart, at this time next year, when appearing before you, we shall be in no worse position than we are to-day, and that there will be no necessity to make any call on the premiums which have been set aside for such periods as that of the past year. Another point to which to call attention is that we have done a work, not for one or two years only, but that we have expended capital which will prove of lasting benefit for many years to come. It would scarcely be fair, after such a heavy capital expenditure, to charge the whole of the depreciation, which can scarcely be said to have begun yet, on the profits of a single year, and your Board thought therefore it was wise to transfer a portion of the premium fund to the depreciation fund; and you will notice that we are permitted out of this Parliamentary depreciation fund to maintain and renew all that is required at our works during the year. Of this money but a comparatively small portion has been expended, so that the transference of this sum from the premiums fund to the depreciation fund does not mean that the money has actually been spent.

The report which has been placed before you is very short and very explicit, and as you are going to receive a dividend presently, the chances are that you do not require so much explanation as you would demand at my hands were no dividend to be declared on this occasion. At the same time, I think it is right you should know what is going on, and I will tell you briefly. There are points shareholders may have overlooked, although those who are accustomed to this class of accounts have probably not done so. One of these is that there is an advantage to the Company of roughly 20 per cent. in the expenses of distribution and generation, relative to the earnings, as compared with 1894, and 30 per cent. as compared with the year before that. But of course this cannot go on for ever, because after a certain point we should be generating the current for nothing. We have not, I hope, come quite to the end of economy in this respect, but I doubt if we shall be able to reduce the cost much below the present figure. There is another item to which I wish to call attention, and about which I may say the larger it becomes the better it will be for the shareholders. I refer to the item of meters. The more we spend under that head the more customers we are getting. There is, if I remember aright, nothing said in the report about the telephone tubes, a very much vexed question in its way, and one that is gradually settling itself. In consequence of the rapid demand for current which has been made in the City it has been necessary to use a great many of these tubes for the drawing-in of cables to supply customers. There are a considerable number of these tubes vacant which we should be willing and pleased for any telephone company to purchase or lease of us. But we have at any rate this consolation, that with the great demand for the electric light from people in the City it has not been necessary to open the streets a second time, which would probably have been the case had not these telephone tubes been laid. You will observe that the actions for vibration have been settled by the purchase of the property to which that action referred, and therefore that dispute has come to an end, and we trust such troubles will cease altogether. So far as I am aware nothing further of the sort has arisen. The expense connected with this action, and also with one or two other matters mentioned in the accounts, the Board having considered it fair to place to the suspense account, spreading it over several years instead of paying it all out of one year's profits. Our auditors concur in this view.

A question has been raised as to whether we could not hold half-yearly meetings and pay interim dividends. I would point out the difficulty and inconvenience of paying an interim dividend, and then discovering at the end of the year that it has not been earned. The case of the electric light companies is very much like that of railway companies—there is a good and a bad half-year. If ever we should get a sufficient income to enable us to safely pay an interim dividend in the first half of the year, clearly it would not be to the interest of the Directors to withhold the money and keep it at the bank. But it may be many years before such a procedure would be considered thoroughly safe. I am just reminded that this applies to the Ordinary shares only. I am sure it would not be the wish of any gentleman present, whatever may be his views in the abstract, to advise your Board to take a step they would deem imprudent at the present time, although they are anxious to see a period when it would be safe to pay a dividend in the first half of the year. Then as to half-yearly meetings, I have to point out that the accounts cannot be rendered until the end of the year. The Board of Trade make it a rule that all accounts shall be made up to December 31st, and to make them up a second time would entail a great deal of expense and work without any advantage being gained, because accounts so rendered would not be final, nor could they be considered as properly audited under such an arrangement. I believe there is a company which, at the time the half-yearly meeting would be held, issues a circular giving the shareholders information as to what has been done in the first six months, and we shall be ready, if it is the wish of the shareholders—and even without your

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express sanction we might take it to be your wish—to issue, half-yearly, a rough rendering of what has been done during that period. It is not our desire to keep anything back from the shareholders, and I feel sure it is not your wish to put the Company to expense and trouble when nothing can be gained. The duty of the auditors, I may point out, is exceeding onerous They go in the most thorough manner through the whole of our accounts, and without auditors who do their duty in such a manner your security for their corrections is gone. So far, they have received a fee of 100 guineas, and we therefore recommend, and I trust the shareholders will agree with it, that this amount be increased to 125 guineas. The suggestion does not come from the auditors, but from us, I undertake to say that no set of officers have taken so much trouble in looking through what is one of the most important parts of your business than have those gentlemen whom you elected as your auditors last year, and whom, I trust, you will re-elect again. And now, apart from any replies to questions you may wish to put to me, I have only to say that our officers and employés have given us every possible satisfaction, and that we are exceedingly fortunate in retaining the services of Mr. Bull, our Manager and Secretary, and of Mr. Bailey, our engineer, and I hope, on behalf of the Board as well as myself, and I may add for you all too, that they may have long life and health to continue in your service and give their devotion to us as they have done in the past. I will now move—

"*That the Directors' report and statement of the accounts for the year ended December 31, 1895, with the appropriation of the reserve, depreciation and premium funds as shown therein, be and the same are hereby received and adopted.*"

Lord SUFFOLK seconded the resolution.

Mr. WALLER inquired if the authorities had yet given their sanction to the lighting of the lesser streets in the City, and whether the circular referred to by the Chairman would be issued every half-year, except when the annual report was issued.

Mr. GEORGE HERRING observed that the report was so good that it was unnecessary to say many words. From what they had heard respecting the applications coming in, he thought it would be fair to assume that during 1896 the Company would have about 60,000 more lamps connected than during 1895. Under these circumstances, and considering what a small extra outlay would be incurred in supplying current to these 60,000 additional lamps, he considered that they might reasonably calculate on earning a better dividend during the current year. He hoped, therefore, that the Chairman would see his way to slightly alter what he had said about paying an interim dividend. Could it not be put in this way : that if the progress of their business continued satisfactory and no unfortunate hitch took place in the earnings of the Company during the current half-year, the shareholders might look forward to an interim dividend, of whatever amount the Board might think fit, being paid at the end of the first half-year, and also a circular stating what progress had been made up to that time. He appreciated the force of the Chairman's remarks about the expense and trouble of making the accounts up twice. The shareholders did not want that to be done. They wanted a short statement as to the progress made by the Company, and what they would like as well or better was an interim dividend equal to 5 per cent. per annum.

The CHAIRMAN : In the first place, as regards the lighting of the minor streets. We are only too anxious to get the contract settled, and our engineer is in communication now with the City authorities on this matter. In answer to Mr. Herring, who has always taken a great interest in this Company, I may say that applications are still coming in for lights at about the same rate as in the past, which is a very extraordinary thing. They come in at the rate of 1,000 per week—sometimes slightly below the figure and sometimes above it. At Christmas and Whitsuntide, perhaps, the number drops for a week, but the applications continue to come in at a steady average, and that appears likely to go on for some time, although it cannot last for ever. With regard to the interim dividend this half-year, I may say it is of no use holding out the slightest hope of that. I am speaking honestly when I say I should be glad if we could promise it ; but experience of the past rather shows that we cannot pay a dividend in the first half of the year until the Company is longer established. I hope the returns may show differently, and if we are able to pay an interim dividend I shall be the first to move that it be done. I give my reason why I think an interim dividend should not be paid in the first half of the year. We were last year rated at a small amount, but this year our rating is really beginning to come into play, and the increased expense in this respect is something enormous. Then we have to make provision for paying the debenture interest and the dividend on the Preference stock and for depreciation. All these things, as a matter of prudence, have to be provided for out of the first half-year's working if you can manage it. Our rates now amount to about £5,000, but the amount will be increased to £6,000 or £7,000 next year. On the whole, therefore, we do not think it prudent to pay an interim dividend during the current year, unless the profits come in to a much larger extent than they have done in the past in the first half of the year. And at the second half of the year there will be the usual report and meeting. You already have the quarterly returns published, from which you can tell in a certain measure how the Company is going on. In the first half of last year, speaking roughly, we only earned enough to meet our outgoings, and the dividend on the Ordinary shares was practically earned in the second half of the year.

Mr. BOOTH thought they would be unwise as shareholders to force the hands of the Directors. If they had confidence in the Chairman and the Board let them be guided by their judgment.

The adoption of the report was then unanimously agreed to.

The CHAIRMAN next moved—

"*That dividends be declared as follows: 6s. per share on the Preference shares, making, with the interim dividend of 6s. per share paid on July 25th, 6 per cent. for the year ; 10s. per share on the Ordinary shares, being at the rate of 5 per cent. for the year.*"

Mr. F. W. REYNOLDS seconded, and it was agreed to.

The CHAIRMAN next moved the re-election of the Right Hon. Earl of Suffolk and Berkshire and Mr. Frederick W. Reynolds as Directors, which was carried.

Mr. WANCKE proposed and Mr. E. J. HARRIS seconded, the reappointment of the auditors (Messrs. W. H. Pannell and Co.) at a fee of 125 guineas per annum, and this was agreed to.

On the motion of Mr. HARRIS, seconded by Mr. HERRING, a vote of thanks was accorded to the Board and to the Chairman for the manner in which they had conducted the affairs of the Company during the past year, which the CHAIRMAN having acknowledged, the proceedings terminated.

Notting Hill Electric Lighting Company (Limited).

The ninth ordinary general meeting of this Company was held on Tuesday, February 25, 1896, at the Company's registered office, Bulmer-place, High-street, Notting-hill, Mr. Sidney Waters presiding, in the absence of Prof. Crookes, F.R.S. (Chairman of the Board).

The SECRETARY (Mr. R. G. Rawkins) read the notice convening the meeting.

The CHAIRMAN said: Ladies and gentlemen, in submitting the Directors' report and accounts, which I presume you will take as read, I have the pleasure to present to you a favourable account of the Company's progress. We propose to ask you to declare the full dividend at the rate of 6 per cent. upon the ordinary Preference shares, and a dividend of 2 per cent. for the whole year, or 4s. per share, upon the Ordinary shares, free of income tax, after placing £700 to the renewal and depreciation fund, and to continue the reduction of the preliminary expenses account by setting aside £151. 9s. 5d., or 3 per cent. of that amount. It has been the custom of the Chairman at previous meetings to refer to the accounts *seriatim*, and I think I cannot do better than to follow the same plan. The first to be considered is No. I. Account, "Statement of Share Capital :" The only change here is the issue of ordinary Preference shares, to which I will refer in dealing with the capital account. No. II., "Statement of Loan Capital :" This remains blank, the Company having neither debentures nor mortgages upon its property. No. III., "Capital Account:" I will first take the credit side, which deals with the capital receipts. Particulars are set forth here of the ordinary Preference shares just referred to. At the commencement of the year we allotted 450 of these shares, which had been previously applied for at par, and more recently 123 shares at £2 premium, in all 573 shares, of which 266 are fully paid up and 307 had £5 per share paid up at the end of the financial year. The improved position of the Company, and also the greater confidence felt in electric light undertakings generally as a medium for sound investments, enabled the Board to raise the price to the premium named. We have subsequently received applications for all the unissued shares at the same premium, and they will be allotted as further capital is required for our extensions. It is a matter for congratulation that the future of the Company is regarded with such confidence that we are able to issue these shares at a premium. The premiums already realised (£246) have been applied to the reduction of the preliminary expenses account, and the further amount (£2,276) which will be realised upon the issue of the remaining shares will be applied in the same manner, and when this is effected that account will be brought within comparatively small proportions and its liquidation will gradually proceed out of revenue. Upon the expenditure side of the account there are two items to notice : "To accumulators and connections at generating station," £1,818. 5s. 3d., and "to mains, including the cost of laying and construction," £2,489. 15s. 7d. With regard to the first item, it has been explained in the report that the expanding business of the Company necessitated an additional battery of accumulators. It has been built by the side of the original battery. I am glad to inform you that it is working very satisfactorily and quite up to our expectations, and if the shareholders care to inspect it we shall be very glad for them to do so at the close of the meeting. With regard to the item for mains, two-thirds of the outlay is for carrying our mains along Addison-road and extensions in its immediate neighbourhood, and the balance is for small extensions all over the system which are showing satisfactory indications of profitable business to the Company. It will be remembered that at one time we contemplated the erection of a second central station in the neighbourhood of Addison-road for the service of that district, but great doubts were felt whether the revenue likely to be derived from that part of the area would justify the outlay involved, and, moreover, a suitable site could not be obtained for the purpose. Under the advice of our engineer, the Directors made the experiment of supplying that neighbourhood from their central station, which is more than a mile distant. The result is a complete success, the concentration of our power under one roof and management proving very economical, while the supply of current to our customers is perfectly satisfactory. Our experience so far shows that our doubts as to a second station proving remunerative were entirely justified, as it is clear that it would not have paid its way for years. The total amount of capital called up you will notice during the year amounted to £4,195, which is about £1,500 less than the year's capital expenditure, and it has been found necessary to call up this £1,500 recently. We will now turn to No. IV. "Revenue Account," and upon the credit side you will notice a very satisfactory increase in the sale of current, 182,327 units having been sold, against 130,266 in 1894 ; this has been caused by the increased number of lamps connected, the total having risen from 15,669 in 1894 to 20,307 in 1895. Upon the debit side are the various items of expenditure, which with our greater output of necessity show some increase, but in most of the items the increase is small, with the exception of that for maintenance and renewal of the accumulators, while in some instances there is actually a reduction. With regard to the expenditure upon the

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accumulators, the Board has thought it advisable to charge it entirely against revenue rather than take it out of the Depreciation and Renewal Fund, which has thus been left intact. I should like here to call attention to the low initial cost at which our current is produced, and by initial cost I mean expenditure in wages, coal and stores. The Directors propose to draw £400 for their fees for the past year, against £300 for 1894, and the remaining item on the account is the balance, which stands at £3,227. 14s 10d. and is carried into the net revenue account We now come to the No. V., "Net Revenue Account," in which 3 per cent. is written off the preliminary expenses, amounting to £151 9s. 5d. With regard to the item for interest, £39. 1s., I may explain that in some instances we have not felt justified in making extensions without a guarantee. The charge is for interest on these deposits, and it will be eliminated by the revenue derived from the extensions, which is gradually paying off the deposit and interest. £40 is written off on account of leasehold redemption, and £700 placed to the depreciation and renewal account, leaving a net balance of £2,329. 9s. available for distribution. No. VI., "Depreciation and Renewal Fund Account": This stands now at £1,300, and we are glad to be able to report that we have had no accident which has caused us to trench upon it. It is the policy of the Board to increase this fund to such a point that the Company shall be in a position to bear the strain of any breakdown to which, with all our care, it is obvious we are at any moment liable, without necessarily inflicting a loss of dividend upon the shareholders. An accident to a dynamo, or the breakdown of a boiler, from which we have so far been free, would make a serious inroad into this amount, and hence the Directors feel sure that a policy of prudence and foresight in the establishment of a substantial reserve will meet with your approval. No accident has occurred in the works during the year, and the only mischance that has happened of any kind was in the time of the great frost, when a number of the water companies' pipes burst in the roadways, and through this three of our longest culverts were flooded. Of course, we lost a good amount of current, but not one of onr customers was deprived of the light, and the pressure was kept up to its proper standard. We have since put in additional drains to mitigate the effects of such an occurrence in the future. The last account is No. VII., "General Balance Sheet," which is practically a summary of all the statements, and I think needs no further explanation. Having dealt with the accounts, I will now read to you the auditors' report. They state: "We beg to report that we have attended at Bulmer-place and checked the postings of the books for the three months ending December 31, 1895, and examined the vouchers for payments made and the invoices for goods purchased during that period. We have also inspected the share books of the Company and checked the transfers. We have prepared a list of the accounts in arrear at December 31, 1895, still outstanding at the date of this report, which amounts to £13. 4s. 4d. We beg to state that we found the books to have been correctly kept and all the vouchers, invoices and transfer deeds in good order. (Signed) Fox, Sissons and Co." I may state that this is a quarterly report, and that we receive a similar one every three months, and, of course, it is quite independent of the auditors' certificate, which appears at the foot of the accounts now submitted to you. In addition to Messrs. Fox, Sissons and Co.'s audit, I may mention that we have an entirely independent audit on behalf of the Board of Trade, which always confirms our own auditors' report in a most satisfactory manner. And now, having dealt with the past, I will, with your permission for a few minutes, look to the future. It is obvious that the business of the Company is increasing at a fairly satisfactory rate, considering that the neighbourhood is not one of the wealthiest in London, and that the houses in many parts are more or less scattered. This diagram, which Mr. Schultz has prepared, shows clearly the expansion of the output during the past four years. It is divided into months, and you will see how the amount of current supplied varies from month to month, and that the line representing each year's output always tops that of the preceding year. There is no reason why such expansion should not continue. In my opinion its rate will depend largely upon whether the improving condition of financial affairs which has undoubtedly begun continues to make progress, as I believe, in the absence of war or other disasters, it will do. People do not wire their houses if times are bad, but with returning prosperity and confidence, and with larger resources, they do not mind the necessary outlay. In addition to this there is a fair amount of new building either in progress or projected within our area, there are a large number of houses not yet lighted, and the use of electricity is increasing for other purposes, such as cooking; we have some of the utensils here to show you if you care to look at them afterwards; it is being used in various ingenious devices for advertising, and I hope soon, when the troublesome Act of Parliament which now stands in the way is repealed, it will be used for road carriages of all sorts. Another important field for our operations will, I hope, soon be available in the northern area as soon as we get the requisite powers; the Bill, which was delayed by the dissolution, is now before Parliament, and will, I believe, soon be passed. Then we shall proceed energetically to lay our mains in the streets we have undertaken, and what is very important we shall be able to carry a trunk line down the Holland Park-avenue (Uxbridge-road) and complete the Addison-road system from the Uxbridge-road, and thus being able to maintain our pressure by a complete circuit. Hence you will see that we have a fair prospect of increase of sales. On the other side we must look forward to some increased expenditure. Our expenses may be divided into two heads, one may be called the works cost or the initial cost of the current we produce, and the other the establishment charges. The works cost is bound to grow with our output, but the establishment charges will not increase at the same rate, and hence it is probable that our total expenses will not grow in anything like proportion to our sales. We may therefore, I think, look forward with confidence to a steady increase in our prosperity, our position being gradually strengthened as we proceed. Our lamp earning, and by that I mean the value of the current consumed by each lamp circuit, on our is still low. It is about 5s. 9d., which is slightly higher than last year, when it was 5s. 4d. It is probably lower than the other London companies, and this is partly due to the superior economy of our consumers, partly to our neighbourhood being lighter than other districts of London, and also to the fact that we have no public buildings such as clubs and theatres, and but few shops in our area. We must exercise great caution in taking such an important step as would be involved in a reduction of price, especially when it is remembered that our lamp earning is so very low. The character of our district must be considered. We have to make many extensions which only just pay their way, and I may mention that of 70 installations in 1894, 23 extensions were necessary, and last year 81 new installations required 23 extensions. We have at present a scheme of rebates which is based upon the value of current consumed by each lamp, which enables those who burn lamps for a great number of hours to obtain a slight reduction, and it is possible that in the future we may consider whether a further extension of this plan is practicable. Our customers may rely upon it that we shall study their interest as far as it is possible for us to do so, and that we recognise that it is the true policy of the Company, besides giving them a light which is perfectly steady, to consider what we can do to reduce its cost when we can do so with safety to the Company's progress. There remains little more for me to say, but I may mention that in view of fires at other electric light stations, besides revising our insurances, we have effected an insurance on our revenue in the event of such a disaster overtaking us. We have had our assessments for rating considerably increased; but, acting on the advice of Mr. J. P. Grolin, we decided not to proceed with the appeal upon this occasion. He then moved the adoption of the report and the declaration of the dividends.

Mr. A. E. FRANKLIN seconded the motion and said that their best thanks were due to Mr. Schultz for the successful manner in which the Company had progressed. Their Secretary also (Mr. R. G. Rawkins) had shown his great interest in the Company's welfare by the manner in which his work had been done. The Directors and shareholders tendered their thanks to the staff generally.

Prof. W. Crookes and Mr. Sydney Waters were re-elected Directors, the Auditors were re-appointed, and the proceedings terminated with a vote of thanks to the Chairman.

Charing Cross and Strand Electricity Supply Corporation (Limited).

The annual ordinary general meeting of shareholders of this Company was held at No. 2, Craig's-court, Charing Cross, on Monday, under the presidency of Mr. G. H. Brougham Glasier.

The GENERAL MANAGER and SECRETARY (Mr. E. Wilmot Seale) read the notice calling the meeting, and the report and accounts were taken as read.

The CHAIRMAN: I will now make a few remarks in connection with the business of the Corporation in the past year. First of all, if you make a comparison—as I daresay those of you who have been shareholders for some time would do—between the accounts we are now presenting and those which we submitted to you last year, you will find that the business has been a continually prospering one; that in all matters where it has been desirable to decrease the expenditure that has been done; that we have in many items been able to save very considerably; and that, as regards the output of the Company, it has been most satisfactory. You will find that the actual increase in the business is equal to 25 per cent. in the number of lamps supplied, and, taken in connection with the increase in the number of lamps supplied during 1894, the business has almost doubled itself in that respect in the period of two years. We have had very severe competition, the price per unit we are obtaining at the present time, as you are probably aware, having been reduced very considerably; but there is little doubt that the present price has commended itself very much to the consumers in the district we supply, and there is no doubt that that has had a good deal to do with extending and popularising electric lighting in our district. In connection with this matter I should just like to refer you to *The Electrician* of May 24th last, in which you will find, at page 127, a chart showing the pressure of the various companies in the metropolis taken on certain days by an eminent electrician. I am referring you to this particularly to show you what a very capital record we have—how regular our pressure is in comparison with that of other metropolitan companies. The pressure was taken in our case on May 6th of last year, and you will find it commenced with 100 volts and finished with 100 volts. The line is almost one continual straight one right through. It is an interesting diagram. You will note that some of the companies vary exceedingly, but that is not the case with us, and it is very satisfactory to the Directors to know that the pressure is so even all through. Of course, it might be said that this is one particular day; but as a matter of fact our records taken at several points on our district show, day by day and week by week, the same uniform pressure. That is a circumstance of very great importance in connection with electric lighting, because if the pressure varies considerably, you will find that your lamps will not stand the same time, and all sorts of unpleasantness arise. There is another thing which I must mention to you, and I have no doubt that you will be pleased to hear it. Notwithstanding the severe competition we have had to contend with, not a single customer has transferred his custom to either of our competitors. That is a very satisfactory matter for the Directors to know, and I have no doubt that it will be regarded as equally satisfactory by you. In No. 3 paragraph in our report we inform you that the station has been maintained in a high condition of efficiency. Looking at the accounts you will see that we have spent on repairs to machinery, &c., £1,517. This is a large sum, no doubt, but it is absolutely necessary that our machinery should be main-

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tained in a very high state of efficiency, and it is also equally necessary that we should put by a fund to meet contingencies. You will find that we have done this already by carrying the sum of £3,000, out of this year's earnings, to depreciation account, which now stands at £5,300. We transfer the £3,000 to depreciation before we arrive at our net revenue. The next paragraph which I desire to allude to has reference to our Provisional Order. Most of you will be aware that we took power to apply some time back for a Provisional Order to supply a very much larger area, viz., the district of the Strand District Board of Works. In connection with that the Board of Trade granted us the Provisional Order for the district we wanted. Our Bill confirming this passed the House of Lords last year, but in consequence of the dissolution of Parliament we did not get it into the House of Commons, but this year we are going to start again at the point where we left off last year. I believe that our Bill will be in the House of Commons in about a fortnight, and you may rely upon it that we are only too anxious to get the Bill passed, and we have every hope that we shall succeed. We have had to meet rather strenuous opposition, which is still being maintained on the part of the Metropolitan Company. In connection with that matter I may mention rather a pleasing circumstance—namely, that petitions were presented to the Board of Trade and the House of Lords in support of granting us our Provisional Order, and the petitions were signed by no less than 850 of the principal owners of property and largest ratepayers in the district, among them being the lessees of the whole of the theatres, the editors and proprietors of the principal newspapers and printing works, &c. We now come to the fifth paragraph of the report. We want more room in order to be able to deal properly with the amount of electric energy we have to supply. An accident occurred last year to one of the companies which brought home very closely to us the disastrous position we might be placed in if any such thing had occurred to our Company—I refer to the fire that took place at one of the stations of the Metropolitan Company. We have secured premises in Commercial-road, Lambeth, occupying an area of nearly three-quarters of an acre, and we are now preparing for the formation of a large station there. The alterations are now being made, and the mains are laid connecting up this station, so that very shortly—in fact almost as soon as we can possibly get our machinery into position—we shall be able to connect up with and supply from our existing area and also the area we hope to obtain. The site of the new station is one which I think will commend itself to you. Commercial-road is on the other side of the river, a short distance from Waterloo Bridge, in the centre of wharf properties with large open spaces around. It is an admirable site for a station, and commended itself very strongly to the Managing Directors, who brought it before the rest of the Board, who were pleased to acquire so eligible a site. It has a river frontage, which is of great importance, because we shall be able to deliver our coals and other goods in connection with our business alongside. We therefore anticipate that we shall be able to considerably reduce our cost of production, besides effecting a considerable saving in freight That brings me to what is probably the most important point in connection with you, gentlemen, which, at any rate, it gives us the greatest pleasure to deal with—I allude to the net earnings. You find by the accounts that our net earnings for division amount to £12,587, after having written off, as I said before, £3,000 to depreciation account. After writing off £700 for preliminary expenses, £300 for law costs suspense account, after paying the debenture interest and the interim dividend for the last half-year, which was at the rate of 4 per cent., we are left with £5,424, which, added to the amount brought forward from last year, makes £5,729. This we propose to deal with as stated in the report, namely, to pay a dividend (less tax) at the rate of 6 per cent. for the half-year to December 31st last, making, with the interim dividend, 5 per cent. per annum for the whole year. This will absorb £4,350, and leave us the very respectable sum of £1,379 to carry forward to this year's trading, as against the £305 which we brought forward this year. Before I move the adoption of the report I will hear whether any gentleman has anything to ask in connection with the accounts.

Mr. T. P. LING inquired whether an estimate could be given with regard to the cost of erecting the new station referred to and laying out the works. He also desired to know whether it was proposed to add to the capital account.

Mr. WALLER asked whether it would not be possible to add in future a clause showing the percentage of generation and distribution expenses and renewals as compared with the earnings. This, he said, was done by some of the companies, and it was a great point to see how the expenses were diminishing.

The CHAIRMAN, in reply, said: In answer to the first question, it is impossible for us to tell you the amount we shall have to expend at the new station, as that is a matter which will entirely depend upon circumstances, owing to the position in which we stand with regard to the proposed increase in the area of our supply. You may, however, rely upon one thing—that the Directors will take care to keep the expenditure down to the lowest possible sum, having due regard to the efficiency and stability of the work. Of course we must increase our capital. That matter was decided at the special meeting we held some time in 1894. We have power to increase our capital, and this will be done in due course. This question, however, enables me to state one thing which I forgot to mention. We have arranged to borrow sums to the extent of £10,000, required in the erection of our new station, in sums as may from time to time be required, at 4 per cent., so that the capital which we shall want for the purpose of carrying out and completing the new station we shall receive as we require it, without having a large sum lying idle.

Mr. T. P. LING inquired if anything had been done yet with the view of converting the debentures from 5 per cent. to 4 per cent.

The CHAIRMAN: Nothing can be done at present in that direction. The debentures were issued for a certain time, but at the expiration of that period we shall no doubt pay off the existing debentures, and get the money we want for very considerably less than we are now paying. The present debentures will expire in 1900. In reference to the other question which was asked, I may tell you that the percentage of costs to revenue in 1894 was 50 per cent., but in the past year that has fallen to 45 per cent.

Mr. WALLER remarked that this was very satisfactory.

The CHAIRMAN: We shall be very pleased in next year's report to include something which will give you this information; but everywhere where we wanted to see an increase there has been an increase, and everywhere where we wanted to reduce the expenditure we have been able, through our engineers and our officers, to do so. The result is that our percentage of costs to revenue has dropped by 5 per cent. since 1894. He then proposed a resolution approving the report and accounts and the payment of the dividend therein recommended.

Mr. HILLHOUSE (a shareholder) seconded the resolution, which was carried unanimously.

On the motion of Sir HUGH MONTGOMERY, seconded by Mr. WALLER, the retiring Directors, Mr. Stefano Gatti and Mr. Richard Chadwick, were re-elected, and Messrs. O. R. Johnson and Son were re-appointed auditors, on the motion of Mr. LING, seconded by Mr. HILLHOUSE.

Votes of thanks were afterwards passed to the Chairman and Directors and the engineers and managers.

The CHAIRMAN: I beg to thank you for your vote of thanks to myself. The duties of the Chairman are probably the lightest of any officer in connection with the Company. We have two most excellent Managing Directors, whose interests are so bound up with the success of this Company that you may be perfectly sure nothing will be wanting on their part to achieve greater success than has been accomplished in the past. We have the greatest belief in the continued success of the Company, and nothing will be wanting on the part of my brother Directors and myself, or, I am sure, on the part of the officers of the Company, to achieve still greater success.

The CHIEF ENGINEER (Mr. W. H. Patchell) also replied, remarking that the success of the Company was attributable to the thorough unanimity with which the Directors, Managing Directors, General Manager, engineers and the staff worked with each other.

The proceedings then terminated.

Central London Railway Company.

The half-yearly ordinary general meeting of this Company was held on Wednesday, at the Cannon-street Hotel, Mr. Henry Tennant presiding.

The SECRETARY (Mr. R. O. Graham) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN, having affixed the seal of the Company to the register of shareholders, said: Ladies and gentlemen, this is the first half-yearly meeting of the Central London Railway Company, and I may say that I and my colleagues are glad to meet you on this account, although, from the nature of the case, there is very little to speak upon, and very little to report. The undertaking in which you are interested, as shareholders, is not one of an ordinary character. I have no doubt you remember that its length is 6½ miles, and that it commences at Liverpool-street Station and ends at Shepherd's Bush, running by the Bank and under Oxford-street to its destination. It is, as you will probably recollect, to be constructed by means of two separate tunnels from end to end. Of course these tunnels, when completed, will be adequately lighted. There are to be 14 stations on the 6½ miles of railway, and these will be placed in such positions as will be most likely to gather up the largest amount of traffic; and you will also remember this other interesting fact—that it is to be worked by means of electricity. A contract was entered into with the Electric Traction Company—a contract which embraces the acquisition of land and property, the payment of compensation, the construction of stations and other works, the provision of rolling stock, and all the machinery for generating the motive power. In short, the Traction Company by the contract are to deliver over the railway and all its adjuncts in a complete state. The report and accounts presented show that the sum of £506,420 has been received on account of the shares issued, and there has been expended a sum of £168,265. The principal item of the expenditure, £115,026, is entered under the head of payment on account to the contractors, and that represents the sum for parliamentary deposit. This shows as a payment under the constructed contract, because the contractors are responsible to the Company for it, they having taken upon themselves the obligation of seeing that that money is returned when the line is completed. The other item, £44,000, is for the parliamentary and preliminary charges. It is provided by the Act of 1894 that interest at the rate of 3 per cent. may be paid on the called-up capital, and that, during the last half-year, has been done and appears in the accounts. Now, if you turn to statement No. 1, you will there find that the total capital powers of the Company amount to £3,800,000; but, as regards the amount to be raised by loan, that is subject to a small reduction, which may extend, perhaps, to about £50,000, under the provisions of the Act of 1894, which relate to the payment of interest. The share capital authorised by Parliament amounts, as you will see, to £2,850,000; and in reference to statement No. 2 it will be observed that the unissued shares have been subscribed for under an agreement by the Electric Traction Company, and that Company has become liable for the sums subscribed. The unissued shares to which I have referred amount to £682,470, and the share capital to £2,850,000. Now, further expenditure on capital account is roughly estimated at £3,380,000, which, added to the expenditure already incurred, brings up the amount to £3,550,000. The authorised capital powers amount to £3,800,000, so that we have a margin of £200,000.

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left for contingencies, which, however, I may say, from anything which I have hitherto seen, are not likely to arise. We can none of us tell beforehand what may happen. We can only speak of circumstances as they exist and as they present themselves to one's mind in looking over the whole of the facts of the case. I may now, perhaps, make a general observation upon the course which it has been found necessary to take after it was decided to proceed with the construction of the Central London Railway. The prospectus was issued at the end of June last. Now you all know that the Central London undertaking is not, as I have said, of an ordinary character. In its execution you cannot break ground just where you like. You cannot go and say "this is a convenient place in this street or that street for making a hole with a view of beginning with the Central Railway." We are necessarily limited to certain points where work may be commenced, as the interests of so many people and authorities are touched by a work of this magnitude. Much negotiation is necessary, and a great deal of work of a parliamentary character has to be undertaken. I notice in the several Acts of Parliament that the Central London Company have that there are more than 50 individuals or public authorities of one kind or another whose interests are specifically protected in some way or another. Therefore, one of the first steps necessary was to enter into communication with the public authorities whose sanction to the plans was required before the works were proceeded with. Proceedings of this kind you all know take time, and when we bear in mind that those public authorities have duties and responsibilities cast upon them which they are expected to exercise and fulfil in the interests of the public generally, it is not a matter of surprise that those public bodies should themselves require a considerable amount of time in order to enable them to mature their views. Now, although a considerable period has been thus occupied, we do not think that the Railway Company, on the whole, has just ground of complaint. The London County Council, the Commissioners of Sewers, and other bodies have, we believe, looked upon the Central London Railway with a favourable eye as an undertaking calculated greatly to promote the public interest and advantage, and have, on the whole, been disposed to act accordingly. We have certain points at which stations are to be erected, and it is from these points that the work of tunnelling must be commenced and carried on, and here arises the important question of the acquisition of property all along the line. Without delay notice was given to those parties whose property was affected, but as business men we all know that we cannot if we would turn out occupiers without due notice, nor can we take possession without a good deal of negotiation as to the precise allowance for compensation, and in many cases arbitration has to be resorted to. A good many purchases have been made, and the subject is receiving every possible attention. The facts I have mentioned will show that where so much preliminary work has to be done the actual work of construction is necessarily delayed. But I am glad to say that as regards the Mansion House station and subways—a work of great magnitude and of a very intricate character—the plans have been approved by the City authorities, and the contractors will before long make a commencement at that point. I may also say that tenders have been invited by the Electric Traction Company for the construction of the tunnels for nearly the whole line. The Waterloo and City Electric Railway, whose terminus is at the end of Queen Victoria-street, have also entered into an arrangement for the use by them of the subways at the Mansion House, which the Central London Company have to construct, and we are satisfied that the arrangement is a good one, the Waterloo Company paying a part of the cost, and we think it will result in benefit to both companies. After a few more observations he concluded by moving the adoption of the report and accounts.

Lord COLVILLE, K.T., seconded the motion.

The CHAIRMAN, in reply to Mr. Griffiths, observed that no Director of the Central London Railway Company was on the Board of the Electric Traction Company, or had any financial interest in the latter. He believed that a great deal of the money they had in hand would before long be paid away to the contractors. If they were to get the whole of their line speedily executed he believed they must begin with it at a number of different points in its course. The parliamentary expenses were heavy, but unavoidable, inasmuch as they had had to get three distinct Acts of Parliament.

The motion was carried unanimously.

The retiring Directors (Sir Francis Knollys and the Hon. Algernon H. Mills) were re-elected.

One of the auditors (Mr. Pannell) was also re-appointed.

The meeting was thereafter made extraordinary, and a resolution, moved by the CHAIRMAN and seconded by the Hon. ALGERNON H. MILLS, authorising the raising of £150,000 additional Ordinary capital by the issue of 15,000 new shares of £10 each, in pursuance of 55 and 56 Vict., cap. 241, was unanimously agreed to, and the proceedings ended with a vote of thanks to the Chairman.

Tramways Union Company (Limited).

At the meeting of this Company on Tuesday, Mr. E. M. Underdown, Q.C. (the Chairman of the Company), said the Directors still adhered to their views as to the importance of substituting electric traction for horse traction in connection with two of their undertakings. Not only did they believe that the maintenance of their present profits depended upon this course being adopted, but that those profits would be very largely increased by the introduction of electric traction. In all countries where you have to carry the inhabitants of large towns you must after a time reduce the fares in order to meet the requirements of, he would not say the lower classes, but of those people who do not feel inclined to pay high charges for being carried about, and therefore it is, under such circumstances, important to carry these people as often as possible so as to keep up your takings per mile. That cannot be done to the full extent by means of horse traction. By means of electric traction, however, they could carry more people in the cars and travel at an increased speed, and what was, perhaps, the most important consideration of all, at different periods of the day, when the traffic pressed most, they could convey large numbers of people to and from particular points in a manner which was impossible with horse traction without keeping a very large and disproportionate stock. Their negotiations for the introduction of this power had been carried on quite satisfactorily in the two cities with which they proposed to deal—Bremen and Madrid. At Bremen the matter had been for some time before the Council of the city, and they were asking for a considerable extension of the period of their concession. The introduction of electric traction would involve an expediture in respect of fixed appliances, and it was necessary that they should have a sufficient time to amortise or get back the outlay they would have to make on these appliances. That part of the bargain had been approved by the Council. The present position of things therefore improved the capital value of this part of their undertaking. With regard to Madrid matters were very much in the same position, although they had not reached a stage quite so advanced. It seemed to be the desire of the public in Spain, as elsewhere, that electric traction should be introduced. He then moved that a dividend at the rate of 5 per cent. for the year be paid.—Mr. George Richardson seconded, and said he believed that by the introduction of electric traction better results than ever would be obtained from their undertakings.

North Staffordshire Tramways Company (Limited).

The ordinary general meeting of this Company was held on Tuesday at the Guildhall Tavern, Gresham-street, E.C. After the report and accounts had been adopted, the Chairman (Mr. W. J. Carruthers-Wain) moved:—"That the Directors be requested to proceed with the pending negotiations with the various local authorities for the adoption of electricity as a motive power instead of steam, and that the agreement with the British Electric Traction (Pioneer) Company (dated January 8, 1896) be approved, and that the Directors be, and hereby are, requested to carry the same into effect." He said that when the Board of Trade inspector, early last year, inspected their lines with a view to the renewal of the permission to use steam power, he found that a considerable amount of renewals was necessary, and he also discovered a strong feeling in favour of the adoption of an improved system of traction. The local authorities through whose districts their lines passed were also in favour of considerable extensions of their present system. If these lines were to be worked by steam there was no possible method of raising the necessary capital, and consequently the question of the adoption of a system of electric traction had to be considered, and the Directors had now prepared a very comprehensive scheme. By order of the Board of Trade they were compelled to relay a good portion of their existing line within two years, and they would have to find the necessary money for that purpose. A well-known company had, however, entered into an agreement with them to find the necessary capital for relaying the remainder of their line, to equip the line electrically from end to end, and to provide the necessary generating plant and do everything else necessary for working the line electrically. The Company's present lease was not a long one, but if they agreed to equip it electrically they would get an extension of about 15 years. If the shareholders considered, however, what they had been able to do with the limited means at their command, he was sure they would unhesitatingly agree to the adoption of the Directors' suggestions for working the line by electricity, and he was confident that that consent would improve the position of the Ordinary shareholders. In answer to a question, the Chairman said the proposed extensions would be made by an entirely independent company, but they would act as considerable feeders to their lines. After the electrical contract came into operation these extensions would be worked by the Company at a rate which would give them a profit. The resolution was then passed unanimously.

Telegraph Construction and Maintenance Company (Limited).

The annual report of the Directors of this Company will be submitted to the members at the thirty-second ordinary meeting, to be held at the offices, 38, Old Broad-street, E.C., on Tuesday next, March 3rd, at one o'clock:—

The report states that the accounts for the past year show a net profit of £32,589. 14s. 1d., after charging interest on debentures; £53,509. 18s. 5d. is brought forward from last year, making a total of £86.099. 12s. 6d. From this is deducted the interim dividend of 5 per cent., paid in July last, amounting to £22,410, leaving £63,689. 12s. 6d. to be dealt with. Of this sum the Directors propose to distribute a dividend of £1. 4s. per share, absorbing £44,820, being at the rate of 10 per cent., and making, with the amount already paid, a total dividend for the year of £1. 16s. per per share, or 15 per cent., free of income tax, leaving £18,869. 12s. 6d. to be carried forward to the next account.

Various lengths of telegraph cables have been manufactured for different cable companies, and for foreign and colonial Governments, including 705 knots for the Government of Japan. Repairs of the Greetseil-Valentia and Hoyer-Arendal cables have been successfully carried out for the German Government. The factories at East Greenwich and Wharf-road and the Company's steamships are in good and efficient condition.

Mr. James Pender, M.P., and Sir Robert G. W. Herbert offer themselves for re-election as Directors, and the auditors, Mr. John Gane (of the firm of Messrs. Gane, Jackson and Jefferys), and Mr. Patrick A. Glegg (of the firm of Messrs. Welton, Jones and Co.), also seek re-election.

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Chelsea Electricity Supply Company (Limited).

The following is the Directors' report, to be presented to the annual ordinary general meeting to be held at the central station, 19, Cadogan-gardens, on Wednesday next, at 12 o'clock :—

During the year an issue has been made of £60,000 Four and a-Half per Cent. Debenture Stock, which was fully subscribed, and the balance of the Ordinary shares authorised has also been allotted and fully paid up. The original Six per Cent. Debentures (£36,900) have been redeemed. A Stock Exchange quotation has been granted for both the Debenture stock and Ordinary shares. The balance of the premiums on these issues (including payment of premium due on the redemption of Six per Cent. Debentures) amounts to £5,798. 8s. This balance has been dealt with as follows :—Renewals and depreciation fund, £1,500; special law and incidental expenses written off, £3,251. 1s. 5d.; reserve fund, £1,047 6s. 7d. The item, £3,251. 1s. 5d., is special capital expenditure, and has been necessitated by legal proceedings in connection with the Cadogan-gardens station. The net revenue for the year (apart from the premiums), after payment of debenture interest (£3,143. 16s. 3d.), is £6,414. 16s. 5d. Of this, £900 has been paid as interim dividend at the rate of 6 per cent. per annum on the Preference shares for the half-year to June 30th last, and the Directors recommend that the balance of £5,514. 16s. 5d. shall be applied as follows :—6 per cent. per annum on the Preference shares for the past half-year (£900); 5 per cent. per annum on the Ordinary shares for the year (£3,500); carried forward, £1,114. 16s. 5d.

The price charged for current was reduced on July 1st from 8d. to 6d. per unit. The number of lamps supplied on December 31st last was 57,354, an addition of 10,068 during 1895, an increase of upwards of 50 per cent. on the number added in 1894.

A considerable part of the capital expenditure has been incurred in extending the mains and enlarging the Cheyne Walk station, in order to meet the increasing demand for current. An advantageous purchase has also been made of the freehold of a large plot of land around and including Cheyne Walk station, in view of the necessity for providing increased accommodation for the Company's works.

Mr. Nugent Daniell and Mr. E. Garcke offer themselves for re-election as Directors, as also do the auditors, Messrs. Cooper Bros. and Co.

Isle of Man Tramways and Electric Power Company (Limited).

The report of the Directors of this Company states that the sum available for dividend, after providing for debenture interest, amounts to £13,240. 1s. 6d. Interim dividends on the Preference and Ordinary shares for the first six months of the year, at the rate of 6 per cent. and 7½ per cent. per annum respectively, amounting to £4,312. 10s., have already been paid, and the Directors now recommend that dividends for the remainder of the year at the same rate (amouting to £4,687. 10s.) be declared, that £2,000 be added to the reserve and renewal fund, and £2,240. 1s. 6d. be carried forward. The traffic upon the electrical section of the line has been very satisfactory, and the Directors contemplate ordering more motor cars to cope with the enormous and increasing traffic. The Directors state that they have arranged for the purchase of the site of the junction of the electric and horse car lines for the erection of a suitable power station. They have secured a further 21 years' lease from 1897 of the Douglas Bay line from the Town Commissioners, also power to double the entire line, and to construct and work a cable tram line to Upper Douglas, which has been commenced. Preliminary arrangements have been made for the purchase of the Snaefell Mountain Railway for £72,500, which the Directors think will prove highly advantageous to the Company. The capital required for the construction of the upper town tramway and for the purchase of Snaefell Mountain Railway will be obtained by the issue of debenture stock.

Liverpool Electric Supply Company (Limited).

The Directors' report for the year ended December 31st last refers to the sale of the Company's business to the Corporation, and to the interruption of the progress of the Bill in Parliament caused by the late Dissolution. The Bill had passed some of the stages in the House of Commons, but was suspended until the present Session. The Directors anticipate that it will receive the Royal assent before Easter, after which the sale will be completed. One of the conditions of the arrangement with the Corporation was that the Company should be entitled to declare and pay dividends at the rate of 6 per cent. per annum from January 1, 1895, till the completion of the purchase. An interim dividend at this rate was paid for the half-year ended June 30th last, and it is now proposed to pay a dividend at the same rate for the second half-year of 1895.

Scarborough Electric Supply Company (Limited).

The report of the Directors states that during the past year the Company continued to make satisfactory progress. The equivalent of 2,285 8-c.p. lamps was added to the Company's mains during the year. The number of customers is now 235, and an equivalent of 12,788 8 c.p. lamps are connected. Since the last report 571 yards of additional mains have been laid, bringing the total up to 13,263. The capacity of the mains and the number and capacity of the transformers have also been increased. To meet the increased demand, an additional boiler and two additional sets of engines, dynamo and condenser (one of 150 H.P. and one of 100 H.P.) have been put in, and are now working very satisfactorily. During the past year 141,101 units of electrical energy had been supplied to customers, and the gross revenue, including meter rent, amounted to £3,613. 19s. 3d. After deducting the expenses, there remains a balance of £937. 9s. 8½d., which was more than twice the profit made in 1894. Adding the balance of £418. 12s. 3d. brought forward from the previous year, there was a sum of £1,356 available for distribution, and the Directors recommend that this should be applied in paying a dividend of 2½ per cent. (which will absorb £772. 13s.), and in writing off the sum of £304. 16s. 0½d. from the preliminary expenses, leaving a balance of £278. 12s. 11d. to be carried forward. The retiring Directors are Messrs. J. E. Ellis, M.P., and Gilbert Wilkinson, and being eligible they offer themselves for re-election, as does the auditor, Mr. C. E. Bradley.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 31 7/16d. per oz. (Feb. 27th). Consols (2¾ per cent.) 109 3/16—109 7/16 for money, 109 3/8—109 5/8 for account; 2½ per cent. 105½—105¾ (Feb. 27th). Stock Exchange Settling Days: Consols, March 2nd; Stocks and Shares Continuation Day, March 10th; Ticket Day, March 11th; Pay Day, March 12th; Mining Share Carry-over Day, March 9th.

BRITISH SOUTH AFRICA COMPANY (LIMITED).—The report of the Directors of this Company to March 31, 1895, contains interesting information regarding the progress made in the Company's land line telegraphs, which is stated to have worked successfully during the year, no complete interruption of communication of any moment having occurred. The work done included the completion of a new wood pole line between Buluwayo and Charter. This route follows the main line of development. A branch line from Gwelo to the Selukwe Mining District has been authorised, and is near completion. An iron pole line between Mangwe and Macloutsie (96 miles) has been completed, and Macloutsie has become the transmitting station for the Company's system, in place of Palapye. The Company has also, under contract with the Beira Railway Company, the telegraph line from Chimoio to Salisbury. This line was made available to the public on September 16th, and in conjunction with the Railway Company's wire to Beira, affords communication between Salisbury and its seaport. The total length of telegraphic line now in operation under the control of the British South Africa Company, south of the Zambesi, is 1,354 miles. The traffic receipts during the year were £9,701, expenditure £6,432. For the six months ended September 30th the receipts approximated £7,632, expenditure £3,390. It has been decided by the Directors to materially improve the pay and status of the officers. With regard to the construction of the Salisbury-Tete section of the Transcontinental Telegraph Company's line, previous anticipations have not been realised, although temporary through connection was made with Tete on October 22nd last, and communication has been fairly well maintained since that date. One hundred and sixty-two miles of permanent and 75 miles temporary lines have been erected. An office at Mazoe, on this section, was opened on September 24th. Since communication was established with Tete it has been maintained by joining the completed portion of the line from Salisbury to the Portuguese wire, which runs in a southerly direction from Tete, by means of a temporary line 62 miles in length. Originally it was arranged that there should be no public telegraph office of the Company within Portuguese territory, but the local Portuguese authorities requested that temporary arrangements should be made for the acceptance of telegrams at their local office at Tete. This placed Tete in telegraphic communication with Delegoa Bay, Mozambique, and the outer world generally. The report states that the importance to the Portuguese Government of the establishment of a permanent office at Tete, from an administrative point of view, and also on commercial grounds, is so great, that it may eventually be found to the advantage of all concerned that a modification of the original stipulation should be made. The Portuguese Government has erected a telegraph line from Chinde to Tete, and that by using the Trans-continental line, which runs through the latter place, the important shipping community of Chinde (the seaport of Northern Rhodesia and the Nyassaland Protectorate) is brought into touch with other parts of Central and Southern Africa, as well as with the rest of the world. Communication has been recently established between Salisbury and Blantyre. For the extension north of Blantyre, 200 miles of material was shipped from the Clyde in June last. A working agreement has been entered into between the African Trans-continental Telegraph Company and the British South Africa Company with regard to telegraph rates, which is described as mutually satisfactory, and follows the general lines of the South African Telegraph Union. The year's telegraph receipts to March 31, 1895, were £3,268. 16s. 7d., against £370. 7s. 6d. to March, 1894.

DOUGLAS SOUTHERN ELECTRIC TRAMWAYS (LIMITED).—The statutory meeting of this Company was held at Manchester last week. The Chairman (Sir J. S. Goldie-Taubman) said the permanent way would be completed by the middle of March, and work in connection with the power station had been commenced. The cars were also in hand, as was also the electrical equipment, and the Directors were well satisfied with the progress that had been already made.

HOVE ELECTRIC LIGHTING COMPANY (LIMITED).—The Directors' report states that the profit for the year amounted to £2,562, compared with £1,243 for the preceding twelve months. The Company has at present an equivalent of 18,403 8 c.p. lamps. The revenue from the sale of current increased from £3,617 in 1894 to £5,343. After adding £15 brought forward, and deducting £1,038 for interest on loans and debentures, a balance of £1,539 remains to the credit of the net revenue account. The Directors propose to write off £134 from the preliminary expenses account, to place £200 to reserve, and to declare a dividend at the rate of 4 per cent. per annum on the share capital, carrying forward £132. The number of shares issued to date is 6,260, and the Directors now offer the balance of 1,740 shares to the present shareholders for subscription, at £5. 5s. per £5 share. The Directors notify that they intend to pay off the £12,500 Five per Cent. Debentures on July 1 next, and offer debentures bearing 4 per cent. interest in exchange, which holders of £7,250 of the old debentures have agreed to accept.

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NEW COMPANIES, STATUTORY RETURNS, &c.

LARNE ELECTRIC LIGHT WORKS (LIMITED).—This Company was registered on February 24th, with a nominal capital of £4,000 in £1 shares (including 500 Five per Cent. Cumulative Preference), to acquire the business of electric lighting contractors lately carried on by J. E. H. Gordon and Co. (Limited) at Larne, Ireland, together with the goodwill, leasehold premises, plant, machinery, capital, contracts, patent rights, property and effects of the said business, including the sum of £100 held by the Larne Town Commissioners as a deposit in accordance with the agreement of July 6, 1894, made between the Commissioners and J. E. H. Gordon and Co., Limited (by D. A. Norris, C.A., Suffolk House, London, E.C., their receiver and manager), and also the three-quarter interest in British Patents Nos. 8,638 and 17,855 (1892) and United States Patent No. 487,356 (1892), and to carry on the business of electrical engineers and suppliers of electricity. The first subscribers, with one share each, are: J. D. A. Norris, chartered accountant, A. H. Tucker, R. H. M. Hill, A. F. Leatherbarrow, W. J. Rivington, R. H. Milward and C. Piper. The first Directors are J. Rivington and J. D. A. Norris.

NORTHWICH ELECTRIC SUPPLY COMPANY (LIMITED.)—This Company was registered on February 24th with a nominal capital of £10,000, in £5 shares, to carry on the business of supplying electricity for lighting, heating and motive power purposes to public and private consumers in the Urban District of Northwich (Chester), the townships of Leftwich, Davenham and Hartford, and such other places as the Company may from time to time determine. The first subscribers, with one share each, are: T. Ward, J.P., R. J. Browne, T. Corry, J. Burgess, N. P. F. Sandford and W. M. Beckett and Edward T. Ward, civil engineers.

L. ALWYN (LIMITED).—The annual return to February 14th has been filed. Out of a nominal capital of £2,000, in £1 shares, 1,521 shares have been taken up, and 507 have been issued as fully paid. The full amount has been paid on 1,014 shares.

HOLOPHANE (LIMITED).—This Company was registered on February 19th with a nominal capital of £100,000, in £1 shares, to carry into effect an agreement for the acquisition of certain patent rights for the construction of Holophane glass globes, and the benefit in any other country (except the United States or France) of all improvements in the said patented inventions, and to carry on the business of manufacturers of and dealers in Holophane glass globes, &c.

INCANDESCENT ELECTRIC LAMP COMPANY (LIMITED).—The annual return to December 27th has recently been filed. The nominal capital is £25,000, in 2,000 Ordinary and 500 Deferred shares of £10 each. 1,200 of the former and 100 of the latter class have been taken up; all the Deferred have been issued as fully paid, and a call of £9 10s. per share has been made on the Ordinary shares.

INRIG AND CHESTER (LIMITED).—This Company was registered on February 21st, with a capital of £2,000, in £1 shares, to acquire and take over as a going concern the business of an electrical and general engineer now carried on at 44 and 46, White Post-lane, Victoria Park, London, and elsewhere, under the style of "The Globe Electrical Company," to carry into effect an agreement made with Alec. G. Inrig, and to carry on the business of electrical engineers, manufacturers of and dealers in electrical plant and fittings, mechanical and general engineers, machinists, &c. The subscribers are: Alec. G. Inrig, electrical engineer (500 shares), and R. Jenkins, J. F. Shallis, Alexander Shanks, engineer, G. C. Murray, electrician, E. W. Athill and A. Chester, electrical engineer (one share each). The first Directors are Alec. G. Inrig and A. Chester.

ISLE OF WIGHT ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return to November 14th has been filed. The capital is £1,000, in £1 shares. Seven shares have been subscribed for, but no calls have been made.

ITALIAN ELECTRICAL LIGHT AND POWER COMPANY (LIMITED).—The annual return to November 27th has been filed. Out of a capital of £60,000, in £4 shares, 307 shares have been taken up, 300 have been issued as fully paid, but no calls have as yet been made on the remainder.

JULIUS SAX AND CO. (LIMITED).—The annual return to December 28th has been filed. The whole capital of £20,000, in £10 shares, has been taken up, and 1,993 have been issued as fully paid. No calls have been made on the remaining seven shares.

LAMINA ACCUMULATOR (ELIESON'S BRITISH PATENTS) SYNDICATE (LIMITED).—The annual return to January 3rd has been filed. Out of a capital of £12,000, in £1 shares, 10,007 have been taken up, and 6,250 have been issued as fully paid. A call of 15s. per share has been made on 3,757 shares.

LAURENCE, SCOTT AND CO. (LIMITED)—The annual return to January 14th has been filed. The capital is £30,000, in £10 shares. 1,407 of these have been taken up, and 500 have been issued as fully paid. £10 per share has been called on the remaining 907 shares.

CITY NOTES.

BRISTOL TRAMWAYS AND CARRIAGE COMPANY (LIMITED).—The half-yearly meeting of the shareholders of this Company was held at the Grand Hotel, Bristol, on Tuesday, Mr. W. Butler presiding. He said they had reason to consider the present aspect of the Company's affairs as most encouraging. With reference to further extensions of their electric traction system, although the Electric Lighting Committee of the Town Council suggested that they should take current from the Corporation mains for all future extensions, the Sanitary Committee had made no stipulation to that effect. If the Corporation seriously meant to impose such a condition on the Company the Directors would make no further attempt to extend their electric traction system. The production of the motive power was one of the most vital parts of the Company's working, for which the Directors were responsible to the public, and they would not undertake that responsibility unless they had full control of the management of their own undertaking.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended February 23rd were £968, against £949 in the corresponding week of 1895, an increase of £19. The total receipts for the half year amount to £7,914, against £7,988 in the corresponding period of 1895, a decrease of £74.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—Warrants for the dividends on the Preference and Ordinary shares of this Company have been posted.

GENERAL HYDRAULIC POWER COMPANY (LIMITED).—At the general meeting of this Company on Tuesday last the Chairman (Mr. H. Chapman) stated that the use of hydraulic power for producing current for electric lighting had advanced a stage during the year. Their supply was now actually being used in the City and West End for this purpose, and there might be further use for the power in this direction. Electricity was often referred to as being a serious competitor with hydraulic power, but for the special purposes for which their supply was mainly used the competition was not so severe.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—The Directors of this Company propose, subject to audit, to pay a dividend of 5 per cent. upon the Ordinary shares of the Company for the year ended December 31, 1895, making, with the 3 per cent. interim dividend already paid, 8 per cent. for the year.

HOUSE-TO-HOUSE ELECTRIC SUPPLY COMPANY (LIMITED).—In our last issue, on p. 567, at the conclusion of the Chairman's opening remarks a sum of £1,800 is given as that spent by the Company during the past financial year in the purchase of additional plant, &c. The amount should have been given as £18,000, not £1,800.

IMPROVED ELECTRIC GLOW LAMP SYNDICATE (LIMITED).—A private meeting of the members of this Syndicate was held at the Cannon-street Hotel on Wednesday.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended February 23rd amounted to £1,059. The amount for the corresponding week last year was £847. Increase £212.

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The half-yearly coupons, which fall due on March 2nd, of the £100,000 Six per Cent. Debentures of this Company will be paid by Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, London, E.C., on and after that date. Coupons must be left three clear days for examination.

MAGDEBURG TRAMWAYS COMPANY (LIMITED).—An extraordinary general meeting of this Company was held last week at Birmingham, to sanction the sale of the Company's undertaking to the Union Elektricitäts-Gesellschaft of Berlin, on the terms of two agreements, dated May 27th and December 13th last. According to the terms of these agreements the amount of the purchase-money was £86,000, but the sale was to be subject to the consent of the Town Council of Magdeburg to the transfer of the concessions and other conditions. After deducting the debenture debt (£25,000) and other sums, there would be £52,700 left for distribution. The Chairman (Major Fosbery), in proposing the resolution approving of the sale, gave a history of the undertaking from its formation in 1886, and ascribed their position to over-capitalisation and mismanagement in the early stages of the undertaking. The result of the sale would be that the shareholders would receive about £5. 10s. for each £10 share, and that was the best bargain the Directors could make. The resolution was seconded by Mr. A. Lloyd, and was duly carried.

NATIONAL ELECTRIC SUPPLY COMPANY (LIMITED).—The annual meeting of the shareholders of this Company was held at the offices, 119A, Fishergate, Preston, last week, Mr. E. H. Booth presiding. The Chairman, in moving the adoption of the report and accounts, congratulated the shareholders on the past year's working. Although the Directors were not in a position to declare a dividend, yet they had made considerable progress. In 1893 their income was £3,345, and their expenditure £4,354; in 1894 the figures were £4,778 and £3,783; and for 1895 their income was £5,739 and expenditure £3,339, a reduction in expenses of £1,016 compared with 1893, and a profit of £2,401. The Chairman then referred to the fact that the Town Council had decided to light most of the public thoroughfares and streets of the town electrically. The Church of the English Martyrs had been fitted up for the electric light, and altogether there were indications of a progressive value in the property of the Company. He anticipated that they would be able to declare a substantial dividend next year. The report was unanimously adopted.

PORTSMOUTH STREET TRAMWAYS COMPANY (LIMITED).—A special meeting of this Company will be held at 7, Poultry, E.C., on Friday, March 13th, for the purpose of considering the Company's proposed Bill in Parliament seeking powers to introduce electric traction on their lines, and to enter into an agreement with the Portsmouth Corporation for the supply of the necessary electric current.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have appointed Wednesday, March 11, a special settling day for 250,000 fully-paid Preference shares of the Sulphide Corporation (Ashcroft's process), Limited, and 40,007 fully-paid shares and 29,993 shares (10s. paid) of the Westralian Electric Lighting and Supply Company (Limited). Application has been made to the Committee to allow the Ordinary shares of Sir W. G. Armstrong, Mitchell and Co., Limited (Nos. 1 to 3,000,000), to be quoted in lieu of the Ordinary Stock of the old company now quoted.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended February 21st, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,384.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Feb. 19.	Price Wednesday, Feb. 26.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business done during Week ending Feb. 28. Highest	Lowest
			TELEGRAPHS.						
£1,012,880	Stock	18/0	Anglo-American ..... xd	46 48	46 48	5 4 2	Jan., Apr., July, Oct.	47½	46
£2,993,560	Stock	36/0	Do. Preferred ..... xd	87 88	87 88	5 12 8	" "	88	87
£2,993,560	Stock	5/0	Do. Deferred	7½ 8	7½ 7⅝	..	.. ..	7⅞	..
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)....	100 104	100 104	3 17 6	January and July ..	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	10½ 10⅝	10½ 10⅝	..	..	10⅝	..
130,000	£10	3/0	Brazilian Submarine	14 14½	14 14½	4 15 3	Mar., June, Oct., Dec.	14½	14
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110 114	110 114	4 8 6	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	160 170	160 170	4 3 0	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine ..... xd	12½ 13½	13½ 13⅝	5 14 4	February and August	13⅝	..
6,000	10	10%	Do. Preference 10 per Cent. ..... xd	20½ 21½	20½ 21½	4 13 0	" "	21	20½
12,981	5	2/0	Direct Spanish (fully paid)	4 5	4 5	4 0 0	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	104% 107%	104% 107%	4 4 3	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	9 9½	9 9½	4 4 3	Jan., Apr., July, Oct.	..	..
400,000	10	2/6	Eastern	17 17½	17 17½	3 14 4	" "	17½	17⅛
70,000	10	6%	Do. 6 per Cent. Preference	18 18½	18 18½	3 4 10	" "	18⅝	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	128 131	128 131	3 1 8	May and November	130½	129
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899.....	105 108	105 108	4 13 0	February & August	..	..
250,000	10	2/6	Eastern Extension	17½ 18	17⅜ 18⅛	3 16 9	Jan., Apr., July, Oct.	18	17⅜
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	127 130	128 131	3 1 2	February & August	128	..
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.)Debs. 1900	100 104	100 104	4 17 1	January and July ..	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb.,1900.	100 104	100 104	4 17 1	" "	..	..
£800,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) ..	105 108	105 108	3 14 8	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 115%	3 10 4	May and November	..	..
130,227	10	1/6	Globe Telegraph and Trust	10 10⅛	10 10⅛	3 18 6	Jan., Apr., July, Oct.	10⅜	10⅛
130,042	10	6%	Do 6 per Cent. Preference	16½ 17	16⅝ 17⅛	3 9 7	" "	17	16⅝
150,000	10	5/0	Great Northern	22½ 22⅝	22½ 22⅝	3 14 9	Jan., April, and July	23⅛	22⅝
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue.....	104 107	104 107	4 15 8	March & September	..	..
17,000	25	12/6	Indo-European	46 49	46 49	5 2 0	May and November	48⅜	46
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	107 111	107 111	5 11 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel.4% Guar. Debs. "Red"1942..	108 111	108 111	3 12 7	.. ..	..	..
11,339	8	4/0	Reuter's	5 6	5 6	..	April and October..	..	..
3,281	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	128 133	133 137	4 7 7	" "	..	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	..	January and July ..	6⅝	..
£288,300	100	5%	* Do. 5 per Cent. Debentures (red.)	101 104	102 105	4 17 7	March & September	102½	..
30,000	10	2/0	West Coast of America	1 2	1 2	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	94 99	94 99	8 4 1	June and December	..	..
88,321	10	1/8	West India and Panama	1 1½	1 1½	..	..	1 1/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 11	10½ 11	5 8 1	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108 111	108 111	4 10 11	June and December	..	..
64,248	15	3/0	Western and Brazilian	8⅞ 9½	8⅞ 9½	5 5 8	May and November	9⅝	..
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	..	..	6⅞	6½
33,129	7½	1/6	Do. Deferred Ordinary	3 3½	2⅞ 3⅛	..	..	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	102 106	102 106	5 13 9	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	102 106	102 106	5 13 9	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds....	113 118	113 118	6 0 11	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	104 107	104 107	5 15 5	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3½ 3⅝	3½ 3⅝	..	..	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance ..	1/16 1/8	1/16 1/8	..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid).....	1/16 1/8	1/16 1/8	..	Yearly	..	..
434,597	5	2/6	National	6⅜ 6½	6½ 7	3 11 5	June and December	6⅝	6½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)....	16 17	16 17	3 10 7	" "	17	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅜ 6⅝	6½ 6⅝	3 12 9	.. ..	..	..
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	104 107	104 107	3 5 9	January and July ..	106½	..
58,000	5	3/0	United River Plate	3 3½	3½ 3⅝	..	" "	..	..
£146,783	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	93 98	93 98	5 3 1	" "	93½	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	5/0	City of London Electric Lighting (fully paid)	14 15	14½ 15½	1 12 3	..	15	14½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	16 17	16 17	3 10 7	..	16⅛	16
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	134 138	134 138	3 18 0	June and December	..	..
19,900	£5	..	Electricity Supply Co. for Spain.....	.. ..	.. ..	..	..	..	..
£30,000	£5	2/0	Charing Cross and Strand Electricity Supply Corp.	5⅜ 6⅛	6⅛ 7⅛	..	..	6⅜	6⅛
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	..	..	..
22,475	£8	..	County of London & Brush Prov. Ord. (fully paid).	8 9	8 9	..	..	..	..
10,000	£10	9½d.	Do. Pref. (£8 paid)	10⅛ 11	10 11	..	..	10⅛	..
8,322	£5	..	House-to-House Electric	.. ..	.. ..	..	..	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	.. ..	.. ..	..	..	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July ..	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅜ 8⅛	7⅜ 8⅛	3 18 10	..	..	..
111,000	5	..	London Electric Supply.....	.. ..	.. ..	..	..	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	12 12½	12 12½	2 13 1	..	12⅛	12⅛
£140,000	Stock	4½%	* Do. 4½% Debs.	115 118	115 118	3 16 9	June and December	..	..
6,452	£10	2/0	Notting Hill Electric	8½ 9	8½ 9	..	..	9	8⅞
..	..	..	Rand Electric	⅛ ⅛ prem	⅛ ⅛ prem.	..	..	..	..
19,980	£5	5/3	St. James and Pall Mall	9½ 10	9⅝ 10⅛	..	..	10	9⅝
20,000	£5	7%	Do. 7 per Cent. Preference.....	9 9½	9 9½	3 18 8	..	9⅝	9½
59,900	5	2/6	Westminster Electric Supply (fully paid)	9½ 9⅝	9½ 10	3 10 0	..	9⅝	9⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1 1⅛	1 1⅛	12 1 0	..	..	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1½ 1⅝	1½ 1⅝	6 17 2	..	..	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures.....	112 115	112 115	3 19 10	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref..	2½ 2⅝	2½ 2⅝	..	January and July ..	..	..
89,261	5	1/6	Edison and Swan United..... xd	1½ 2	1½ 2	..	..	1⅝	1 1/16
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 106	103 106	4 5 6	..	102⅝	..
£30,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	.. ..	.. ..	..	..	1 1/16	1
110,000	2	..	Electric Construction	⅜ ⅝	1⅛ 1⅜	..	..	..	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2 2⅛	2⅛ 2⅜	5 1 10	..	..	..
91,195	2	..	Elmore's Patent Copper Depositing	⅜ ⅝	⅜ ⅝	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	⅜ ⅝	⅜ ⅝	..	..	..	..
50,000	10	5/0	India Rubber, Gutta Percha, &c., Works	20⅛ 21⅛	20⅛ 21⅛	3 9 9	February & August	21	20⅛
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 7 5	March & September	..	..
15,995	£10	..	International Okonite Ordinary.....	.. ..	.. ..	..	..	..	..
16,000	£10	..	Do. 8 per Cent. Preference.....	.. ..	.. ..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid).....	⅛ ¼	⅛ ¼	..	..	..	..
37,850	12	12/0	Telegraph Construction and Maintenance	38 41	38 39	6 3 1	March and July.....	41	38½
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	102 105	4 15 8	January and July .	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)..	.. ..	.. ..	..	..	..	..
41,098	£5	..	Do. Preference (fully paid).....	.. ..	.. ..	..	..	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary.....	13½ 14½	15 16	3 15 0	..	15½	..
£30,000	10	7/0	Do. 7 per Cent. Preference	16 17	16½ 17½	3 19 9	..	..	..
£50,000	Stock	4½%	Do. 4½% Mort ge Debenture Stock.....	109 112	109 112	4 2 0	..	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway Con. Ordy.	40 42	40 42	2 19 6	May and November	41	40
7,650	10	5%	Do. 5% Perpetual Preference	14½ 15	14½ 15	3 6 8	..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130 132	130 132	3 0 7	May and November	133½	..
37,500	£10	3½%	Liverpool Overhead Railway	13⅛ 13⅝	13⅝ 13⅞	2 1 8	..	..	..
10,000	10	5%	Do. 5% Preference	15⅝ 16	15½ 16	3 2 6	..	..	..
115,000	Stock	4%	Do. 4% Debenture	112 114	113 114	3 10 2	January and July ..	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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THE ELECTRICIAN

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NOTES.

AFTER a discussion lasting nearly six hours, the House of Commons on Monday evening last agreed, without a division, to the second reading of Mr. RITCHIE's Light Railways Bill. This Bill, as is generally known, differs from the one introduced last year by Mr. BRYCE, in that it contemplates State loans in aid; and it was this new departure which was subjected on Monday evening to a vigorous but unavailing onslaught. We agree with the President of the Board of Trade in thinking that light railways "may do *something* to improve the agricultural industry," but we also agree with the member for the Spen Valley division of Yorkshire that the real root of the depression of our farming industry lies beyond the reach of this particular parliamentary palliative. However, since a few millions are apparently about to be spent upon some sort of mechanical traction in rural districts, the many merits of electric traction should ensure a copious flow of orders in the direction of the electrical industry, and enable the makers of motors, railway generators, and car-gearing to regard the economic heterodoxy of the proceeding with the equanimity begotten of a well-filled order-book.

To all water-power and day-load enthusiasts we would commend a careful perusal of Mr. RUTHVEN-MURRAY's report to the Electricity Committee of the Worcester Corporation, which will be found in another column. At the time when it was decided that Worcester must have a municipal electric supply, there was, of course, the usual clamour for the utilisation of the flow of a local rivulet. The idea received the genial benediction of the advisory engineer, although it involved placing the generators some three miles away from their work. With "power for nothing" and municipal management, only a day-load was wanting to ensure complete success. A day-load lay ready to hand in the shape of the pumping work at the municipal waterworks, and this was accordingly gladly undertaken by the Electricity Committee. It is, perhaps, unnecessary to remark that we have no prejudice against water-power or day-loads. What we do contend, and we think the experience at Worcester is a case in point, is that water-power schemes in this country are not, as a rule, likely to prove economical, and that day-load does not of necessity spell profit.

TAKING the past year's figures, Mr. MURRAY finds that the total cost of the Board of Trade unit, exclusive of the charges for interest and sinking fund, comes out at 2·97d., fuel being responsible for no less a sum than 1·06d. The fact is, says Mr. MURRAY, "the available water-power did not come anywhere near its calculated value, with the result that from the end of May until the end of November it was necessary to run a portion of the day on steam only. About midsummer there was so little water in the Teme that as much as 75 per cent. of a total week's running hours were done on steam power"; and as the engines are all of 286 I.H.P. a low engine load-factor was inevitable. Then Staffordshire coal was objected to by the surrounding inhabitants, and Welsh smokeless had to be partially substituted. So much for the outgoings. Excluding meter rents and such-like adventitious aids which bring the figure up to 3·16d. the average price realised at Worcester per unit sold was only 2·73d., an undesirable consummation which was mainly due to the contract to sell energy to the Water and Sewerage Committee at 1d. a unit; all for the sake of a day-load. As the Water and Sewerage Committee took no less than 42 per cent. of the entire output of the station, the average price of 3·99d. per unit which was realised for the balance of the output did not avail to prevent a nett deficit of some £1,400 on the year's operations.

OF course, Worcester will do better than this as time goes on. Moreover, there was undoubtedly a most unfortunate concatenation of unfavourable circumstances. Just when the water failed, costly Welsh coal had to be burnt, and so on. But the question remains, was it worth while to go so far to fare so ill? Was it business to contract to supply nearly one half of the entire output at a price which could not possibly pay unless water-power were available? And water-power in this country, where we have no series of inland seas to perform the useful function of a natural reservoir, is notoriously not to be relied upon.

PROF. SILVANUS P. THOMPSON advanced an ingenious hypothesis at the Physical Society last week in regard to the cause of the lag of apparent resistance and of current in an alternating arc behind the phase of impressed potential difference. The existence of this lag, he said, pointed to a phenomenon "in the nature of a back electromotive force;" and it will be remembered that some time ago Prof. AYRTON showed that this apparent back electromotive force resembled that of the self-induction of a coil when an alternating potential difference is impressed on its terminals. The cause of this much-debated

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phenomenon Prof. THOMPSON now sought in a probable lag of temperature of the carbon behind the current. It does indeed seem reasonable that a "thermal flywheel" action of the carbon should throw the phase of temperature behind the phase of current. Nor is it altogether improbable that the element of non-ohmic or elastic resistance in the total apparent resistance is due to a directly thermo-electric phenomenon. It occurs to us, however, that there should be no lag between the phase of temperature and the phase of intrinsic brilliancy, and that Prof. THOMPSON's hypothesis might be put to an exact test by seeing whether a back electromotive force in step with the intrinsic brilliancy would be sufficient to account for the observed facts. On the other hand, it is just possible that something may happen in the alternating arc—where things occur which nowhere else occur—to throw the back electromotive force out of phase with the intrinsic brilliancy as photometered. It might, for example, be in phase with the intrinsic brilliancy of the 2nd, 3rd or *n*th stratum of carbon molecules beneath the surface of the crater—an awkward place to probe with a photometer.

ANOTHER matter relating to the alternate-current arc, and one possibly of more practical importance, was discussed at the same meeting. Conflicting statements have from time to time been put forward by various authorities, in regard to the relative efficiencies of alternating and continuous arcs. On the one side, Prof. THOMPSON has asserted that there is no inherent superiority in the continuous current over the alternate current, so far as light production is concerned. On the other side, Prof. FLEMING and Mr. PETAVEL have found that under what the former calls "semi-practical" conditions the continuous-current arc gave twice the light that was obtained with equal watts from an alternate arc. Arc lamp makers will be pleased to hear that there is now professional unanimity in respect of the uncertainty of these "semi-practical" conditions; and that at the Physical Society there was general agreement that it is impossible to settle *à priori* that there is any intrinsic difference between the two kinds of current, as regards their arc-light-generating capacity.

INDEED, attention seemed to be called away from the differences of currents and directed to the difference between makes of carbons. Both Prof. AYRTON and Prof. THOMPSON strongly insisted on the probability that the best quality of carbons for any given lamp will depend not only on the class of current used, but also upon the volts, watts, and even the frequency. The use merely of cored positives for continuous and solid positives for alternate arcs, or the use of carbons of different diameters in the one case, and of equal diameters in the other, does not constitute sufficient selection. Apparently we ought to adapt the quality and size of the carbons to each particular system of supply. Evidently, too, from Mrs. AYRTON's latest discovery, we must expect to find the quality of carbons changing with time; and the value of a make of of carbon, as of a vintage, may improve with age. These considerations, while they may serve to put arc lamp makers on the track of improved methods, will not bring unalloyed happiness. The necessity for so many different qualities of carbons, and the care needed in making a proper selection, will neither conduce to cheapness in arc lighting nor to simplification in the manufacture and supply of lamps. Probably, however, the makers will be content with only "semi-theoretical" conditions.

IT is not always easy to decide what quantities to keep constant, when working with several variables; and Prof. FLEMING's researches on alternate-current arcs are a case in point. But his comparison between a continuous and an alternating arc, in which the power supplied is kept constant and the other variables "are left to look after themselves," as Prof. FLEMING puts it, does not strike one as being strictly logical. In fact, we can find no better illustration of this comparison than the one suggested by Prof. AYRTON. Imagine a comparison between continuous and alternate currents for incandescent lighting, in which two sets of lamps were taken, quite irrespective of their voltages, and supplied with equal amounts of power at the same voltage. The continuous-current glow lamps might be made to appear any number of times better, or worse, than the alternate-current lamps, merely because essentially important variables were left to take care of themselves. Before we can compare the two kinds of arc, we must discover what are the best conditions for each. We are glad to learn that this is what Prof. FLEMING and Mr. PETAVEL intend to do.

THE patient efforts of Mr. D. MCFARLAN MOORE to obtain a useful degree of illumination by means of his so-called "etheric" light, are meeting with a gradually improving success. He has now been able to photograph himself by its rays with an exposure of only three minutes; and the reproduction from the untouched negative which the *Electrical Engineer* of New York publishes as a supplement is a very respectable picture. The photographs were taken in a room 10ft. by 11ft., with four vacuum tubes placed along the cornices, each tube being 9½ft. long and 1½in. in diameter. The glow in these tubes was produced by an interrupted current, the circuit being broken 100 times per second by one of Mr. MOORE's high-vacuum contact-breakers. The interruption occurring in a vacuum so high that glow discharge cannot take place in it gives rise to an enormous electromotive force of self-induction; and, at the same time, the removal of the atmosphere from around the contact-breaker increases the effectiveness and frequency of its movements. It is to be regretted, however, that our contemporary publishes no data which would enable an electrical engineer to form an idea of the power expended.

Cable Interruption:—

	Date of Interruption.
Puerto Plata—Martinique	December 19, 1895.

Electrical Communication with Lighthouses.—The Royal Commission will probably issue a fourth report in the course of the next few months. The final report will not be ready until the end of the year.

French Telegraphic Enterprise.—A project in connection with the establishment of submarine cable communication between France, North America, and the Antilles has been passed by the French Chamber.

The Islington Central Station.—The Lord Mayor and the Sheriffs of London drove in state to Islington on Wed-

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nesday afternoon last, and formally inaugurated the electric lighting station which has been constructed by the Islington Vestry in Eden-grove, Holloway. There was a very large attendance.

Personal.—Mr. H. J. S. Heather, A.M.Inst.C.E., who was sent out by Messrs. Easton, Anderson and Goolden to erect the electric power transmission plant for Moodie's Gold Mining and Exploration Company, has now been appointed engineer to the latter company. Considerable extensions of the present plant, the capacity of which is 250 H.P., are in contemplation.

"Booster" Patent Litigation in America.—The Siemens and Halske Electric Company of America has just brought an action against the Toledo Traction Company for an infringement of the so-called booster patent, No. 417,668, issued December 17, 1889. This patent is looked upon by its owners as a fundamental one, and great interest in the litigation just begun is felt in America.

Expiring Patent.—On Tuesday next, the 10th inst., will expire patent No. 1,163, of 1882, granted to Edward Weston, of Newark, U.S.A., for "IMPROVEMENTS IN ELECTRIC LIGHTING APPARATUS." The invention relates to the Weston arc lamp, and the specification describes the mechanism of the lamp. There are claims for (1) the combination of magnets and clutch gear, (2) change-over mechanism, and (3) an arrangement of carbon carriers.

Sleet on the Chicago Elevated Railway.—Great annoyance was caused to passengers on the Metropolitan Elevated Railroad in Chicago on the night of January 22nd. The current is delivered to the cars through a third rail. A sleety rain caused a coating of wet ice to form and short-circuit the whole system until the ice could be cleared from the line, which took several hours. As drops of rain fell upon the ice, sparks were given out, and at times the whole line glowed as if it were ablaze.

The Hopkinson Three-Wire Patent.—On Saturday last, before the Judicial Committee of the Privy Council, motion was made by Mr. Graham for permission to admit the caveat of the Richmond Electric Lighting Company against the petition for the prolongation of this patent. Counsel admitted that the time for lodging caveats—the 24th ult.—had passed, but he hoped their Lordships would relax the rule in this case. The motion was, however, dismissed.

The British Association.—The presidents of the various sections of the British Association (Liverpool meeting) have now been chosen. The Presidents of the three sections which concern our readers are as follows:—Prof. J. J. Thomson (Section A), Dr. Ludwig Mond (Section B), and Sir Charles Douglas Fox (Section G). Prof. Flinders Petrie, and probably Sir Andrew Noble, will deliver the evening discourses, and Dr. J. A. Fleming will give the lecture to working men.

Post Office Telegraphs.—A Parliamentary return has been issued showing the gross amount received and the gross amount expended in respect of the telegraph service from the date of the transfer of the telegraphs to the State to March 31, 1895. The total receipts between 1870 and 1895 were £43,137,892 7s. 6d., and the total expenditure (including £2,636,982. 2s. 3½d., balance to meet interest on stock created on account of the telegraph service and the redemption of debt) was £43,967,675 15s. 8¾d., leaving the balance of receipts over expenditure at £829,783. 8s. 2¾d.

A Wire-Wound Flyweeel.—At the works of the Mannesmann Tube Company, in Germany, there has recently been erected a large wire-wound flywheel. The carcase of the wheel is of cast steel, with plate steel flanges forming a peripheral groove. Into this groove the toughened steel wire is wound, so as to form the body of the rim. Some 50 tons of No. 5 steel wire is used for this purpose. The wheel, which is 20 feet in diameter is driven at 240 revolutions per minute, thus the peripheral speed is normally about 260 feet per second. This wheel, therefore, has about three times the speed and more than nine times the regulating power of a cast-iron wheel of equal mass.

A Westinghouse-Baldwin Locomotive.—The first locomotive made by the Westinghouse-Baldwin combination has just been completed, and contains some departures from former practice. The locomotive is 38ft. long and 9ft. across, with an eight-wheel truck. There are four motors each of 200 H.P., one connected to each axle of the trucks. The motors are geared, it being believed that this will give a higher efficiency, while the cost of manufacture is less. The gear has been designed for a maximum speed of 75 miles an hour, although this could be pushed to 125 miles an hour if demanded. The weight of the locomotive completely equipped is 80 tons, and the cost is stated to be less than one-third the cost of the locomotive used in the Baltimore tunnel, which was $50,000.

An Imperial Elektrotechniker.—The German Emperor, of course, takes the liveliest interest in all technical matters, and to bring himself up to date in electrical subjects, he "commanded" a lecture by Prof. Slaby at the Technical High School at Charlottenburg on February 10th. In the course of two hours—such was the aptitude of the Imperial student—Prof. Slaby was able to run through several subjects, viz., electric transmission of power, the latest developments in electrochemistry, electrometallurgy, water-power plants, the different methods of electric lighting, and the electrical production of calcium carbide. After the lecture the Emperor held the usual *critique*, and ultimately granted Prof. Slaby the Order of the Crown "of the Second Class."

Research Fellowship.—The Executive Committee of the City and Guilds of London Institute have awarded the second Salters' Company's Research Fellowship for the encouragement of higher research in chemistry in its relation to manufactures to Sidney Williamson, Ph.D., F.I.C., F.C.S., who was for two years a student at the City and Guilds Technical College, Finsbury, and subsequently for three years at the City and Guilds Central Technical College. The Fellowship is tenable at the latter, and Dr. Williamson proposes to work on some questions bearing on food stuffs generally, more particularly the examination of some definite albumenoids, with the ultimate object of ascertaining the influence of various manures on the growth of crops in so far as *quality* of produce is concerned.

Telegraphic Communication with India.—In the House of Commons last week Sir J. Leng asked the Secretary to the Treasury, as representing the Postmaster-General, whether, in view of the restrictive effect of the present high tariff for telegraphic messages between the United Kingdom and India, he would favourably consider the proposal of the Bengal Chamber of Commerce that the charge should be reduced from 5f. to 3f. per word, and endeavour to give effect to the recommendation at the forthcoming International Telegraph Conference. Mr. Hanbury stated that the Postmaster-General could not find that such a proposal had reached him from the Bengal Chamber of Commerce, and he thought it was more likely to have been addressed to the Government of India, which was directly concerned in the matter. He had, however, received representations on behalf of the merchants and others in this country who used the telegraph to India, and he was in communication with the cable companies on the subject.

Electrolysis at St. Louis.—The annual report of Mr. A. J. O'Reilly, Superviser of City Lighting at St. Louis, tells, says the *Street Railway Review*, of the steps taken during 1894 and 1895 to learn the extent of, and to prevent electrolysis. In April, 1894, a circular letter was sent out to all persons engaged in placing pipes of any kind underground, requesting their co-operation by informing the Superviser of City Lighting as to any evidences of electrolysis discovered by them. Fourteen people responded to this request, and 20 cases of electrolysis were reported. These reports do not seem to indicate a very alarming condition of things. In addition to the reports, and in order to find out more accurately to what extent electrolysis was taking place, copper plates were put in the ground at the bottom of stop-valve boxes and ground fire plugs. At each place there were two plates 1½in. by 6in. and weighing 15 grammes. One of these was connected with the water pipe and the other was not. They were carefully cleaned and weighed before putting in the ground. After being buried for 100 to 150 days they were taken out, cleaned and weighed again.

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The difference in weights gave the effect of electrolysis. The report states that in some cases the tramway rails were examined and found to be reduced fully one-third around the base. It is recommended that promiscuous connecting of rails and water pipes be not allowed, but that if this is done it be only in a systematic manner.

The New Heilmann Electric Locomotives.—At a recent meeting of the Société des Ingénieurs Civils de France, M. H. de Grièges gave some further particulars with regard to the new Heilmann locomotives which may interest our readers. The engines adopted to drive the generators will be six-crank engines designed by M. Mazen, track inspector of the Compagnie des Chemins de Fer de L'Ouest. These engines will run at 400 revolutions, and will only weigh eight tons. They will have a piston stroke of 15·6in. The first Heilmann locomotive, "The Rocket," could only develop 600 H.P., whilst the two new "locos" on order will develop 1,400. This increase is arrived at by increasing the grate area from 26 sq. ft. to 36 sq. ft. The resistance to rolling of the new Heilmann locomotive is expected to only be about 13lb. per ton, as against 20 to 24 in the case of the compound steam engines now used for the same sort of traffic. The railway company, not wishing to bind itself to any particular system, is about to instal an overhead trolley line between Saint-German-Ouest and Saint-German-Grande-Ceinture. It is hoped, therefore, that this summer two system of electric traction will be tried on this section, viz., the two new Heilmann locomotives and trains run on the overhead trolley system.

The Relationship of Mathematics to Mechanics.—The following comments are made by *Engineering* on the coalescence of mathematics and mechanics in a professorial chair at South Kensington. Mechanics in such circumstances, we may add, are usually only *mixed* mathematics :—

"We regret to note that the Science and Art Department are calling for candidates for the chair of Mathematics and Mechanics at the Royal School of Mines, South Kensington. We believe we are right in stating that no one person is competent to teach both these subjects efficiently. The successful candidate is likely to be either a mathematician with little or no knowledge of engineering, or an engineer with a knowledge of mathematics limited solely to the practical applications of the science. Of the two, the former is probably the more pernicious, and unfortunately it is almost certain that one of this class will be appointed. If this should be the case, it is to be hoped that, at any rate, the gentleman in question will not be responsible for the papers set in Steam and Applied Mechanics in the May examinations of the Department. The least the authorities can do, since they are determined to maintain the objectionable connection between the two subjects, is, at any rate, to confine the mischief done to the college itself, and not let the unfortunate students at our evening classes suffer. These latter, as matters stand, exercise no little self-denial in endeavouring to extend their theoretical knowledge by working in the evenings, after a hard day in the workshops, and it is not too much to ask that the time thus gained from their scanty leisure should not be wasted by the misdirection of their studies. Unfortunately there is in some quarters a disposition to look on such classes less with a regard to the benefit of the students, than with a view to increasing the emoluments of teachers and examiners. This state of mind is by no means confined to Government officials, for our universities have done much bad work in the same direction by appointing as extension lecturers young men often ignorant of their subjects, simply because they have taken a good degree, and there did not happen at the moment to be a fellowship open at their college."

The Action of High-Frequency Currents on Bacterial Toxines.—At a recent meeting of the Académie des Sciences MM. d'Arsonval and Charrin read an interesting Paper on this subject. The authors state that, having investigated the effects of the various forms of electrical energy on the bacteria themselves, they thought it would be interesting to ascertain the effects upon bacterial secretions. They allude to the experiments of Smirnoff and Kruger with continuous currents, and state that, owing to the difficulty of differentiating the electrochemical from the purely electrical phenomena, experiments carried out by means of the electrolysis of solutions containing bacterial toxines do not yield reliable results. To eliminate electrolytic effects, and because they found from preliminary trials that 7 coulombs of induced uni-directional electricity had more effect than 78 coulombs due to an ordinary continuous current, MM. d'Arsonval and Charrin employed currents of extremely high frequency (225,000 oscillations per second, according to Thomson's formula) derived from condenser discharges. The average strength of the initial discharge current was 50 amperes; the mean value of the current traversing the toxine solution was 0·75 ampere, and the mean current density was 0·250 ampere per square centimetre. The experiments made show conclusively not only that the toxines are greatly weakened by exposure to the action of high-frequency currents, but that the toxines so weakened may be used to render persons immune. Diphtheritic and pyocyanic toxines were investigated. A quarter of an hour exposure to electrical influence sufficed to diminish the strength of the toxines by about 50 per cent.

The Frédureau Diffusing Globe.—The following is an abstract of a report on the diffusing globes of M. Frédureau and their application to electric illumination, prepared by Prof. Silvanus Thompson. The globes are of transparent glass, so shaped as to properly distribute and diffuse. Assuming the globe to present, at its interior surface, a smooth figure of revolution, spherical, spheroidal or cylindro-spherical, the light which passes through the transparent envelope in nearly radial directions may be directed downwards by shaping the outer surface in prismoidal zones, each of which has its lower surface horizontal and its upper surface a portion of a paraboloid of revolution confocal with the luminous centre. A second solution consists also in shaping the outer surface with prismoidal zones to reflect the light; but these, instead of being bounded by portions of confocal parabolas above, and horizontal surfaces below, are calculated according to a different plan. The lower faces of the annuli are all made to be portions of cones described around the vertical axis, and radiating from the common centre; whilst the upper faces, the breadth of which is determined by the limiting angle of total reflection, are also conical instead of parabolic. Both constructions concentrate the beam downward generally, but also disperse it around the lamp in all directions; and both soften the light for the observer's eye. Both constructions also produce another effect on the light, namely, they slightly change the tone of the light by modifying the proportion of rays of higher refrangibility, which ordinarily give the arc light its bluish hue. The globes tested are manufactured of glass or crystal, moulded with a sharpness of surface which leaves nothing to be desired, and which are quite inexpensive when their cost is compared with the cost of producing similar globes by cutting. This result is due to the care at first bestowed on the production of the moulds that are to be used. By photometric measurements the globes have in every case been found to be effective in concentrating the light in the desired direction. With a 16 c.p. (nominal) incandescent lamp and a diffusing globe provided with an upper hemispherical reflector, Prof. Thompson made a series of measurements to test the actual increase in the light in the downward direction, with the results given below. The direction downward was taken as zero :—

Angle at which light was measured.	Amount of light with naked lamp.	Amount of light with reflector only.	Amount of light with reflector and diffusing globe.
0°	8	17·5	34
10°	8·5	17·5	24
20°	9·25	18·75	22
25°	10·25	15·2	16·25
30°	11·5	15	12

From this it will be seen that the lamp was giving only eight candles in the downward direction until provided with the diffusing globe and reflector, but when so provided it gave a light downwards of 34 candles. This increase was, of course, obtained by utilising rays that would otherwise have been wasted by being emitted upwards, or in directions where they would produce little result. A prolonged and careful examination of the effects obtained in interior illumination by the aid of the diffusing globes convinces Prof. Thompson that the redistribution of light effected by these globes is of very real advantage. For all effective purposes a 16 c.p. lamp, provided with a diffusing globe, illuminates an apartment better than a 32 c.p. lamp not so provided, thereby effecting a distinct economy. For, if we assume the 16 c.p. lamp to take 60 watts at 6d. per unit, the 16 c.p. lamp would cost under 0·36d. per hour (or about ⅓d.), and the 32 c.p. lamp would cost 0·72d. per hour (or over ⅔d.). The saving in cost of light at the end of a 1,000 hours of lighting would therefore be nearly 30s., besides providing a light more agreeable to the eyesight. Messrs. A. and E. Cohen, of 2, Bury-street, St. Mary Axe, are the sole agents for Great Britain and the Colonies.

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BRISTOL MUNICIPAL ELECTRIC SUPPLY STATION.

Early Developments.

The instructiveness of an electric supply undertaking, as, indeed, of all commercial ventures, increases according to the length of time during which experience has been gained by means of it. When a new station is opened, more or less with a flourish of trumpets, the associations of the event savour more of excitement and sentiment than of real instruction. But when any concern has been running for some time, we can note not only of what particular plant it is composed, but also the degree of suitability and success in its selection. Accordingly, we turn to the Bristol municipal electric supply station, which has been running since the autumn of 1893, expecting to learn more from it than we should were it only just now commencing its career of full-fledged existence.

Before, however, describing either the details of the station and its outlying network of mains and sub-stations, or the history of the concern since the day of commencing work, we will briefly notice the earlier stages of development which preceded the inauguration. Bristol was one of the earliest of British towns to have the matter of its electric supply undertaken by the municipal authorities. For, in 1883, the Bristol Sanitary Authority acquired a Provisional Order giving them the necessary powers. During many years, however, this Order lay dormant, the authorities having been advised by their consulting electrical engineer, Mr. W. H. Preece, that electrical matters were not ripe enough to justify active steps. Thus passed the time until May, 1889, when Mr. Preece advised his clients that the time for action had arrived; and in the following June the consulting engineer presented a report recommending that the authorities should on their own account erect and run a supply concern. This they decided to do, and in December, 1890, Mr. Preece was instructed to prepare a report for a station to run 10,000 glow lamps and 60 arc lamps. A site for the station was selected adjoining the Floating Harbour, and most conveniently situated for obtaining water and coal. Mr. Preece's actual report, which was presented in March, 1891, contemplated the following items:—

Number of glow lamps	10,000
Number of street arc lamps	100
Total outlay on concern	£66,000

Subdivision of estimate:—

Buildings	£5,000
Plant	24,000
Mains	20,000
Distribution	6,000
Working capital	5,000
10 per cent. for contingencies	6,000
	£66,000

Estimated working expenses:—

Arc lamps	£2,520	per annum
Glow lamps	7,100	„
	£9,600	„

Estimated revenue:—

Arc lamps	£2,500	per annum
Glow lamps	10,500	„
	£13,000	„

The system recommended in this report was the high-pressure alternate-current system, with transformers in sub-stations, and 500-watt arc lamps, in a number of series circuits supplied with continuous current. Six sub-stations were contemplated at the start.

In April of 1891 Mr. Preece was joined by Mr. Gisbert Kapp in the capacity of consulting engineers to the authorities. The following July witnessed the first of a series of untoward events, which tended to delay the progress of the scheme. The authorities issued specifications for building contracts, but these were boycotted by the entire building trade. The reason seems to have been that these specifications were not drawn up according to the orthodox and eternal traditions of the building trade. The hitch, however, was overcome after a time, and the building trade tendered to plans prepared by Mr. H. Williams, architect to the electrical committee. It was found, at about this time, that the nature of the ground at the site would render it necessary to erect a strong river wall or buttress, and to pile drive the entire site. These things were decided upon in December, 1891, and were carried out at a cost of about £12,000, the pile driving alone costing £9,659. About this time it was decided that, owing to the large percentage of corrosive and other chemical matter in the harbour water, and the amount of mineral matter held in suspension, Lancashire boilers should be used. The same considerations rendered it necessary to decide upon surface condensers, in order that very little feed-make-up might be required (*see* section on Machinery Room Equipment). During 1892 the following tenders were accepted:—

1892.	Plant.	Firm.	Sum.
May	Boilers.	Messrs. Tinkers.	£7,400
May	Dynamos.	Messrs. Siemens.	14,011
October	Buildings.	Mr. C. A. Hayes.	13,346
December	Condensers, pumps, steam pipes, &c.*	Messrs. W. H. Allen and Co.	...

During the following year, 1893, the subjoined further tenders were accepted:—

1893.	Plant.	Firm.	Sum.
February	Distributing cables.	Messrs. Siemens Bros.	£16,580
May	Sub-station transformers.	Brush Electrical Engineering Co.	1,752
May	Switchboard, battery, &c.	Mr. F. M. Newton.	1,553 10s.

It is interesting to mention that in October, 1892, Mr. H. Faraday Proctor was appointed electrical engineer to the Bristol Sanitary Authority, and took charge on the spot of the various operations of the contractors. Mention might also be of interest of the building strike which, in August, hindered operations at the river wall. The original scheme of 1883 had contemplated supply to only a portion of the city; but in November, 1892, an extension of the scheme took place, involving supply to the entire city. In June of the following year, 1893, the building contractor asked for additional payment, owing to the unforseen costliness of the building operations, but this request the authorities refused. In the following August the electrical authorities came into collision with the Poor-Law Guardians in regard to the assessment of the buildings and plant. It seems that a gross assessment of £3,000, or a net assessment of £2,000, was made by the latter body. It may here be mentioned that the Bristol electric lighting concern, from the outset until the present time, has been saddled with heavy charges on this head; and in 1894 the assessment was at the rate of 1·18d. per unit. (*See* section on Progress since Starting.)

Supply to the consumers was commenced at the end of August, 1893, and to the street arc lamps in November of the same year. By the middle of December all the streets in the area agreed upon were being supplied with current, the station was working with 90 per cent. of its power utilised, and there were 14,000 lamps—4,000 lamps above the estimate—already connected to the mains. Up to this date a sum of £80,000 had been expended upon the concern.

The Station and Out-Works.

Locality of Station.—The accompanying map (Fig. 1) shows that the supply station is situated within the area of supply, and somewhat near its present boundary. All around the station, but more especially to the north-westward, are districts likely to take up the electric light as fast as cables are laid down. In the immediate neighbourhood are business premises and factories; but further to the westward and northward are well-to-do residential suburbs, through some of which cables have already been laid. The advantages of the site in respect of water and coal supply—owing to the adjoining Floating Harbour—have been mentioned; and the only drawbacks which the site has had have been due to the rotten-

* The tender of Messrs. Woodhouse and Rawson for this plant had originally been accepted, and was, in December, 1892, transferred to Messrs. W. H. Allen and Co

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ness of the ground and the highly corrosive nature of the harbour water, this last being due to the chemical works further up the harbour.

Present Equipment of Station.—At the present time the plant actually installed or on order, for the arc lighting and general supply, comprises the items set forth in Table I. Of this plant, one 210-kilowatt alternator set has been erected since the starting, and one of equal size is now about to be erected. An extension of the feeder switchboard has also taken place, owing to the addition of several new feeders.

Table I.—*Present Equipment of Station.*

Plant.	No.	Remarks.
Boilers	4	Lancashire, 28ft. by 8ft.
Boilers	3	Lancashire, 24ft. by 8ft.
Stoker engines	2	Vertical engines driving coal conveyers and stokers.
Feed pumps	2	Kirkaldy type, built by Owen, each 4,000 gallons per hour max. Duplex direct-thrust type.
Donkey pump	1	2,500 gallons per hour.
Feed heaters	2	Feed heated by live steam on occasion.
Water softener	1	Howatson's.
Tank	1	For softened water. Capacity 3,760 gallons.
Tanks	2	For cold water, on roof. Each 14ft. by 14ft. by 6ft. 6in.
Tank	1	For air pump discharge. Capacity 790 gallons.
Hot tank	1	For feed pump suction. Capacity, 1,200 gallons.
Reservoir	1	Excavated beneath boiler house, to serve as a cold well for the circulating pumps &c. Supplied with harbour water through a culvert and sluice valve.
Engines	4	Willans (IIIS. type), compound, three-crank, each of 360 I.H.P. Coupled direct to alternators.
Engines	2	Willans (GGGS type), compound, three-crank, each of 150 I.H.P. Coupled direct to alternators.
Engines	4	Willans (GGS type), compound, two-crank, each of 100 I.H.P. Two coupled direct to exciters, two coupled direct to arc light machines.
Gas engine	1	38 H.P. "Stockport" gas engine and small alternator. Formerly used for the day-load, but now in disuse owing to not being large enough to take day-load.
Condenser	1	W. H. Allen's surface condenser, surmounted by feed-make-up evaporator. Capacity of condenser, 30,000lb. exhaust steam per hour.
Air pumps	2	W. H. Allen's vertical direct-coupled type. Capacity of each pump 250 c.ft. per minute. Pumping engines are compound, with cylinders 10in. and 16in. diameter. Pump barrel, 16in. diameter; stroke, 10in.
Circulating pumps.	2	W. H Allen's "Conqueror" centrifugal type, direct-coupled to vertical compound engines. Capacity of pump, 2,800 gallons per minute, raised from 15ft. fall. Engine cylinders, 6in. and 12in. diameter; stroke, 12in.
Oil filter	1	Filter of coke and shavings in tank between air-pump discharge tank and hot tank, with by-pass.
Alternators	4	Siemens. Each of 210 kilowatts, driven direct by IIIS engine.
Alternators	2	Siemens. Each of 88 kilowatts, driven direct by GGGS engine.
Exciters	2	Siemens. Each of 50 kilowatts, driven direct by GGS engine.
Arc light dynamos	2	Siemens. Each for 80 amperes, at 600 volts. Driven direct by GGS engine.
Battery	1	A small storage battery of 54 cells in a room on the station, is used for exciting the alternators, on occasion, and for some of the station lights.
Switchboards	2	One panel switchboard for five alternators and 17 feeders, and one arc and exciter switchboard.

Boiler House Equipment.—All seven of the boilers are of the Lancashire type, with Galloway tubes in the flues, and are stoked mechanically by means of Vicars' automatic coking stokers. They were made and set by Messrs. Tinkers, Limited. Small Welsh coal, at about 7s. 6d. per ton, is used. The coal is brought alongside the station grounds in barges, from which it is hoisted on to the roof of the boiler house, where it is weighed and then shot into a coal pocket. Through a trap door in the bottom of the pocket the coal descends to the chain-and-bucket conveyor, whence it passes to the channels along which it is distributed to the several boiler hoppers. The conveyor gear, together with the range of four larger boilers, and the arrangement of the pipes, &c., in the boiler house, are well shown in the illustration in the SUPPLEMENT. A set of scale drawings of the boiler house is given in Fig. 2. It may here be mentioned that the performance of the boilers is a very satisfactory one; for example, when burning Welsh small peanuts, one of the 28ft. boilers evaporated 6,200lb. of actual feed-water per hour, and one of the 24ft. boilers evaporated 4,530lb. per hour, both working at 125lb. per square inch—the usual working pressure.

Between the range of four large boilers and the range of three smaller ones there is a glazed house or closed-in shed serving as a pump room. Within this room are the duplex pumps and the donkey pump. Immediately behind this pump room is a large tank, which serves as a hot well for holding the condensed steam from the surface condenser. This tank is situated close to the chimney, which is of brickwork 110ft. high and 17ft. exterior diameter at the base. As shown in Fig. 2, the chimney is of circular section, and is provided with separate inlets for the two batteries of boilers. There is a ventilated air space between the courses of the main chimney and the inner hot shaft at the bottom. An independent duplicate system of feed pipes supplies all the boilers, both sets of pipes being easily controlled by hand gear from the gangway along the boiler fronts. There is, however, but one feed inlet to each boiler, this being protected by a

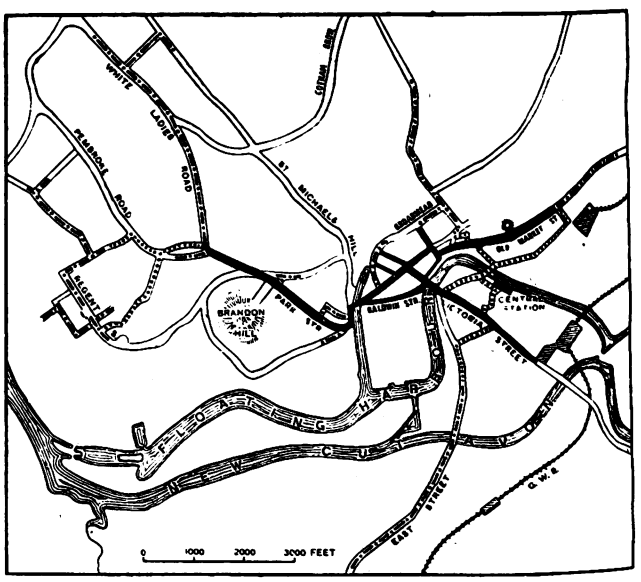

FIG. 1.—Map of Bristol Municipal Electric Supply System.

Distributing Mains and Arc Mains in original contract.

Distributing Mains since added.

Extensions of Feeders where there are no Distributing Mains.

* Electric Tramway Terminus in Old Market Street.

double check valve. Feed water is usually taken from the hot well, the deficit of supply being made up by an evaporator attached to the condenser; but when requiring to fill up a boiler, after emptying, cold water is passed through two live steam heaters. The condensed steam from the surface condenser is cleaned of oil by being passed through a coke and shaving filter, as well as by the use of compounds which saponify the oil in the boiler. Each boiler is provided with only one steam standpipe, which supplies steam through a single 5in. branch pipe to the ring main in the engine-room. The arrangement of these branch steam pipes is shown in Fig. 2. A subsidiary 2½in. steam ring supplies the pump-room and feed heaters. The main steam ring is of 7in. and 6in. pipes. All the flanges and T-pieces of the steam pipes were electrically welded by the Bernardos process, and have been tested to 1,500lb. pressure. We may add that the boilers and steam pipes are fitted throughout with "Hopkinson" valves, made by J. Hopkinson and Co.

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The following additional data in regard to the piping, &c., may be of use and interest :—

Table II.—*Feed and Steam Pipes.*

Main feed pipes	3in. diameter
Branch feed to boilers	2in. diameter
Feed delivery to heaters	3½in. diameter
Air pump discharge tank pipe to oil filter and hot tank	3½in. diameter
Suction from soft-water tank	4½in. diameter (C.I.)
Suction from cold well	3in. diameter
Discharge from tanks to water softener	3in. diameter
Steam branch pipes	5in. diameter
Safety-valve escape pipes	6in. and 8in. diameter (C.I.)
Feed pump steam ring	2½in. diameter
Blow-off pipes	3in. diameter
Main steam ring (in machinery room)	6in. and 7in. diameter

Machinery Room Equipment.—The general arrangement of the plant in the machinery room is shown in plan in Fig. 3, and a view of the room is also given in the SUPPLEMENT. The steam ring, which is not shown in Fig. 3, is rectangular in shape and embraces the entire area of the main machinery floor. It is suspended at a height of 10ft. 6in. from the floor, and is supported by brackets which are secured to the walls to a gallery running entirely round the room. The width of this gallery is principally about 3ft., but in one place it is widened out to an extreme width of 12ft. 6in., where it forms the switchboard platform. As already stated, the steam range is immediately below this gallery, an arrangement which conveniently allows of all the steam stop valves, whether on the ring or one of its branches, being worked from the gallery. At one extreme end of the machinery room, and at a lower floor level, the condensing plant is situated. At the other extreme end are the two 88 kilowatt alternator sets, direct coupled to 100 I.H.P. Willans compound two-crank condensing engines, controlled by variable expansion gear. These machines develop power at 2,100 volts, at a frequency of 93 cycles per second. Next to these, in line down the room, are the four larger alternator sets, one of which is not yet quite erected. Each of these sets will develop 210 kilowatts at 2,100 volts, at the same frequency. Arranged parallel with this line of alternators are four direct-coupled continuous-current generator sets. The two end machines

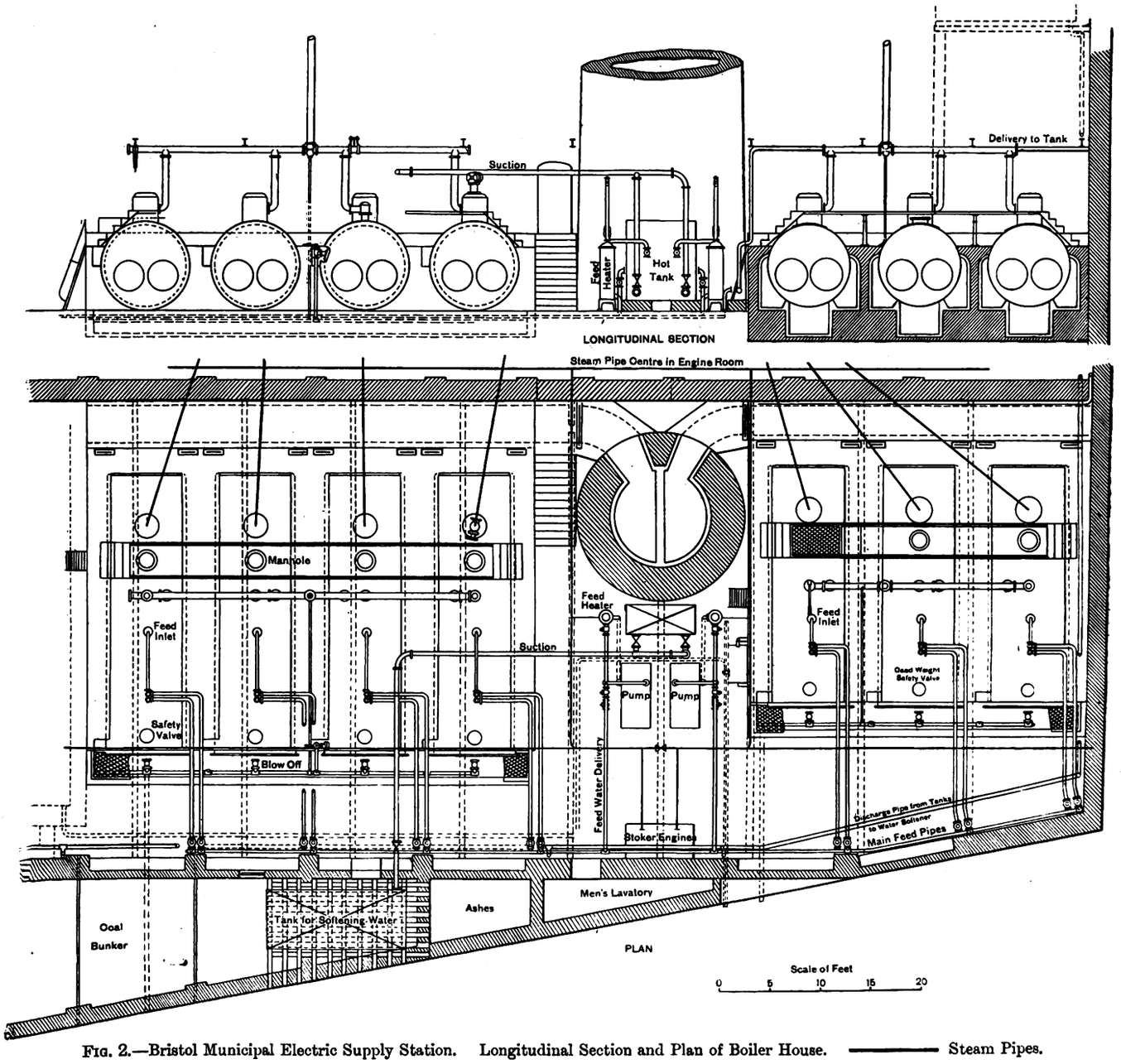

FIG. 2.—Bristol Municipal Electric Supply Station. Longitudinal Section and Plan of Boiler House. ——— Steam Pipes.

are used as exciters, and each will develop 50 kilowatts, either at 100 volts for exciting or at 130 volts for charging the small battery of storage cells. The other two of these are used for running the arc lamp circuits, and each set will develop 80 amperes at 650 volts. These four sets are each driven by a Willans compound two-crank 100 H.P. engine, with throttle gear. Space exists within the present steam

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ring for two more of these continuous-current sets. There is a steam separator on each of the nine engines, but none at the boiler end of the steam ranges.

Exhaust Ring.—The exhaust main forms a ring parallel with the steam ring, but lying beneath the floor-plates. It is of 15in. internal diameter, with copper expansion joints. The pipes are anchored at the four corners of the ring, and are free to expand. The branch exhaust pipes from the engines are of 7in. W.I. pipe, with copper bends, for the 360 H.P. engines, and of 4in. W.I. pipe, with copper bends, for all the other engines. The main exhaust pipe to the condenser is 18in. diameter. There are three ways of dealing with the exhaust steam, and accordingly the ring is provided with

exists for two more condensers and the necessary extra pumps. A separate plan of the condensing plant, but, however, showing *two* condensers, arranged as at Bristol, is shown in Fig. 4. The condenser is of the surface type, and consists of an outer horizontal cylindrical shell, 4ft. 1in. diameter and 8ft. 6in. long between tube-plates, with a large number of longitudinal ⅝in. gun-metal tubes secured between these plates. A diaphragm at the front end of the shell divides the tubes into two sets, and provides that the cold water shall be carried twice along the length of the condenser. The total condensing surface is 2,422 sq. ft. Circulation is produced by two "Conqueror" centrifugal pumps, direct coupled to Messrs. Allen and Co.'s vertical compound

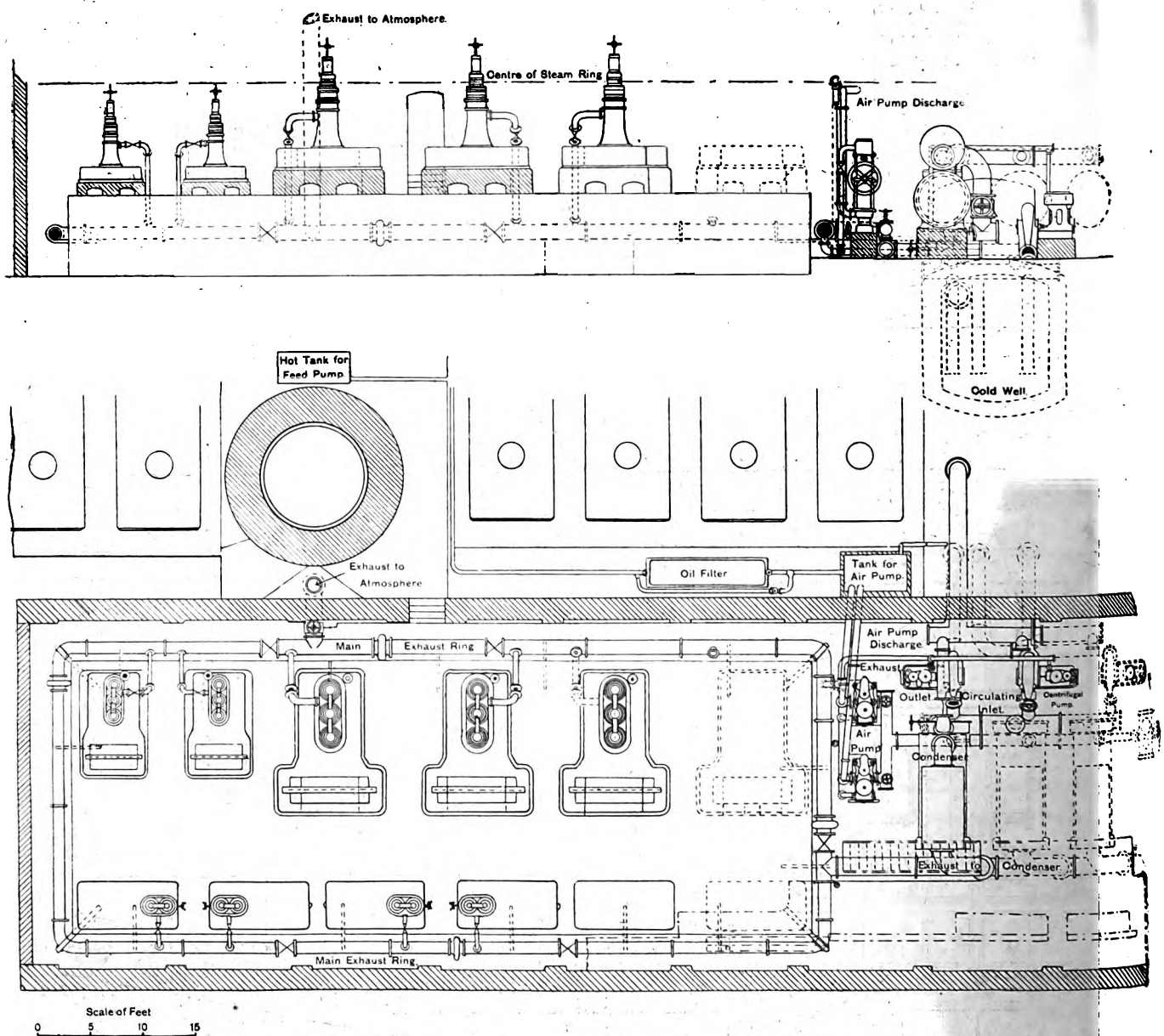

FIG. 3.—Bristol Municipal Electric Supply Station. Longitudinal Section and Plan of Machinery Room and Condenser Annexe.

three discharge branches. One of these leads direct to the condenser, another to an air outlet which is erected beside the chimney, and the third to a water-sealed auxiliary trap, which is of use in changing over from non-condensing to condensing, or in the event of the air pumps failing. The air outlet consists of several 9ft. lengths of 16in. C.I. pipe, carried up the outside of the chimney and stayed at 9ft. intervals; the pipe terminating in a double-funnel cap, from which the exhaust is discharged into the atmosphere.

Condensing Plant.—The floor of the condensing annexe is 6ft. lower than that of the main machinery room, and is eached by a stairway from the latter. There is, at present, t one surface condenser with duplicate pumps; but space

steam engines. The engine cylinders are 6in. and 12in. diameter, and 12in. stroke, and the pumps are capable of raising 2,800 gallons of river water per minute from a depth of 15ft. A safety governor is fitted to each engine, which would come into action in the event of the pump losing water, and each pump is provided with a charging apparatus, by which it may be quickly charged before starting. The air pumps are two in number, and are direct-coupled to two vertical compound engines. Each pump has a capacity of 250 cubic ft. per minute. The engine cylinders are of 10in. and 16in. diameter, and the stroke is 10in. The diameter of each pump barrel is 16in. The piston rods of the engines are direct coupled at the cross-heads to the pump rods by means

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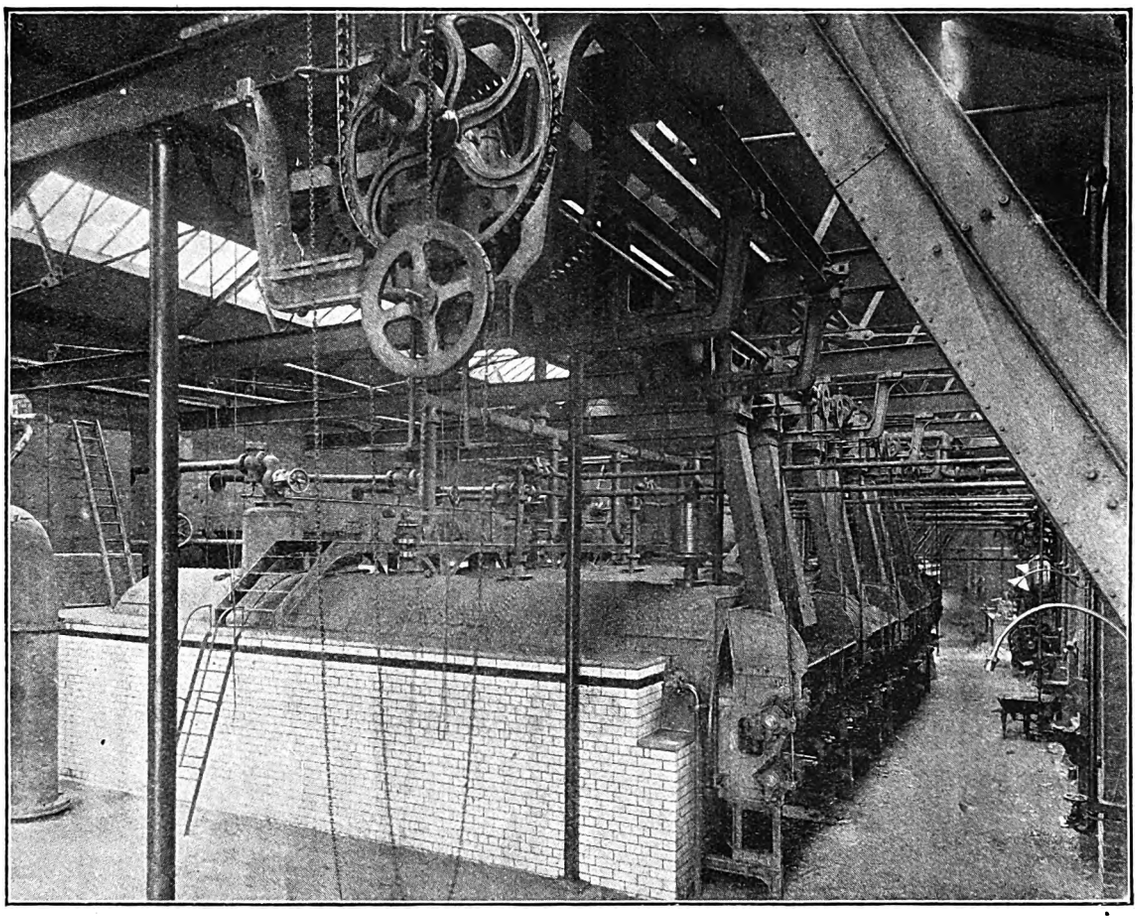
BRISTOL MUNICIPAL ELECTRIC SUPPLY STATION.



VIEW OF BOILER HOUSE.

VIEW OF MACHINERY ROOM.

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of two stiff rods working in guides. The cross-head also drives a crank shaft by means of a connecting rod, and thus turns a couple of small flywheels, which are keyed to the shaft. The flywheels are designed to give steady rotation at low speeds. A crank shaft governor controls the engine when the pump fails to lift water. These engines are well lubricated from an oil reservoir, the oil being distributed to each part through a separate pipe with a sight-feed regulator. Surmounting the condenser shell is the feed-make-up evaporator, which it will be convenient to describe at this point. This evaporator consists of an external horizontal cylindrical shell, within which is a smaller cylinder arranged like the flue of a Cornish boiler. The inner cylinder is transversely crossed by 26 diagonal circulating tubes of 2in. diameter, which communicate with the space between the two cylinders. This space is partially filled with harbour water from the cold well or reservoir beneath the boiler house; and a 3in. pipe forms a communication between the empty space in the upper part of the evaporator and the vacuum of the condenser, so that the pressure over the dirty water is very low. Through the internal cylinder of the evaporator the exhaust steam passes on its way to the condenser; and it is found that the temperature of this steam is sufficient to evaporate the dirty water at the low pressure of the vacuum. Thus the water is distilled over into the condenser and passes on to the hot tank along with the condensed steam. In the event of an extra large quantity of feed-make-up being required, live steam can be turned into the evaporator in place of the exhaust steam. It should be stated that the circulating water is discharged direct into the harbour and not into the cold well. The existing condensing plant is capable of dealing with 30,000lb. of exhaust steam per hour.

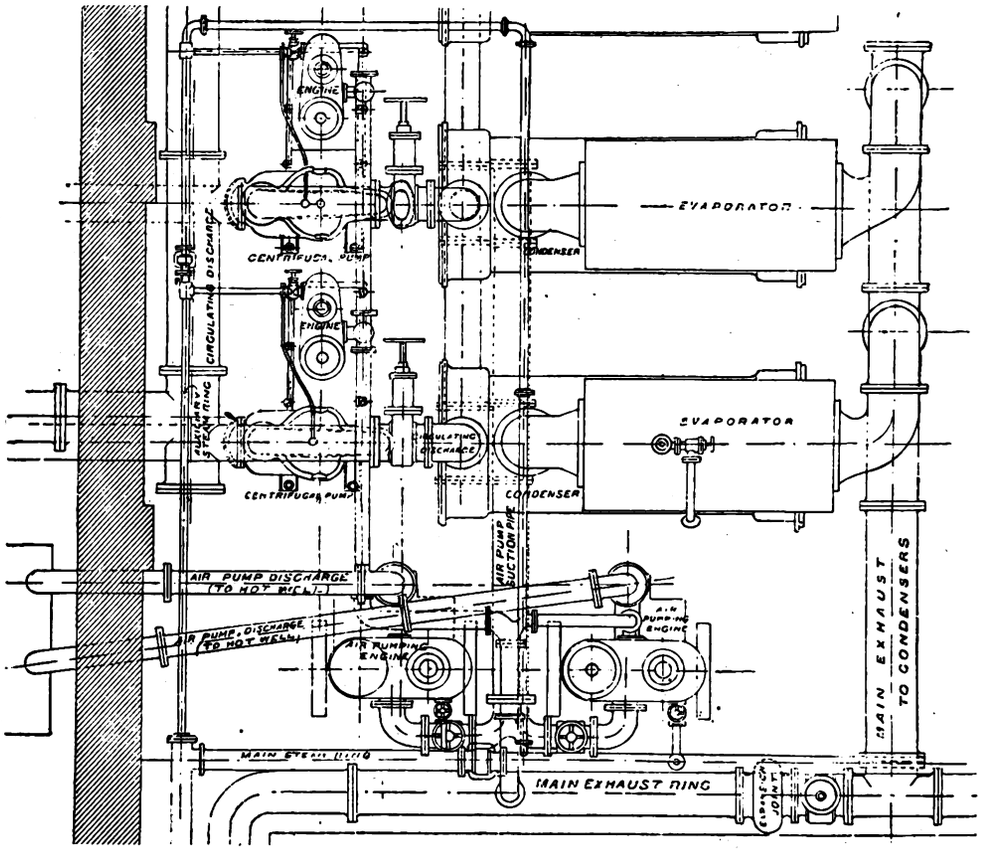

FIG. 4.—Plan of Condensing Plant at the Bristol Electric Supply Station.

Alternators.—All of the alternators are of substantially the same design, and were built by Messrs. Siemens Bros. and Co. The smaller machines are miniatures of the larger. The 210-kilowatt machines are of the $\left(\frac{W\,32}{4}\right)$ type, *i.e.*, each machine has 32 complete fields, with the poles set at 4in. pitch. The output is 100 amperes at 2,100 volts, at a frequency of 98 cycles, when running at 350 revolutions per minute. These machines are each coupled to a Willans III S engine, *i.e.*, three "I" engines side-by-side, and strengthened for extra heavy loads. The smaller alternators are of the $\left(\frac{W\,24}{3\frac{1}{2}}\right)$ type, with 24 magnet fields at $3\frac{1}{2}$in. pitch. Each develops 88 kilowatts, viz., 42 amperes at 2,100 volts, running at 465 revolutions per minute. In all the machines the armatures consist of flat coils, which, in each machine, are secured to a steel disc keyed to the shaft. The magnets are mounted on circular cast-iron frames on either side of the armature. The field-magnet cores are of wrought iron of high permeability, with wrought-iron pole-pieces rivetted on. Over the pole face a layer of ebonite is moulded and afterwards vulcanised *in situ*. The field-magnet coils are of copper wire; the armature coils, which are of sector shape and are secured to stout metal side plates, are wound with a strand of fine copper wires pressed into a flat strip and insulated with specially prepared tape. The insulation of these coils, including that between the coils and the brass cheeks or side plates, is prepared so as to enable the machine to withstand a high temperature for long runs.

Continuous-Current Machines.—The exciters are of the $\left(\frac{H\,B\,18}{20}\right)$ type—*i.e.*, the field-magnets are single circuit, or half the old type of D machine—and the drum armatures are bar wound; the armature is 18in. diameter, and the pole face is 20in. Each of these machines, coupled to a GGS Willans engine (*i.e.*, a strengthed doubled G type), develops 400 amperes at 130 or 100 volts, when running at 465 revolutions per minute. Both the arc light machines are built on lines similar to the exciters. They are single-magnet, drum-wound, bar armature machines of the $\left(\frac{H\,B\,18}{24}\right)$ type. Each machine is direct-coupled to a GGS Willans engine, and develops 80 amperes at 650 volts. It is possible, therefore, to run all the eight arc light series circuits upon either of these machines. These continuous-current machines are wound with wire on the field coils, and with tape-insulated bars on the armatures, the bars being joined by curved end connections, insulated with tape and mica. The armature windings are held in place

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and driven by wooden pegs, and are secured to a charcoal iron disc core by insulated circumferential bands.

Switchboards.—Erected upon the platform formed by widening the gallery immediately over the condensing annexe, is an imposing array of well-equipped switchboards, extending in all 42ft. 6in. in length. To the extreme right, when facing the boards, is the positive exciter board; next to this is the arc-light dynamo board; beside this again the arc-light circuit board. These together occupy 11ft. in length and stand 6ft. 6in. high. To the left of this set of boards is the switchboard for the general supply. This consists of a feeder board for 17 feeders, arranged in panels along a length of 21ft. and an alternator board, arranged in panels for the existing five machines, together with a synchronising board communicating with an artificial load. These last occupy 9ft. in length. The feeder and alternator boards are 7ft. in height. Details of all these switchboards are given in Fig. 5. The system of mains laid down for the general supply necessitates the paralleling of the alternators. This operation is carried out very quickly at Bristol, and without the use of the artificial load, by means of an arrangement devised by Mr. Faraday Proctor. The method consists in the insertion of choking coils between the two machines which are to be paralleled, the inductance of the coils being gradually switched down to zero. All the switchboard equipment has been admirably carried out by Mr. F. M. Newton, of Taunton.

Arc Lighting and Supply Mains.—The high-pressure feeders are of Siemens' concentric, lead-covered, double-steel-armoured cable. These cables are laid chiefly under the foot pavements, and are protected by a continuous covering of brick, and then covered over with earth and the ordinary paving. Originally the feeders were led to sub-stations in hired cellars, &c., but the more recent sub-stations have been placed beneath the foot pavements. The distributing mains are arranged on the three-wire 210 and 105 volt network system, and are of triple-concentric, lead-covered, double-steel-armoured cable. The low-pressure mains are laid in the same manner as the feeders, and are in general placed in the same trenches.

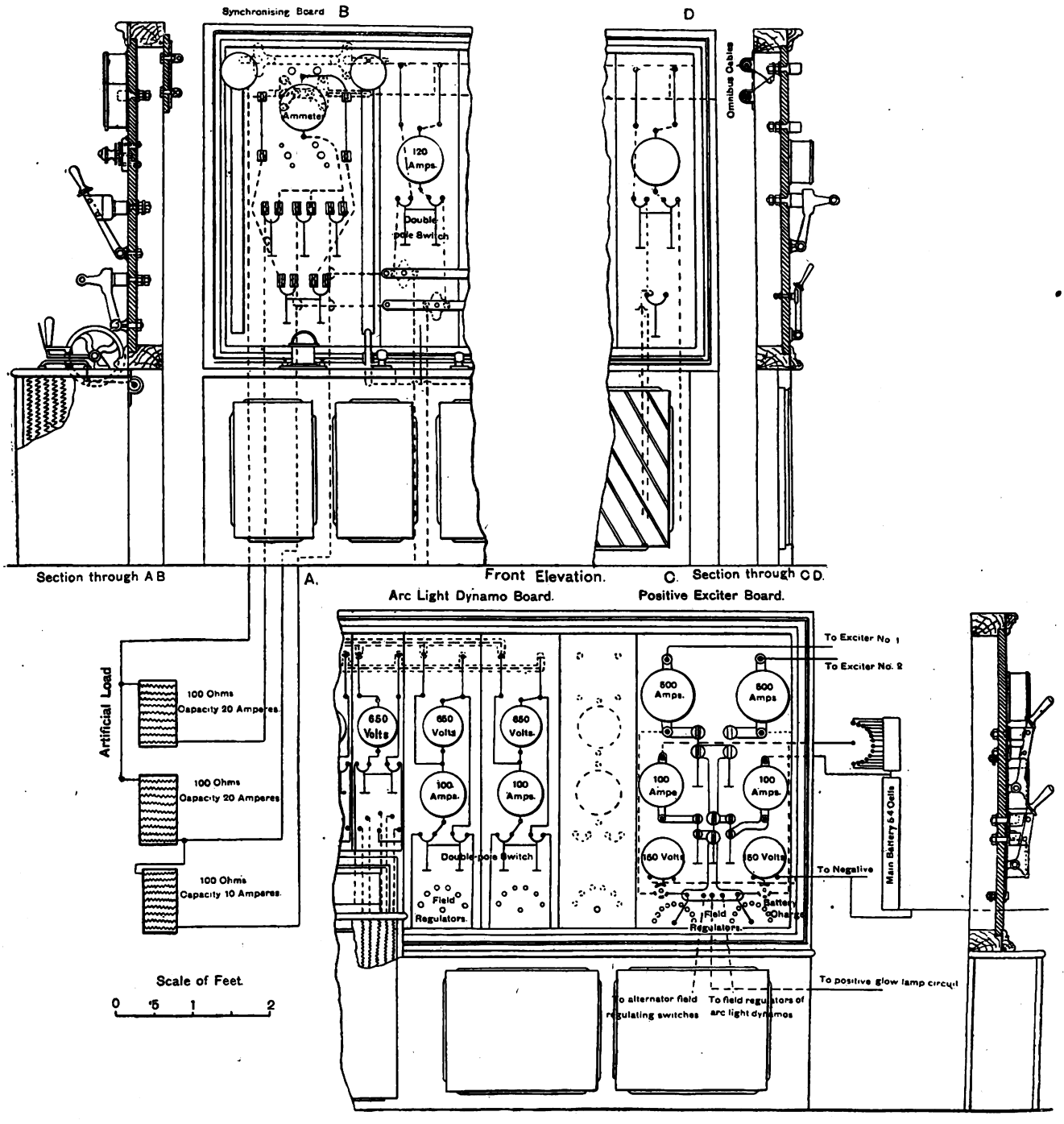

FIG. 5.—Bristol Municipal Electric Supply Station. Details of Alternator, Feeder, Exciter and Arc-Light Switchboards.

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The following are some further details of the sizes and manufacture of the cables, all of which Messrs. Siemens Bros. and Co. have supplied. The high-pressure feeders are in three sizes, of 0·05, 0·075 and 0·10 sq. in. section of conductor respectively. All three are manufactured in the same way, as follows: the inner conductor consists of five strands; surrounding this is an insulation of jute treated with insulating material, in which two test or pilot wires

The low-pressure distributors are of similar construction, but are arranged in triple-concentric for the three-wire system. The section of copper is 0·15 sq. in., and there are no pilot wires. Between the outer and second circle of conductors, the layers of insulation are the same as between the second and the inner conductors, and the same, too, as the insulation between inner and outer of the feeders. A somewhat different construction is adopted in the house service mains, which are

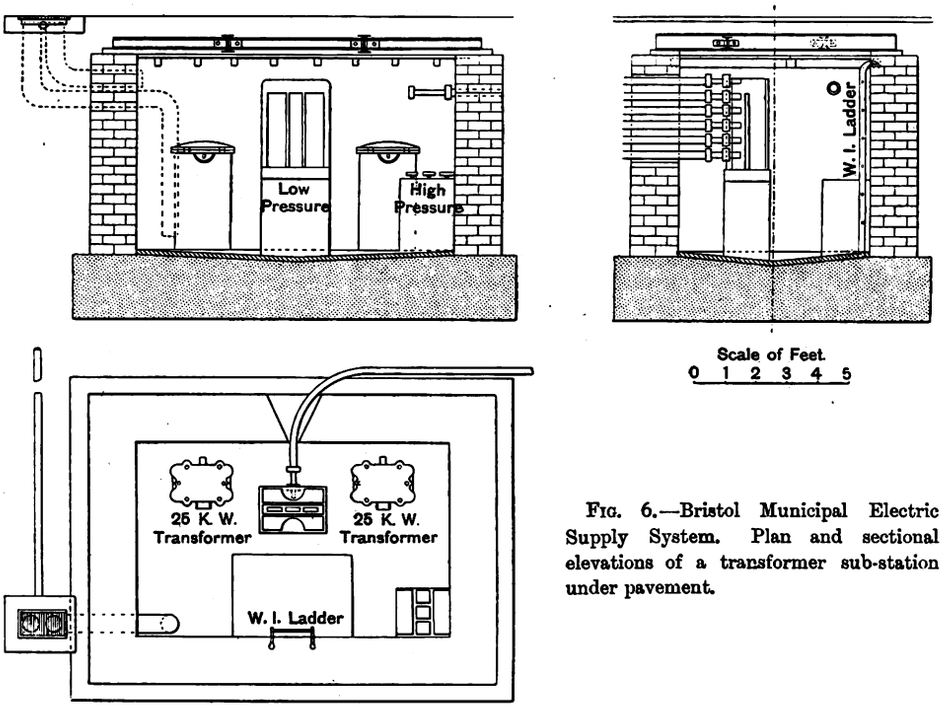

FIG. 6.—Bristol Municipal Electric Supply System. Plan and sectional elevations of a transformer sub-station under pavement.

are embedded. Around this insulation the outer conductors are equally spaced in a circle, together with the return test wire, over these comes another layer of insulating jute, over this a seamless tube of wrought-lead is hydraulically pressed at a pressure of 6,000lb. per sq. in. Then comes a serving of soft fibrous material to act as a bed or cushion for

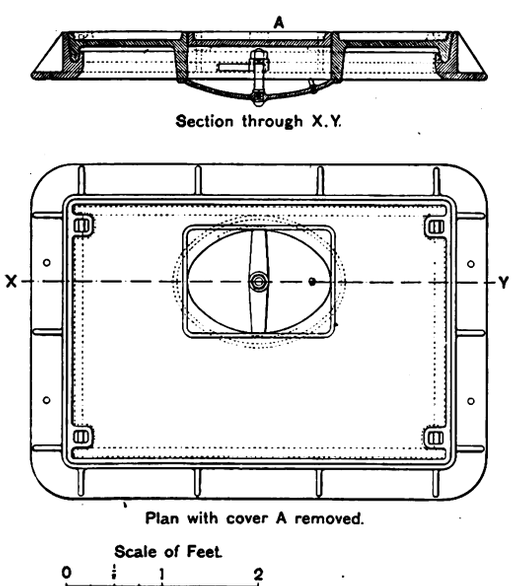

FIG. 7.—Bristol Municipal Electric Supply System. Cover used for transformer sub-station under pavement, showing smaller cover to manhole.

the steel hoops; upon this cushion two layers of steel hoops, arranged to break joint, are laid; over the outer hoop comes a layer of jute overlaid with insulating compound. The lead tube is produced from a solid cylinder of cold lead.

made in sizes to suit the customers. All these are constructed as follows:—The positive and negative cables are stranded, and embedded separately in rubber; the two are then embedded together in jute, treated with insulating material; over this a tube of lead is wrought, this being covered with jute and compound. There is no steel armour in these cables.

Two forms of arc lamp cables are used, one for burying and the other for running up the lamp posts. The buried cable consists of a single stranded conductor of 0·023 sq. in. section, embedded in jute treated with insulating material; over which comes a layer of wrought lead, covered with a bedding, and then steel stranded wire armour, over which are jute and compound. The cables carried up the posts are not armoured, and consist of forward and return stranded conductors, placed side by side in a matrix of jute treated with insulating material, over which a lead covering is wrought, this latter being covered with jute and compound.

Sub-Stations.—As previously stated, the original sub-stations consisted of hired cellars and such-like places; but this plan proving expensive and unnecessary, later sub-stations have all been built in excavations beneath the foot pavements. Details of one of these latter sub-stations are shown in Figs. 6 and 7. The former of these plans and sections of a 50 kilowatt sub-station, fitted with two Brush 25 kilowatt transformers and high and low pressure switch-boards. Since the lamentable fatality at one of these sub-stations all the high-pressure terminals and switches have been boxed in with easily removed frames of timber. The ventilation of sub-stations beneath pavements is a matter of importance. At Bristol this is carried out in the manner shown in Fig. 6, where it will be seen that two 6in. iron drain pipes communicate between the upper and lower parts of the vault respectively and a ventilated foot-plate in the pavement. This foot-plate is partly in the form of a perforated grid and partly—*i.e.*, directly over the pipes—of blind plate; and the ends of the pipes project sufficiently to prevent water from entering the vault through the pipes. Any water which

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may accumulate beneath the foot-plate will be trapped into the sewers. Fig. 7 shows the form of cover used in these sub-stations. It consists of a large frame for the main cover, containing a smaller frame to serve as a man-hole. The larger frame will only be removed in the event of plant having to be taken into or out of the vault. These covers are, of course, made perfectly water-tight. Recently, one of the sub-stations at Clifton has been converted into an intermediate sub-station, from which five branch feeders radiate to five other sub-stations; and it is intended to adopt this plan of having branched feeders in other parts of the system.

Arc Lighting System.—There are at present 108 arc lamps in the arc-light system, and these are grouped as follows:—Eight series circuits, each composed of 12 Brockie-Pell double-carbon lamps, manufactured by Messrs. Johnson and Phillips; and 12 alternating arcs run in series of two or four on the low-pressure three-wire mains. Of the continuous-current arcs, five are now used in the station. The street circuits are arranged in duplicate, in such a manner that if one circuit temporarily fails, only the alternate lamps will be extinguished. By an automatic device, also, it is arranged that when the series-arc circuits are switched on, in the

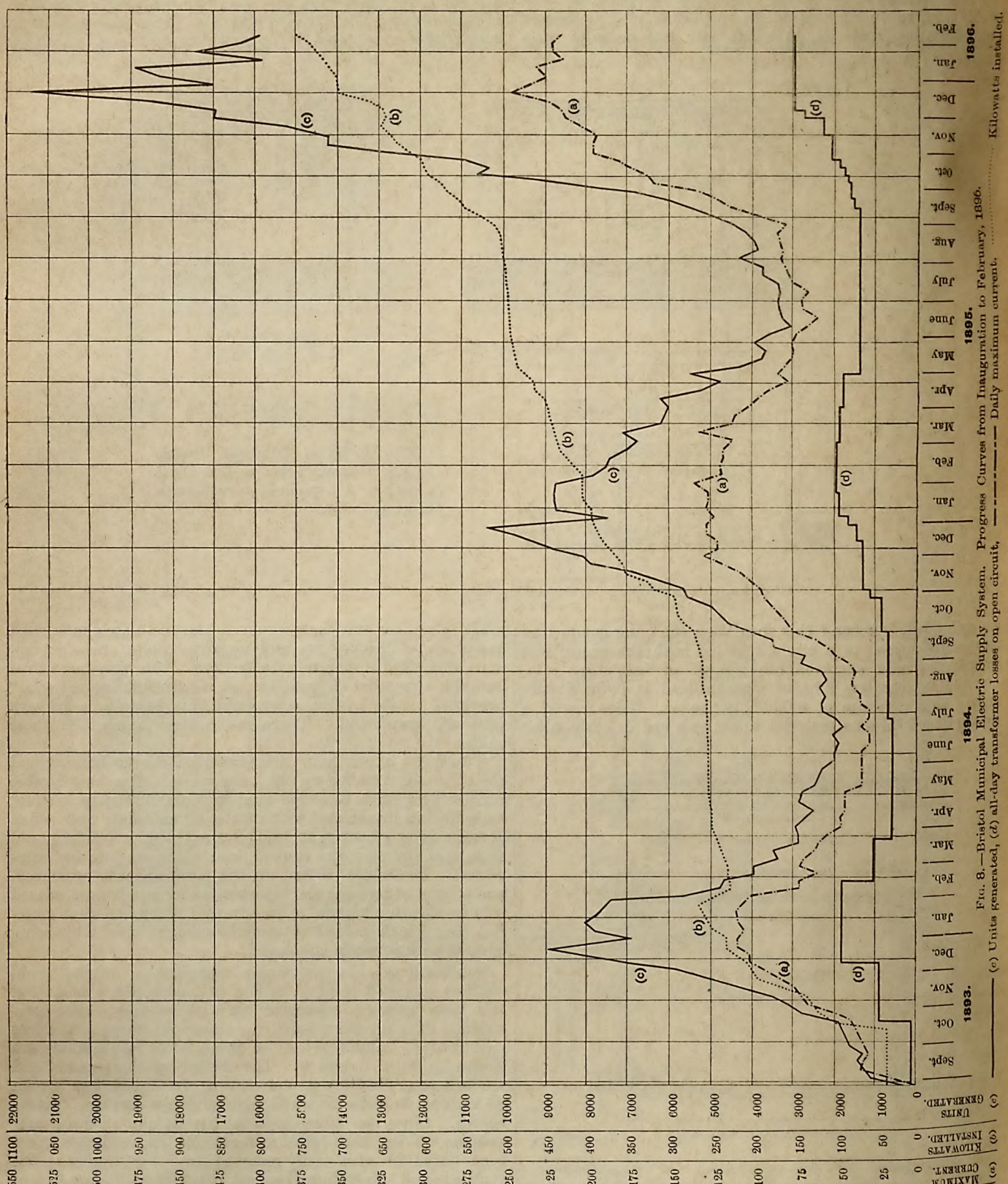

FIG. 8.—Bristol Municipal Electric Supply System. Progress Curves from Inauguration to February, 1896.

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evening, those street lamps which are on the low-pressure mains shall be automatically turned on at the same moment. The lamps are carried on massive and artistic cast-iron posts, arranged in some places in the centre of the streets, but generally along the side-walks. The street lighting appears to be very efficiently carried out and to give satisfaction.

Progress since Starting.

Progress Curves.—We will now resume our study of the history of the Bristol electric supply system, taking it up at the point at which we left off—the commencement of supply. The set of Progress Curves in Fig. 8 indicates the variations of the chief items of electrical importance, from the end of August, 1893, to February 2, 1896. These curves show the following items: Curve *a*, the daily maximum current; curve *b*, the total plant installed, including lamps, motors, &c., in kilowatts; curve *c*, the daily units generated; and the rectangular stepped curve *d*, the open circuit transformer losses—*i.e.*, the all-day losses in the transformers connected to the feeders when there is no secondary current in the distributing mains. In regard to this last-named matter, it is curious that Mr. Faraday Proctor finds that this open circuit loss in the transformers very closely equals the actual total distribution loss; so that if the ordinates of curve *d*, in Fig. 8, are deducted from the corresponding ordinates of curve *c*, the difference curve will be a curve of units supplied to the consumers. It should be stated that from this set of curves (Fig. 8) the arc lighting operations are excluded; they relate only to the alternate current supply. We cannot refrain from congratulating Mr. Proctor and the Bristol authorities on the excellent progress which this set of curves indicates; but, beyond this, comment on the curves would be superfluous, as they so clearly show on the face of them what they have to teach. Perhaps, however, there is just one little point which needs elucidation, namely, that the extraordinarily high and brief peak in the curve of "units generated" in December, 1895, was produced by the short run of a pantomime. Probably, though, an expert would have guessed as much.

Daily Records.—In order to understand how the data for the Progress Curves are obtained, we must look a little into the daily routine of work at the Bristol station. On page 622 there is reproduced in type the daily log for Thursday, January 2, 1896, a sheet which is typical of the log-sheet filled in at the station every day. A close inspection of this sheet will afford considerable useful information. The blank log-sheet is a printed form, on the back of which are faint square rulings for plotting the load diagram of the corresponding day. The switchboard attendants fill in the instrument readings every half-hour, and mark with a cross to indicate the boilers which are giving steam; and the particulars of any change in the working plant, of a breakdown, or any incident of importance are recorded in the "Remarks" column. At the end of the day the quantities registered in the space at the bottom of the sheet are worked out and entered, these quantities comprising:—(1) the total hours run, total units, amount and time of the maximum current, total ammeter readings and average load of the alternators and feeder circuits; (2) the total ammeter readings, average load, total hours run and total units generated for the arc light circuits; (3) the ampere-hours' charge, the ampere-hours' discharge, and the difference between charge and discharge of the battery; (4) the in-take and consumption of gas, coal and oil; and (5) the total output of the station, in units, for the week ending at the end of that day.

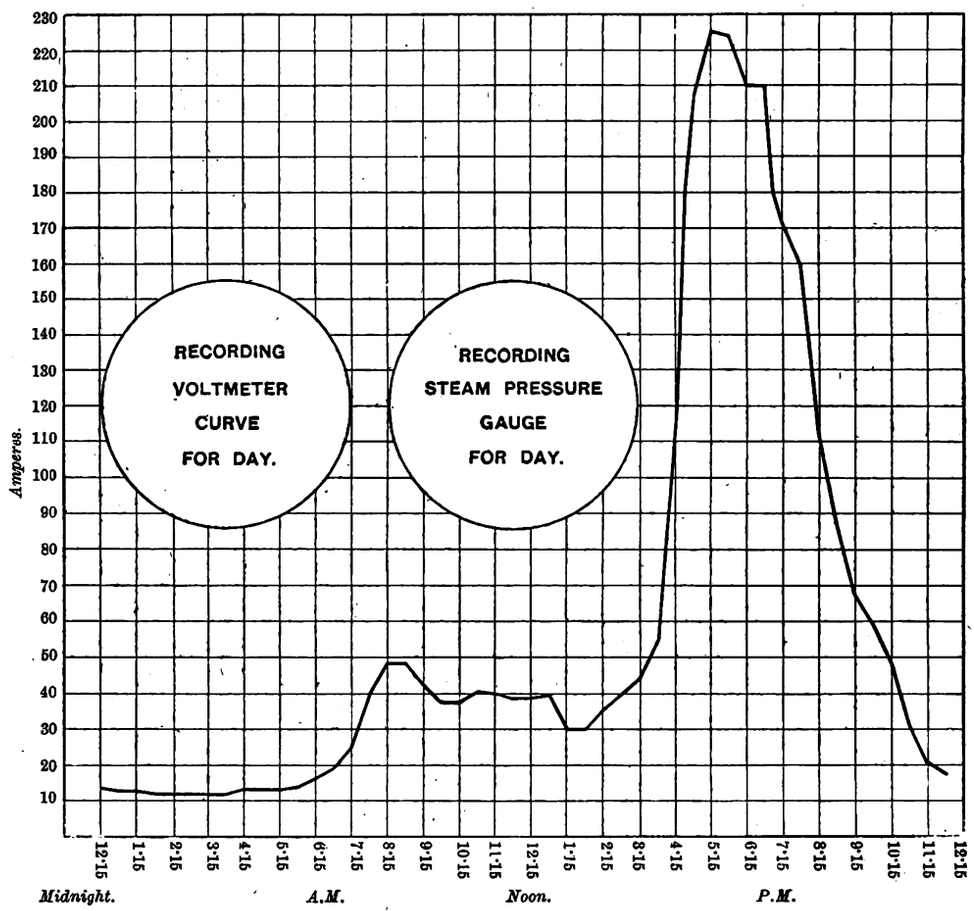

FIG. 9.—Bristol Electric Supply System. Load Curve for Thursday, January 2, 1896.

Load Diagrams.—It will be seen that the "total amperes" readings for the alternate-current supply are entered in the first column, annexed to the "time" readings. This is to facilitate the plotting of the load diagram for the day, which is done in the following way:—The first two columns of the log sheet are folded back, so as to appear on the back of the sheet. This back is ruled in squares, and has a scale of "time" printed on its base and a scale of "current" printed vertically from the zero point. The two columns of figures folded back will be seen at the extreme right, and thus will make it easy to plot the load diagram for the day. When this has been done the day's sheets from the recording station

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BRISTOL ELECTRIC LIGHTING STATION.

DAILY LOG, Thursday, the 2nd day of January, 1896

Total amps.	Time.	Private supply circuits. I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	Alternators. I.	II.	III.	IV.	V.	VI.	Total amps.	Arc circuits. A 1	A 2	B 1	B 2	C 1	C 2	D 1	D 2	Dynamos. I.	II.	Exciter No. I. Volts.	Amps.	Boilers. 1	2	3	4	5	6	7	Battery. Charge.	Discharge.	Remarks.
	A.M.																																															
14	12:15																		14					14	10		10		10		10		40		100	50						×					Mr. Hill in charge at 12:0.
13	12:45																		13					13	10		10		10		10		40		100	50						×					
13	1:15																		13					13	10		10		10		10		40		100	50						×					Switched off Arc Circuits A_2, B_2, C_2, D_2 at 12.
12	1:45																		12					12	10		10		10		10		40		115	117						×			65		
12	2:15																		12					12	10		10		10		10		40		117	137						×			87		Started charging at 1:30 a.m.
12	2:45																		12					12	10		10		10		10		40		117	129						×			78		
12	3:15																		12					12	10		10		10		10		40		117	127						×			76		Paralleled Alt. No. III. and shut down No. II.
12	3:45																		12					12	10		10		10		10		40		117	123						×			72		at 7:20 a.m.
13	4:15																		13					13	10		10		10		10		40		118	112						×			60		
13	4:45																		13					13	10		10		10		10		40		119	102						×			50		Shut down Arc Machine at 7:40 a.m.
13	5:15																		13					13	10		10		10		10		40		126	128						×			74		Shut down Exciter and stopped charging at
14	5:45																		14					14	10		10		10		10		40		126	120						×			66		7:45 a.m.
17	6:15																		17					17	10		10		10		10		40		127	115						×			62		
19	6:45																		19					19	10		10		10		10		40		127	117						×			58		
26	7:15																		26					26	10		10		10		10		40		128	110						×			58		
40	7:45																			40				40																		×				35	Mr. Phillips in charge at 8 a.m.
47	8:15																			47				47																		×				33	
47	8:45																						47	47																		×				33	Paralleled Alt. No. V. and shut down No. III.
42	9:15																						42	42																		×				33	at 8:20 a.m.
38	9:45																						38	38																		×				33	At 1:40 p.m. high-pressure gland packing blew
38	10:15																						38	38																		×				33	out of No. I. Circulating Pump; shut down
41	10:45																						41	41																		×				33	and repacked gland, and started up again at
40	11:15																						40	40																		×				33	1:45 p.m.
38	11:45																						38	38																		×				33	Opened out Boilers 4 and 5 at 3 p.m.
	P.M.																																															[direct).
38	12:15																						38	38																		×				33	Started Exciter No. II. at 3:5 p.m. (exciting
39	12:45																						39	39																		×				33	Opened out Boiler 7 at 3:45 p.m.
30	1:15																						30	30																		×				33	
30	1:45																						30	30																		×				33	
36	2:15																						36	36																		×				33	Mr. Bishop in charge at 4 p.m.
40	2:45																						40	40														No.	II.				×				33	
44	3:15																						44	44														100	40				×	×				Paralleled Alt. No. IV. at 4:8. p.m.
54	3:45	1	2	10	10	7	2	3	2	3	6	2	2	1	2	1							54	54														100	45				×					
112	4:15	1	2	19	20	13	10	7	9	10	7	2	2	2	4	3						14	98	112														100	80				×	×	×	×		Started up arcs at 4:35 p.m. No. II. Machine.
208	4:45	2	6	29	31	20	19	13	22	22	10	4	7	5	9	9			16			94	98	208	10	10	10	10	10	10	10	10	80		100	125				×	×	×	×		
224	5:15	3	6	30	32	21	21	12	24	24	11	5	8	6	10	10			25			99	100	224	10	10	10	10	10	10	10	10	80		100	125				×	×	×	×		Paralleled Alt. No. I. at 4:40 p.m.
222	5:45	3	7	30	31	20	21	12	24	24	10	5	8	6	10	10			24			98	100	222	10	10	10	10	10	10	10	10	80		100	125				×	×	×	×		Shut down Alt. No. I. at 7:5 p.m.
210	6:15	2	7	29	30	19	20	12	24	24	7	3	8	6	10	10			12			98	100	210	10	10	10	10	10	10	10	10	80		100	125				×	×	×	×		Banked up Boilers 4 and 6 at 8 p.m.
210	6:45	3	10	29	30	18	18	10	23	24	7	3	8	6	10	10			15			95	100	210	10	10	10	10	10	10	10	10	80		100	125				×	×	×	×		Banked up Boiler 5 at 9:20 p.m.
172	7:15	3	14	24	24	16	13	7	15	16	6	3	8	5	10	9						72	100	172	10	10	10	10	10	10	10	10	80		100	110				×	×	×	×		
160	7:45	2	15	23	23	14	9	7	14	13	6	2	8	5	9	9						60	100	160	10	10	10	10	10	10	10	10	80		100	108				×	×	×	×		Shut down Alternator IV. at 8:45 p.m.
112	8:15	1	13	14	14	9	7	6	11	10	4	2	4	4	7	7						15	97	112	10	10	10	10	10	10	10	10	80		100	105					×	×	×		
88	8:45	1	13	9	9	7	6	5	9	9	2	2	3	3	6	4							88	88	10	10	10	10	10	10	10	10	80		100	70					×	×	×		Paralleled Alt. No. I. and shut down No. V. at
68	9:15	1	13	9	8	5	5	5	6	6	2	2	3	2	5	3							68	68	10	10	10	10	10	10	10	10	80		100	70					×	×	×		10:45 p.m.
59	9:45	1	12	7	6	5	5	8	6	6	2	1	2	2	4	2							59	59	10	10	10	10	10	10	10	10	80		100	70						×			
48	10:15	1	10	6	4	3	2	3	5	5	2	1	1	2	3	1							48	48	10	10	10	10	10	10	10	10	80		100	70						×			
31	10:45																						31	31	10	10	10	10	10	10	10	10	80		100	70						×			
21	11:15																		21					21	10	10	10	10	10	10	10	10	80		100	50						×			
17	11:45																		17					17	10	10	10	10	10	10	10	10	80		100	50						×			

Total hours run, 24.
Total units, 2,858.
Maximum current, 224 amps. at 5:15 p.m.
Total readings 2,858.
Average load, 29·7.

Total readings, 1,800.
Average load, 60.

Total hours run, 15·08.
Total units, 588·12.

Battery.
Amp. hours charge, 403.
Amp. hours discharge 248·5.
Difference, 154·5.

Thursday, Midnight.	Gas. Thous. feet.	Coal. Tons.	Cwts.	Oil. Galls.
		121	4	
Add		65	5	
Total		186	9	
Amt. used ...		68	0	
		118	0	

B.T. Units Output, for week ending Thursday, Jan. 2, 1896, 19,920.

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voltmeter and recording steam pressure gauge are stuck upon it. The finished load diagram for January 2, 1896, is shown in Fig. 9. The recording voltmeter and steam pressure gauge are of the "Bristol" type.

Extension of Mains.—The greater part of the extension of the Bristol system has taken place in the mains laid. This item of development is shown in detail in the accompanying map of the area supplied (Fig. 1).

Financial Progress.—Finally, we have to consider the progress of the Bristol electric supply system from a financial point of view. We have stated that the concern commenced work saddled with a total expenditure of £80,000, as against an originally estimated cost of £60,000, with £6,000 for contingencies. The succession of unforeseen events, such as the discovery of the rotten nature of the ground on the site, and the increasing magnitude of the scheme, no doubt account for much if not for all of the difference. We have also seen that from the outset the concern has been saddled with heavy charges for rates and taxes, an item which for the year 1894 amounted to 1·18 pence per unit sold, and which exceeded the outlay on salaries, wages, repairs and maintenance, and almost equalled the total cost of coal for the year. So large an assessment must be a burdensome standing charge upon the concern; and we have only to compare Bristol, in this respect, with Brighton or Manchester, to see how much more

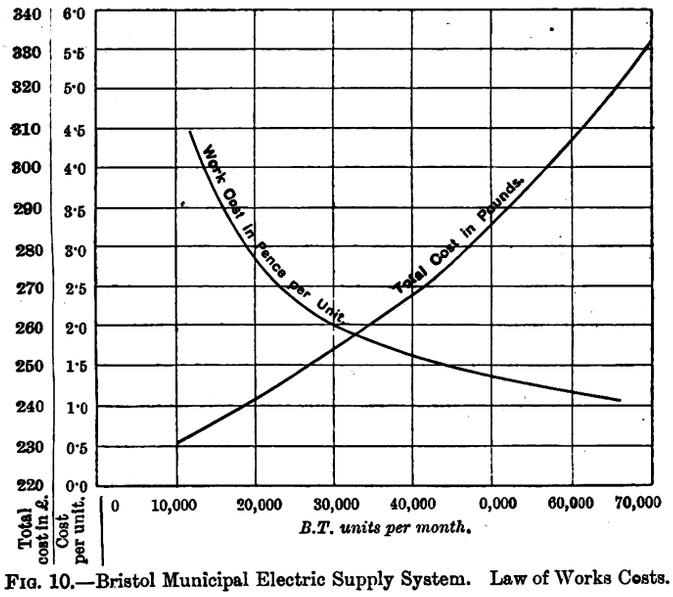

FIG. 10.—Bristol Municipal Electric Supply System. Law of Works Costs.

fortunate other municipal concerns are. At Brighton, the total charge for "rent, rates and taxes" was only £165 on a total capital outlay of £119,382, of which £44,918 had been expended on buildings, lands and plant. The capital account for Bristol, up to December 31, 1895, is set forth in Table III.; in Table IV. the outputs for 1894 and 1895 are analysed; and in Table V. the revenue accounts for 1894 are given in detail.

Law of Works Costs.—During the year 1895 Mr. Proctor analysed the works costs, with a view to obtaining some sort of law connecting the monthly output with the total cost and with the cost per unit generated. The curves showing the relations between these three quantities, for the Bristol system, are given in Fig. 10.

Table III.—*Capital Expenditure to December 31, 1895.*

——	To Dec. 31, 1894.	To Dec. 31, 1895.
Amount sanctioned	£90,000	...
Total capital received	90,000	£100,000
„ „ expended	82,186	97,794
Capital expended in lands and buildings	26,609	26,668
„ „ „ plant	30,796	33,267
„ „ „ mains	18,442	29,754
„ „ „ meters	1,236	2,422
„ „ „ public lamps	3,538	3,538
„ „ „ miscellaneous items	1,560	2,145
Total capital expenditure per Board of Trade unit sold	5.59s.	4.85s.

Table IV.—*Analysis of Output for 1894 and 1895.*

——	1894.	1895.
Total B.O.T. units supplied during year	293,523	408,301
B.O.T. units supplied for general use during year.	143,106	251,708
B.O.T. units supplied for public lighting during year	150,417	156,593
Price per unit during year	4d. & 6d.	4d. & 6d.

Table V.—*Analysis of Revenue Accounts for year ending December 31, 1894.*

——	Total in £.	Per unit sold in pence. *
Receipts during year	6,624	5·42
Expenditure during year	6,168	5·04
Item: Generating expenses	3,177	2·59
„ Distribution expenses	79	0·06
„ Management expenses	880	0·71
„ Rent, rates and taxes	1,453	1·18
„ Attendance, repairs, carbons and renewals of public lamps	579	0·48
„ Coal	1,560	1·27
„ Oil, waste, &c.	186	0·15
„ Salaries and wages	1,156	0·94
„ Repairs and maintenance	275	0·22

* This includes the units supplied to the City for public lighting.

At the present date the accounts for the year ending December 31, 1895, have not yet been published in detailed form. It is therefore impossible to give an exact analysis of the revenue accounts for that year. We are, however, in a position to state that there has been a gross profit of £4,019 19s. 10d. for the year 1895; as against a gross profit of only £456 7s. 11d. for the previous year. On the other hand a sum of £4,557. 11s. 9d. has been obtained from the General District rate. The total cost of the public lighting for the twelve months ending December 31, 1895, was £3,447 3s. 10d., including attendance, repairs of lamps, carbons and the supply of power.

Conclusion.—In conclusion, we desire to express our great indebtedness and thanks to Mr. Faraday Proctor, the resident and consulting electrical engineer to the Bristol municipal authorities, for the courtesy he has extended to us, in supplying us with particulars of the large and interesting concern under his charge. Our thanks are also extended to Mr. Palgrave Simpson, of Messrs. Siemens Bros. and Co., for supplying us with particulars of the alternators, continuous current machines and cables, which were made by his firm.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, March 6th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting in the Library of the Institution. Paper to be read: "A Simple Method of Analysing Harmonic Curves," by E. Basil Wedmore.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Tunnel under the Thames at Blackwall," by A. R. Binnie.

INTERNATIONAL HORSE AND HORSELESS CARRIAGE AND ROADS LOCOMOTION EXHIBITION.

3 p.m. Meeting of the Honorary Council of Advice at the Mansion House.

SATURDAY, March 7th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Light," by the Right Hon. Lord Rayleigh, F.R.S.

MONDAY, March 9th.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting at the Palatine Hotel, Hunt's Bank, Manchester. Adjourned discussion on "The Paralleling of Alternators," by R. Hammond.

TUESDAY, March 10th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Mr. W. H. Wheeler's Paper of last week will be further discussed, and, time permitting, three Papers dealing with Metallurgy will be read.

THURSDAY, March 12th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion on "High Voltage Lamps and their Influence on Central Station Practice," by G. L. Addenbrooke.

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HOUSE WIRING.

The discussion on Messrs. SAM MAVOR and FRED BATHURST's Papers on "House Wiring" no doubt suffered seriously from the long interval that elapsed between the date of their reading and the first night of their discussion. The majority of members were indifferent to the merits of interior conduits as practised in the United States of America and the Continent, and cared little about a system of concentric wiring which was inapplicable to the great majority of installations owing to Board of Trade restrictions. And, perhaps, the fact that both systems as described in the Papers were covered by patents tended largely to destroy a general interest. Viewed broadly, however, the discussion shows that there is a growing dissatisfaction with wood casing, and that there is a decided tendency to use conduits, preferably pipes, wherever the nature of the work and the price obtainable admit of it. This is chiefly due to a desire to conceal the wiring in a safe and permanent manner. It is obvious that iron pipes can be laid in plaster, beneath floor-boards or behind wainscoting with the same freedom from accidental damage as is the case with gas and water pipes. The same cannot be said for wood casing as ordinarily used. In new buildings it is obviously desirable to conceal the wiring, and hence wood casing, which has done yeoman service in the introduction of electric lighting, bids fair to gradually sink into desuetude. Yet it will die hard. Its erection does not require much skill, and carpenters and joiners are "as plenty as blackberries." Wood casing is, therefore, in most instances the cheapest class of work, and neither interior conduits nor concentric wiring are likely to supersede it for the general run of work until they can compete with it in the prime essential of low first cost. And this, as Mr. G. BINSWANGER pointed out, depends largely on the demand. Economy, in spite of fire insurance offices and patented systems of safety wiring, is the crux of the whole matter. Do either of the systems advanced offer any striking advantage in

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this respect? Interior conduits without substantial armour do not commend themselves to the leading fire offices unless treated precisely like wood casing as regards the separation of the wires, and this at once rules the system out of court on the count of expense. Armoured interior conduits are evidently more expensive than plain iron tubes, both on account of the cost of lining them, and also because the outer tube must be of greater section. Mr. BATHURST's proposal to divide the insulation between the wiring and the tube appears to us to be a step in the wrong direction. It lessens the insulation between wire and wire, and probably also between copper and earth, and does not provide sufficient protection against moisture. It appears to us that insulation is most effective around the conductor, and can there be most cheaply applied. Of course, special care is necessary with bare iron pipes. They require to be reamed out and painted inside; the mouths should be bushed with insulating material, and precautions may sometimes have to be taken against condensation of moisture. Judging, however, from a large number of installations erected by various firms, and carried out according to their own plans, and thus subject to no patent royalties or similar limitations, it would appear that iron pipe work is a success, and that its use is extending. Mr. ADDENBROOKE's proposal to use iron pipes with a single insulated wire, the pipe forming the return, may become an accomplished fact before long. Mr. CROMPTON almost prophesied so. This plan has been tried in places where neither Board of Trade nor fire office regulations applied, but with doubtful success, owing to the difficulty of keeping the resistance of the joints sufficiently low, but the material used was unsuitable. When the middle wire of a low-pressure distribution system may be earthed at the feeding points (as most of us wish they might), there should be no real difficulty in the way of the iron-pipe return other than the competition of Mr. MAVOR's concentric system.

From an engineering point of view there is much to commend concentric wiring as originally introduced by Mr. J. D. F. ANDREWS, and since modified by Messrs. MAVOR and COULSON and others. That it has not found more favour is perhaps due chiefly to the Board of Trade restrictions which, even now that the middle wire may be earthed at the station end, practically prevent the use of an earthed outer on premises supplied from a central station network. It is to be regretted that the new regulations do not give a fair field to concentric wiring and enable it to take its place on its merits. It seems to offer certain advantages on account of simplicity and of the standard patterns which have been devised by the owners of the patents, and although we do not think their fittings and details to be such as are likely to be finally adopted when the system is more generally understood, yet they make for sound work at a minimum cost. Mr. ANDREWS estimated the reduction of cost of interior wiring at from 20 per cent. to 30 per cent. below that of wood-casing a conductor. This is a sufficient economy to make electric lighting possible in many cases where the initial cost of installation is at present prohibitory.

The policy of the fire insurance offices was criticised from different points of view. Major Gen. WEBBER and others contended that the "Rules" were unnecessarily severe, while Mr. SAM MAVOR considered them none too stringent for double wiring in wood casing. Some uncomplimentary opinions were advanced by speakers who apparently forgot that the offices deal with averages and take the risk at the option of the insured, and hence have a definite right to make their own terms. Moreover, the "Rules" have never pressed unduly on sound conscientious work, and have certainly been instrumental in placing a limit on jerry work in buildings over which the Board of Trade has no control.

The latest new thing, the 200-volt supply, did not meet with universal approval, and Mr. GEIPEL went so far as to urge wiring contractors to combine with consumers in emphatic protest against the practice. There is unintentional irony in this suggestion, which the cheap wiremen will no doubt appreciate; for the higher pressure will undoubtedly find out defective work which will just pass muster with the present standard of 100 volts. The futility of so-called insulation tests is well recognised even by the fire offices, but the automatic continuous test of a 200-volt current will soon break down shoddy work.

Mr. FRED. BATHURST certainly made an excellent reply on behalf of his interior conduits, and although we cannot agree with him that the system is the only one which makes for "safety, durability, convenience, accessibility and economy," we concur with much that he said. We are fully of opinion that before electric light can be generally used it must compete with gas, not only as to cost light for light, but also as to cost of installation. To fulfil this latter condition Mr. BATHURST boldly proposes to use a cheap class of twin-wiring which, with an unarmoured insulating conduit, costs, he says, no more than the wire in an ordinary job. He thus hopes to save the price of the wood casing, as well as part of the labour of erection. If the insulated interior conduit really prove as cheap and convenient as its advocates assure us it will, the system is bound to make its way to the front, and Mr. BATHURST may therefore rest content and cheerfully await events, notwithstanding the prejudices of fire offices, the official frowns of the Board of Trade, and the academic criticisms of all who do not see eye to eye with him in this matter. Time and trial will soon teach us the truth.

REVIEWS.

Applied Magnetism: an Introduction to the Design of Electromagnetic Apparatus. By J. A. KINGDON, B.A. (London: Alabaster, Gatehouse and Co.)

It is to be hoped that the time is not far distant when the fundamental theory and equations of the magnetic circuit will be as much a part of the preliminary training of the young electrical engineer as the corresponding equations of the electric circuit. When he reaches the subject of dynamo-electric machinery he should bring to its study a familiar acquaintance, not only with Ohm's law, but also with its magnetic analogue, and a power of applying the latter as automatically as the former. The pages of the text-book on dynamos would then be relieved of the inevitable elementary chapters on "lines of force" and "magnetic fields," and the author could assume that a knowledge of ampere-turns, flux and reluctance is as much a matter of course as of volts, amperes and ohms. The first title of the present book, "Applied Magnetism," leads one to expect a manual dealing with the theory and design of magnets in such a manner as would pave the way for a treatise dealing more specially with dynamos and transformers, in which applied electricity is combined equally with applied magnetism. Some such purpose seems to have been present in the mind of Mr. Kingdon, but to our thinking he has either not confined himself sufficiently closely to the subject of magnetism, or has given to his book a title which is somewhat of a misnomer. The opening chapters deal with the elementary facts and theory of the magnetic circuit, but before long we reach chapters headed "The Alternator," "The Dynamo," "Commutator and Collectors," "Electromotors." Outline sketches of these subjects are alone possible within the limits of the pages allotted to them, and thus the book comes in the end to be a preliminary treatise on dynamo-electric machinery at large. Alternators, continuous-current dynamos, motors and transformers, all alike are touched upon, their

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most salient features being shortly described and summarily dismissed.

As such an introductory treatise, "Applied Magnetism" is lucidly written, and, so far as its scope permits, adequate and accurate. Indeed, the author can only be charged with the fault—if it be a fault—of excessive orthodoxy in his method and facts. Unit pole and $4\pi n c$ are again made to go through their eternal round. We are even thrown back on Ampère's man swimming with the electric current, which is surely an old-fashioned device for connecting direction of current and polarity. It is surprising that not a single *curve* connecting **B** and **H** for different classes of iron and steel is given; tabulated data alone appear, and Dr. Hopkinson's figures for annealed wrought iron and grey cast iron are again made to do service, although the advances of modern metallurgy are usually regarded as enabling the manufacturer to better the results of 1886. We cannot congratulate Mr. Kingdon on his adherence to his own peculiar name of "mags" for C.G.S. lines. Since a mag is nothing more or less than a C.G.S. line, what advantage is gained by the substitution of one monosyllable for another? By the adoption of rational units we had hoped to see the author solve the mag – π question, but so far from this, the whole book only illustrates the irrationality of the present system, since almost every magnetic formula contains a cumbrous constant of 1·257.

The elementary theory of the dynamo and motor is clearly set forth, and the chapter which gives the theory of non-sparking commutation appears to us a distinct advance on the ordinary text-book treatment. The short-circuited coil is not separated from the rest of the armature, and regarded by itself as possessing energy stored up in it by virtue of its self-induction. The armature and magnet are treated as a whole, and it is shown that the magnetic effect which would be due to the simple mechanical rotation must be balanced by the magnetic effect due to the changing current, so that the total flux remains constant if sparking is to be avoided. The statement that the devices of stranding or laminating the bars of large armatures are so effectual in preventing eddy currents that "the armature loss is practically only the $C^2 R$ loss" is open to question. No mention is made of the fact that as regards hysteresis the rotation of the armature core of a continuous-current dynamo in a steady field is not precisely analogous to the alternating magnetic flux of a transformer, and that there are good grounds for caution in transferring experimental results from the one case to the other.

Appendices in which the units and formulæ employed are tabulated, and a good index, add not a little to the usefulness of the book, while a final word of praise should be given to it on the score of its clear arrangement of paragraphs, good type and excellent printing.

HOUSE-WIRING.

CONCLUDING DISCUSSION ON THE PAPERS READ BY MESSRS. FRED. BATHURST AND SAM MAVOR BEFORE THE INSTITUTION OF ELECTRICAL ENGINEERS.

Speakers who have revised the abstracts of their remarks have asterisks placed against their names.

THURSDAY, FEBRUARY 27TH.

*Mr. G. BINSWANGER said he wished to add a few words to the discussion as to the manner in which this subject struck him as a manufacturer. The question whether this or that system of wiring should be adopted for any particular installation was a question to be decided by the contractor. Manufacturers had to find out what demand there was likely to arise. He came into contact with a good many contractors, and he found a general concensus of opinion that wiring in wood-casing must be some day or other superseded. It certainly was not a system which recommended itself to the fancy of an engineer or an architect. He had also found amongst contractors an idea that the fire insurance offices, and especially the Phœnix office, recommended, or even insisted upon the adoption of wood-casing. He might say that such an idea was erroneous. Mr. Heaphy had passed wood-casing because, as he had often told him (the speaker), from his point of view he had never had a failure, he had never had a fire to record; but if any system could be proposed which gave the same security—and, after all, the consideration of fire risk was the first which they had to study—and if such a system should present advantages to the engineer and to the architect, he was sure Mr. Heaphy would be one of the foremost to recommend its adoption. Contractors often asked him the question whether, if they adopted any of the new systems proposed, they would be able to obtain the materials required readily and at reasonable cost. His answer was that of course the question of supply depended upon the demand; the larger the demand the more ready the supply. As to cost, that must depend, and did depend, to his mind, largely upon the contractor himself. If he enabled manufacturers to lay down a plant to manufacture cheaply, no doubt the cost of the material would be low. The material required for wood casing had had an enormous sale for the last ten years, and naturally the cost of such material was at present very low. To compare therefore, the cost of installations of the new methods proposed with that of the old methods was to his mind unfair to the new methods. There was another question, that of standardising. Let them at the very beginning of a new system fix on standards. Every article should be standardised by a competent authority, and every contractor could use nothing else. What struck him most in Mr. Mavor's very excellent Paper was his successful attempt at standardising. The same might be said of Mr. Bathurst's system, which also lent itself very well to being standardised from beginning to end. He was inclined to suggest that some committee should be appointed by the Institution to give them some standards, which he believed every manufacturer in England would be glad to adopt.

*Mr. H. BOOT said so far as the discussion had gone very few speakers seemed to have realised the importance of the question at issue. They might say, whether central station engineers, manufacturers or whatever they were, that everything depended upon this one question. It often happened that at the same time they were obtaining an estimate for wiring for electric lighting people got an estimate for fitting with gas, and when the two costs were compared the difference was simply ridiculous. Unless they adopted some system whereby they could reduce everything to the lowest cost, especially for point wiring, he did not think that there was any good in introducing further systems. What they really required was a system that could be put up by any ironmonger of repute. It was a question very much of labour in all these jobs. If they looked critically at the cost of wiring they would find it came out that it was carpenters, joiners, and wiremen that cost the money, and not the actual material. If they reduced this labour and made the matter so simple that any intelligent man could put up an installation, they would be doing a great thing for the electrical industry as a whole. A great number of members seemed to be under the impression that electrical wiring and contracting business should be undertaken only by firms of great repute. This was natural, and was the case in the early days of the gas industry. The tubular system undoubtedly came out dearer because it had not been generally adopted, but if it were long on the market it would probably come out cheaper than the present method of wiring. With regard to Mr. Mavor's system, his experience tended to show that the fittings were rather expensive, and required a special class of labour; he was rather surprised, therefore, that Mr. Mavor should claim cheapness for his system. If the readers of the Papers had given a few more particulars as to how the cost was made up, how much was allowed for labour, how much for holders and various other items, they would have been able to judge better and compare with the present systems.

*Mr. W. R. RAWLINGS said he would like to point out a defect in the tubular system as exhibited by Mr. Bathurst. The tubes themselves were not flexible. It was of no use saying they could do without a flexible tube, because contractors were asked to place wires behind valuable cornices, which they were not allowed to cut, and unless the tube was flexible it would not answer in that case the purpose for which it was required. Another important point was that, where it was buried beneath plaster, the wiring should be nail-proof. While on the subject of insulation tests, he should like to state that he considered that the unit was some what of a myth. It was, he thought, the duty of the Institution to stamp out the workmen who were going about, the scum of other trades, who called themselves wiremen. He understood that the City and Guilds of London Institute was doing something in this direction; but whatever they might do, if they qualified the men, they would not necessarily make them honest, and it was honesty of purpose they wanted in their men. A few weeks ago they had on the table specimens of bad joints supposed to have been put in by a firm of repute. He had not the least doubt that that firm had every reason to believe their installation was put up rightly, for they assumed the honesty of their workmen. He would suggest that the Institution should have a method of registering the men. Let the members support the men so registered, and if necessary blackball those who did not come up to the standard of honesty.

*Mr. H. HUMAN said, when reading over the Papers under discussion, he recognised that the fire office question was bound to crop up, and that he was, therefore, in for a bad quarter of an hour. Though he would prefer to have ignored that part of the subject, he could not deny that it had been very prominent during the discussion, and was so vigorously handled by Major-Gen. Webber that it was impossible for him to do so. He might say, then, at the outset, and speaking only for himself, that he agreed with a great deal that had been said anent fire office inspections of electric installations. He admitted that many of those inspections were more or less a farce, and must necessarily be so; he would even venture to say that fully nine out of every ten of such inspections might well be dispensed with, being little else than a waste of valuable time, and wholly unjustified. Indeed, the day must come when the electrical inspector, pure and simple, of the fire office, would disappear from the scene, and his rules with him. With regard to fire office forms, again, he agreed that some of them were unnecessarily long; they attempted too much. A form is a useful thing in its way when kept within moderate limits. It serves as a record in the books of the company, and further enables one to judge as to whether there is any special feature calling for further attention. But a few simple questions easily put, and as easily answered should suffice. Some of those forms are very entertaining reading, and he noticed in particular that contractors have a remarkable affinity for the

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word infinity when speaking of insulation. Well, he hoped they knew what they were about when using it. There is ample documentary evidence to prove, if needed, that if the Institution recommend that all tests for insulation should show infinity, there would be no difficulty on the part of contractors in meeting that little requirement. Gen. Webber appears to be very much incensed at the present rating of central stations by the fire offices, but while he (the speaker) could quite understand that gentleman's feelings in the matter, he begged him not to put the whole burden upon the one animal. When those stations first came up for consideration the fire offices regarded them very favourably, and accepted them at exceedingly low rates. The offices have now bought their experience, and paid for it dearly, for "there stands at present a large deficit against you. There is no sentiment in the matter whatever; it is purely a business transaction. We may not be interested, as you are, in the conservation of energy, but we are very much interested in the conservation of pounds, shillings and pence. We now recognise that not only have we underated those risks, but have, in consequence, undersold our indemnity, and, as business men, are simply rectifying that little error by raising our rates." Gen. Webber objected, apparently, to being tarred with the same brush as his friends. That he (the speaker) could quite understand, and sympathised with him, for it was a process which fire office surveyors too frequently experienced at the hands of engineers when dealing with electrical matters. But in Gen. Webber's case he failed to see how it could be obviated, for it must be remembered that where you legislate for a class there must be no exemption in favour of individuals. As so often happens in other matters, the good have to pay for the bad. That might be poor consolation for Gen. Webber, but it was the best he could offer him under the circumstances. As to making reductions in favour of electric lighting—particularly in such buildings as dock warehouses—he would remind Gen. Webber that the lighting was by no means the one and only thing to be feared, but that the risk in such places was inherent in the varied nature of their contents, and to allow for electric lighting in those risks would, indeed, be straining at a gnat and swallowing a camel.

Mr. J. N. SHOOLBRED said he would confine his remarks to one particular point, and that was with regard to the table of insulation tests which Mr. Bathurst had put in his Appendix B. He was very glad to see that in that table Mr. Bathurst had adopted as the basis for the test the ampere and not the lamp, as was commonly the case with several of the various sets of rules we had in use in this country.

*Mr. DYKES said at the present time the question which was the best system of electric wiring was on a par with the question, which was the best engine or boiler. It simply depended on the circumstances of the case. In fact, practically every system which had been mentioned was good in the proper place. They had heard a good deal in dispraise of wood casing, but he maintained that if proper care was taken and wood casing was put in the proper place they could make quite as good a job with it as with any other device. He had in his mind at that moment an installation where, he thought, they had a sample of pretty nearly every kind of wiring which had been mentioned. There were certain rooms having a good deal of panelling and there, naturally, one would put in wood casing to match the woodwork, and if it were properly put in and properly used he contended it was as safe any other parts of the installation. There were other parts where the wires were simply run in iron pipes coated with Angus Smith's composition, those places being conservatories, stables and so on, where it was important to have the wires thoroughly protected and where there were no decorations to be studied. In still other parts of the same installation were wires run in compo piping placed where it was impossible to be damaged by nails. The concentric system of Mr. Mavor certainly possessed considerable advantages in cases where it could be used. It did not matter what system of wiring they used, it seemed to him; the trouble was not in the wire or in the conduit system itself; it was practically always at the accessories, the switches, fuses, and so on. If they made the switches, cut-outs, wall plugs, and so on, good, they could pretty well use any system of wiring they liked, provided, as he had said, they suited the system to the place where it was to be employed. With regard to the use of iron pipes carrying insulated leads, the pipes being uninsulated, they were told by Mr. Bathurst that if they wished to use iron pipes they must insulate them inside. He (the speaker) maintained that that was entirely wrong. If they were going to use an iron pipe they should not insulate it at all. If they had leakage from their wires, then let it go direct to earth, blow the fuse, and all would be over. That meant, of course, they must break up their system, and only use comparatively small fuses; in fact, he went so far as to say they should not use anything larger than circuits to carry five or six lights. In the class of buildings which was now becoming so general for insurance offices, banks, public halls, &c., where the flooring was of wood blocks laid direct on the iron and concrete fire-proof floors, and where the walls were faced with marble, tile work, or hard plaster he was of opinion that the iron pipe system offered advantages over all others. As his firm had had some considerable experience of that system, a few particulars might perhaps be of interest. To begin with, they found that it could be put in at a cost not exceeding that of good wood casing in a similar building. The pipes were laid as the work went on, the cement floors being floated over them, thus avoiding the usual cutting away of plaster, floors, &c., and although some of the pipes might be in position months before they were covered by the floor blocks, tile work, or plaster, no damage was done and not a single yard of wire had to be replaced through being damaged by workmen. The heavy joiner's bill, too, was, of course, abolished. There was no trouble in getting a very high insulation, as high as with any other system; it only meant, as usual, that fittings, switchboards, &c., must be well insulated; until these were put up the insulation was practically infinite. As the current was generally switched on in sections, as the work was finished, it was often difficult to get a test of the installation as a whole; but he might say that a test at a City bank wired to their specification on this system gave, when tested some weeks ago, and repeated once or twice at intervals, an insulation of 1½ megohms for 135 lights. At a similar installation a section of 40 lights, tested the day before, gave only the faintest movement on the ohmmeter, which was calibrated up to 5 megohms. In both these cases the switches were let in flush with the tilework, and in the former case there was a large number of points on glazed brickwork in the cellars. At another installation in a private house, tested a week or so ago, where a mixed system was used, the total number of points was 114, there being four distributing boards, and the insulation of the whole above earth was 2·9 megohms. These figures would show that it was not at all impossible to get very high insulation by taking a few precautions, although at the same time he personally put very little trust in insulation tests. They had an iron pipe installation of about 430 lights where all switches were, as usual, sunk in the tilework, hidden by fancy metal-cover plates. In this instance switches of the "tumler" pattern were used, the flat cover plate being screwed on in place of the usual cover. With these plates off the installation tested out quite as well as the rest, but when the covers touched the tile work the leakage over the numerous switches was sufficient to bring down the insulation very considerably indeed, although still above the ordinary fire office requirements. This could be remedied partly by slipping a piece of mica between the plate and the tile. Their fuse boards, always of marble, as they found slate too unreliable, were carefully insulated on porcelain or ebonite insulators from the iron frame or wooden bearers. If the marble touched the iron at any part down went the insulation. The ideal system would be, of course, to connect all fittings, electroliers, standards, &c., direct to the iron pipes, but at the present time it was found impossible to get sufficient insulation between the frame and the lamp holders to allow of this being done, and it was necessary to carefully insulate the fittings from the pipes. One point in conclusion seemed to be of importance—the question of gas mains touching the iron pipes. He urged that the iron pipes should be continuously connected throughout, and an efficient connection from the pipes made to earth at one or two points; then it would not matter whether the pipes touched gas or water pipes, or, as was certain to happen, the iron joists of the building. Unless these precautions were taken it was conceivable that serious consequences might follow.

*Mr. R. E. B. CROMPTON said the remarks he wished to offer lost a great deal of point through being given at the wrong end of the discussion. He had intended in December to open the discussion by pointing out to the members that a committee had been sitting for some months to revise their wiring rules, and that that committee looked with great interest to the discussion to follow these Papers, as the question of casing and of various systems of conduit and concentric wire has been under consideration, and they hoped to hear the experience of members in regard to the use of these various methods. To a certain extent they had been disappointed in this, and he regretted very much that so few remarks had been made by those who had used these systems and who, they had hoped, would have given them their experience. It appeared to him that they were on the eve of a very great revolution in the art of house-wiring. The new Board of Trade regulations in allowing the use of a greater pressure were also stipulating that one side of the system should be earthed, and therefore they had to contemplate a new condition of affairs, and they had really now to consider whether they could not at once direct their ideas to the most perfect system of wiring, which he thought had been already mentioned by one speaker, by putting one highly-insulated wire concentrically within a pipe which at the same time formed the casing and also formed the return wire. That did appear a very perfect system. No doubt it had many disadvantages for those accustomed to the present systems, but he believed that when thoroughly thought out they would really get to that in the end. They had to thank Mr. Andrews and Mr. Mavor for being practically the first to lead them in that direction. He believed he was one of the first speakers who had done justice to those gentlemen. His firm had used a considerable amount of concentric wiring, and it had been very successful. He was quite surprised to hear so little said in praise of the system by other speakers. No doubt it had been more used in factories and places of that kind than in private houses, but it had been used in very difficult situations, in places where it would have been difficult to obtain high insulation by the ordinary methods, and it had obtained that insulation by what he might call the air-tightness of the system, every single part being closed and the insulation resistance kept up by preventing the entrance of damp to all those very weak points to which previous speakers had called attention, the points at which the fittings were attached. This concentric wiring system was the only one which thoroughly drew attention to the importance of protecting and making continuous the casing up to these points where the air could be excluded from the insulation. It appeared to him so easy to do with the concentric system and so difficult with the double-wiring system that it pointed very much in favour of the concentric system. There was another point which had not been sufficiently dealt with, and that was the lamp fittings. Mr. Mavor had said how much superior the concentric lamps were to the ordinary kind. He thought they would find the double-wire lamp fittings which they had been using for some time past a great nuisance and very expensive, and householders would find that they made their insulations very costly to maintain. The reason was obvious; they had to get a number of small parts, and it was difficult to make comely fittings with so many small parts. This was greatly avoided by the concentric lamp fittings, and was a point strongly in their favour. He thought they might find other strong points in the extra simplicity of only having one insulated wire. He wished very strongly to say, speaking as one of the committee on wiring rules, that one of the real good things they had got out of this discussion was the strong condemnation of casing, and it was evident that the days of casing were numbered. Casing had been a very good servant when nothing else was available, but the time has come when they must go in for something more substantial and less liable to cause a

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trap in the shape of electrolytic bridges between the wires. There could be no doubt that it had caused these traps and that fires had resulted, although probably Mr. Heaphy would not admit it.

Mr. BATHURST, in his reply, said that an analysis of the criticisms advanced would show that the economical rather than the technical side of the question had been taken throughout. Starting with his five cardinal points for good wiring—safety, durability, convenience, accessibility, and economy—although convenience had, in some small measure, been touched upon, the last two points were the only ones that really stood questioned. Taking accessibility first, perhaps the main criticisms were at once removed when he stated that he used this word mainly in the sense of reliability. Conductors were not to be pulled in and out, except in the case of mishap; but he maintained that it was a factor of paramount importance to feel that it was possible to remove or replace electric conductors without any disturbance of their surroundings. It was Mr. Corlett, he thought, who said he was of opinion that there was a great deal of unnecessary prejudice shown about burying wood-casing enclosing wires directly in plaster, and argued that they had never yet heard of householders complaining of the "inaccessibility" of their gas pipes. Perhaps not: but a gas pipe, under ordinary circumstances, would not allow more than a certain quantity of gas to pass through it, no matter how many burners were put on to it; the flow of gas could never damage the pipe. If gas pipes had an unfortunate facility for leaking or bursting upon the slightest provocation, say upon the appearance of moisture or an unanticipated extra consumption, would they not have complaints? Would not every gas pipe have to be accessible? Several speakers have intimated the necessity of controlling the work of irresponsible workmen or contractors; have any suggested a "check" which is more legitimate or satisfactory than "accessibility"? Turning to economy, this was really the crux of the whole question. It appeared at least to be tacitly admitted that wood-casing was technically wrong and undesirable, although its cheapness and ready convenience were in some quarters considered to outweigh its immediate or prospective disadvantages. As he had tried to point out the technical defects incident to its use and employment, those conservatives who still pinned their faith to it had questioned conduit methods on the score of economy. He would try and rebut their statements. Those critics all admitted the mischievous and harmful commercial conditions which now obtained in the electric wiring industry, and in face of the complaints rife from every section of it they could indeed hardly do otherwise. He believed they had reached the turning point when inquiry into their present methods must and would be made, for, in spite of an enlarging commercial field it could almost be said that no one was deriving any benefit. The wireman complained that he could not make a "living wage," and was being ousted by inferior workmen. Wood-casing manufacturers said that they made casing without profit, and simply in order to keep their moulding machines full of work. The porcelain manufacturers were combining in an endeavour to keep up even present prices, whilst the sum total effect was being most seriously felt by the electrical supply houses, who were asked to make cheaper fittings and extend longer credit. Those conditions must be faced and a solution found. He contended that the principle they had heretofore been working upon was incorrect. They had been using wood-casing and metal pipes, and by so doing had not only introduced unnecessary difficulties and troubles, but had crippled themselves commercially. For want of any suitable protecting medium they had had to adhere to highly insulated, costly and expensive wire, but as a principle they had insisted upon having electric conductors insulated so that they could practically look after themselves without receiving anything beyond a slight mechanical protection from the supporting or surrounding medium. They had now nearly exhausted that demand for wiring which came from those who were willing to pay any price they were asked, and were beginning to feel the pinch and necessity for lower cost wiring. He held that wood casing or ordinary metallic piping was unable to meet those conditions. Let them take the cost per point to a contractor for wiring a certain building, as say 10s. per point (that was for the wiring only, without fittings), the analysis of this cost would probably be approximately, 1s. 6d. for wood casing and accessories, 4s. 6d. for wire and jointing material, 4s. for labour of erection. Casing was the lowest item, whilst labour and wire came out about equal. His contention was that it was advantageous to the contractor to employ methods which would reduce the labour item, and perhaps also the wire item, even if the other one remaining—casing or other supporting material—was thereby increased. If using the plain insulating conduit then before them, the work would cost, say, 3s. for insulating tubing and accessories, 3s. for wire, and from 2s. to 3s. for labour of erection. The special twin wire to be used was listed at prices 25 per cent. lower than the ordinary 400-megohm quality, and contractors could testify to the satisfaction it gave, and the labour-saving possibility of conduit methods. He was speaking from what had already been done, and stood by the statement that contractors could buy plain tubing and special twin-conductor wire together at the same cost as ordinary wire, so that the cost of wood casing was entirely saved. Technically considered, wiring of that nature must, on fair examination, admittedly be at all points superior to that employing wood casing; practically it has distinctly proved itself so in other countries, and it was making its reputation in England. Answering Mr. Rawlings' point as to "flexibility," he did not think that this was really necessary, and did not know how to make a flexible conduit "nail-proof" without making it "as hard as iron." Several speakers had advocated that iron piping was preferable to wood casing, from the fact that it afforded better mechanical protection. He was glad to hear one engineer at least—Mr. Campbell Swinton—say his experience made him believe that iron piping led to as much and even more trouble electrically than wood casing. Many well-known contractors had personally told him (the speaker) of the troubles they had already experienced with iron pipe—some of those faults were caused electrolytically, others of the damage done to the rubber insulation by excess of oil used when screwing up the couplings of pipe length; others of mechanical injury to wires whilst being drawn in, but strange to say, they had in that room, before their brother contractors, preferred to remain silent. Surely it was better to face the question there and find solution rather than wait until the public themselves decided whether or no there was any cause to find fault with it. Economically, however, they had no ground to stand upon; they could not, if following their present lines, give a system of iron piping with two or even one insulated copper wire inside it, and compete in price with ordinary gas piping. Although it might appear paradoxical, that could be achieved with an insulating-tube system, even if that tube had to be iron-armoured throughout its length. One or two speakers had doubted the necessity of placing an interior insulation on the inside of an iron pipe. They could take it that if it was doing no actual good there, it was at least doing no harm. The main fault in their eyes was that it added extra cost. It would be allowed that a lining prevented mechanical damage to the wire and increased the facility with which wires could be drawn in. It prevented internal condensation, and so obviated the presence of moisture and consequent rust. It must, therefore, tend to preserve the conductors under more favourable conditions. The insulating coating being under the iron pipe was not liable to any chance mechanical injury, and therefore, some sort and thickness of insulation could always be depended upon. In other words, insulation was added to the conductors. Did not this fact of being able to preserve some insulating material intact under all circumstances tell against those who advocated a very high insulation on the wire itself? His statement as to the actual insulation that particular lining gave to conductors within it, and the voltage it could stand without breaking down, as well as its shielding and subduing effect in the case of a short circuit, he could only accentuate by asking those interested to verify by test. Two million lamps were making that test in other countries. So much for technical reasons for advocating insulated iron pipes. If economy was sought, the co-operation of the wire manufacturer must be invited. Without arguing the fact that the present quality wire had primarily been designed to look after itself, and that instances had been given by which its possibilities in that respect could be proved, and admitting that the present type of insulated wire was as near the margin of efficiency as it should be, consistently for present methods, it could be urged that other types could and should be found. Had those who cried out against permitting lower insulation wires ever considered their own practice? Had those critics ever protested against the use of the ordinary flexible cord? The insulation test on that (excepting the vulcanised variety) could not be taken in water, and probably gave 300 megohms in open-air conditions. The insulating medium was a thin strip of pure rubber secured by a cotton covering. Oftentimes the rubber was a covering only in name. Yet experience surely sanctioned its use and admitted its convenience and economy. Did those critics remonstrate because they found commercial exigencies made it convenient to put further trial on that thin insulation by hanging a 3lb. or 4lb. weight at the end of each cord in the shape of lamp holder and shade? What did they say to its further aggravation by passing it over a number of friction pullies in adjustable fittings? The present stress of competition was noticeably increasing the amount of flexible cord being used, and his critics must notice that single lamps were rapidly changing into three or four light clusters. The development of that practice might not prove that it was right or even desirable, but he maintained that it did point to the possibility of getting away from the "megohm" variety of wire. What harm, he asked, could result even if wires of no better insulation, were installed, in an armoured insulating tube which could look after them mechanically and electrically, and in which any short circuit it was possible to make under practical conditions was rendered innocuous. Once this question of wire was settled, they saw the gain of further advantages from conduit methods. A small twin conductor was employed which required a tube of smaller orifice for the conveyance of electricity than was required for the conveyance of gas, taking light for light capacity. An armoured insulating tube created the possibility of a large labour saving factor, for sliding couplings and cemented joints could be used and would make a water tight electric system. Screwed couplings were rendered necessary in gas piping so as to successfully resist the internal pressure. Working on centre of distribution methods they would find that only ⅜in. and ½in. tubes need be used, for all twin conductors up to 5 or 6 ampere capacity would go into the former, and up to 10-12 ampere capacity in the latter. Sub-mains could feed from main fuse and distributing boards in ¾in. or perhaps 1in. tubes. The bugbear of wood-casing, the difficulty of estimating labour, would be removed, because the conduit wiremen would put up tubes by contract per foot run as was now being done with gas piping. Tenders for work would then become comparable with one another. He would like to support Mr. Geipel in his statement, or in his belief, that the Edison lamp holder was the best yet produced, both for socket and lamp; the vibration difficulty had been entirely overcome, and the holder satisfied every requirement. His belief was that they were already in a position to compete directly with the cost of gas piping. Insulating conduits had prejudice to overcome just as the other innovations of modern days. It might be of interest for them to learn that in spite of difficulty and opposition the last nine months had not been wasted in respect to the particular system he advocated, for, thanks to the co-operation of the General Electric Company, they could estimate that some 25,000 incandescent lamps in England were already testing the merit of conduit methods. So far he had only dealt with the criticisms made on his own Paper; but if it would not try their patience too much he would like to refer to points of resemblance and dissimilarity between Mr. Mavor's Paper and his own. He must challenge Mr. Mavor to show the superiority of the concentric system at any point, mechanically, electrically, or commercially. Again, whilst he appreciated the ingenuity with which Mr. Mavor had worked out his metal joints, he considered that it was open to criticism at least from its electrical functions. Poor joints heated and caused trouble

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They had taught their wireman that he should never depend entirely upon solder for a jointing connection even if he must occasionally use it as a fuse. He had been told to make a mechanical connection and rely upon solder to make it airtight. It seemed to him that Mr. Mavor required his solder to fill a current-carrying function. At any rate the simplest method of jointing would be preferred, and, given his choice of two evils, he would rather chance an ordinary mechanical connection under a screw head. The main objection he made to the concentric system Mr. Mavor so admirably and forcibly advocated—and sooner or later those points would have to be fully discussed—were lack of accessibility and the grounding of the outer. Accessibility he had already accentuated, but he thought conviction grew upon one the more the point was discussed. Mr. Mavor twitted accessibility as a "relic of olden days." It might be so, but there are many engineers who would cherish it for some time to come. As regards grounding the outer, that one question could be discussed with an evening to itself. Even admitting the desirability of earthing the outer in street mains, personally he did not see the wisdom of enlarging the distributing network *ad infinitum* by including customer's premises. That end he would rather suppose should exist only with both wires insulated. The consumers' wires had to be installed under every kind of trial, contiguous with gas and water systems and passed over steel girders and other metallic constructions. Would Mr. Mavor have all those earthed as well, as if not he feared hazardous conditions would arise. The risk of electrolysis might be greatly over-estimated, but the troubles referred to in America had, he was creditably informed, convinced the authorities that even one-thousandth of a volt difference of potential was too much, and meant deterioration, if not destruction to gas and water pipes and other metallic bodies in the vicinity. After listening to Mr. Mavor's eloquent exposition of the advantages of a grounded outer, he was surprised when on his last page he suggested two simple remedies which *might* be adopted. He should like to have heard some discussion on that point, particularly when they had heard Mr. Andrews express his pet ideas, and they found the two champions at variance. Mr. Mavor seemed to imply the necessity of keeping intact (by a protecting lead sheath) a light insulation over the whole length of the outer conductor, except at distant ends. That being so, he asked him why not keep a slightly heavier one, and, following Mr. Andrews' leadership, use an iron armour instead of a copper tube, and having got so far he should by preference put two insulated conductors inside it. When Mr. Crompton could show them how to use one insulated wire in an ordinary iron pipe, he would try and prove commercially the advantage of putting a *bare* conductor in an armoured insulated pipe.

LONGITUDINAL LIGHT.*

BY G. JAUMANN.

The following theoretical dissertation consists of two portions: in Chapters 1, 2 and 5 results are communicated concerning the nature of light in a vacuum and of cathode rays, which follow from the experiments of Elster and Geitel, Lenard, and the author taken together; in Chapters 3 and 4 a theory of electric phenomena in rarefied air is propounded, which makes cathode rays and kindred phenomena perfectly intelligible.

I.—Determination of the Direction of Vibration of Electric Rays.

Introduction.—In a previous Paper † (1888) the following law of discharge was propounded: "Oscillations of electric force taking place immediately at an electrode and in a direction normal to it (*see* pp. 793 and 802) have a specific favourable effect upon the discharge, but, in order to have an appreciable effect, their amplitude must be the greater, the greater their vibration period."‡

In the present state of our experimental resources this discharging effect may be produced not only by light, but by electric rays falling upon the electrode, and by electric wire waves conducted towards the electrode. In all these cases the effect shows a distinct difference of species.§

The oscillations of electric force have a greater effect as the static electric field in the immediate neighbourhood of the electrode increases in strength. The product of these two factors determines approximately the occurrence and current strength of the discharge.

* *Wied. Ann.*, 57, 1, pp. 147—184, 1896.

† Jaumann, *Wiener. Ber.*, 97, p. 765.

‡ Of this specific effect of electric oscillations the Hertzian effect of ultra-violet light (1887) is a special case. The fact that the period of the oscillations with which I worked was 10^6 times as great, and the amplitude had also therefore to be 10^6 times that of the ultra-violet light, made it very much more difficult to discover that these slow oscillations also have a specific discharging effect. But decisive experiments were quoted (*see* pp. 785, 788, &c.) to show that these great and slow oscillations do not only act by increasing the electric intensity of the field. To a first approximation the product of the amplitude into the frequency (or, in other words, the maximum rate of change of the electric force during the oscillation) is a measure of the discharging effect.

§ My experiments may also be regarded as an imitation of the Hertzian light experiment by means of wire waves, but they were undertaken as original research. At that time (1888) the imitation of light experiments with slow electric oscillations was not yet undertaken, since electric rays were still undiscovered. Also the absence of effect from ordinary light would have militated against the supposition that electric waves of still greater period should again be effective, which, nevertheless, is the case.

Method.—The above law of discharge offers a means of investigating electric rays. This method has been found effective, as will be shown in the cases governed by Maxwell's theory, and is now to be applied to further phenomena.

The law of discharges was propounded without reference to the range of phenomena to which it is now to be applied. Experiments with electric rays, or photo-electric experiments, have hitherto not contributed anything new to it. Neither have theoretical suppositions in this direction influenced the formulation of this law. It is easily recognised, by the whole manner of expression and the date of the Paper referred to, that it belongs to the pre-Hertzian period.

Limitation of the Method.—Since it is almost exclusively the electric oscillations taking place in the immediate neighbourhood of the electrode surface which influence the discharge, a free ray can hardly be tested by the aid of discharge experiments, but only a ray reflected by a conductor, good or medium, or by an electrolyte—and even then only at its point of reflection. But beside the Hertzian rays there are also luminous rays and rays of a different nature (cathode rays) which are open to our method.

Further, the ray is not tested under normal conditions, but in the presence of the discharge, or, at all events, of the great static force of the field. The ray does not simply superimpose itself upon the discharge field, but produces the discharge, and therefore may also itself suffer a modification.

Testing the Method by Hertzian Rays.—According to the discharge law, only that component influences the discharge which coincides with the normal upon the electrode. A vibration parallel to the surface has no influence whatever.*

This gives a means of experimentally determining the direction of electric oscillation of a ray.

Faraday, Hertz,† Naccari‡ and others describe experiments which I should describe as the production of a discharge by the Hertzian rays proceeding from an adjacent discharger. They describe this effect as undirected, however. But according to the discharge law the ray must show a maximum effect when its electric oscillations are perpendicular to the electrode surface, and none when they are parallel to it.

Mr. J. Wanka§ made this experiment (different orientation of the exciter) with the complete effect predicted, and that not with a convection discharge, where it is quite easy, but with a spark discharge, which requires great delicacy.

We see, therefore, that the direction of the electric oscillation of a ray may be determined by discharge experiments.

Proof of the Electric Nature of Light.—By reference to the discharge law, *i.e.*, the experimentally studied effect of electric oscillations, the Hertzian light experiment may be regarded as a qualitative proof of the electric nature of light, supposing that the vibrations of no vector besides that of the electric force have any effect. There is no reason to suppose otherwise.

Now, according to Hertz, light favours discharge. Hence one of the vibrating light vectors is electric force.‖

Confirmation of the Discharge Law in Photo-electric Phenomena.—Theory gives us information concerning the direction of vibration of a polarised ray of light. On the strength of my discharge law it was predicted in 1892¶ that a polarised light ray can only have a discharging effect when its electric oscillations have a component in the plane of incidence. The experiment referring to this, which Hertz (1888)** and Wanka (1892, *loc. cit.*) had unsuccessfully tried to perform, the former without special theoretical views, did not succeed in my case either, owing to the difficulty of obtaining strong parallel polarised ultra-violet light.

This difficulty was surmounted in a beautiful manner by Elster and Geitel,†† who had found that alkali metal electrodes are sensitive to ordinary light, and who employed a mirror of potassium-sodium alloy as an electrode. Their experiment (1894) had almost perfectly the effect predicted (1892). A ray falling under the angle of

* Elster and Geitel have not yet accepted this proposition, in spite of their measurements with polarised light. They say (*Berl. Akad.*, p. 213, 1895; *Wied. Ann.*, 55, p. 692, 1895): "A ray of light oscillating in the plane of incidence excites a stronger photo electric current than a ray of equal brightness vibrating parallel to the cathode surface in the proportion A : B." The ratio B : A may increase up to 1 : 3.

† Hertz, *Ges. Werke*, 2, p. 288.

‡ *Wied. Beibl.*, 13, p. 421, 1889.

§ Wanka, "Mitth. d. Deutschen Math. Gesellsch. in Prag., 1892." It is easily seen that this work was executed under a course of ideas suggested by myself.

‖ The explanation of the Hertzian light effect as a special case of my discharge law was published in 1892. The previous explanations by Wiedemann (1888) and Elster and Geitel (1891) only assume intermediate electric effects. They proceed from the assumption of a *resonance* of the molecules of the cathode, and no conclusion was arrived at with regard to polarised light. The molecules can hardly resound both to ultra-violet light and to vibrations 10^6 times slower.

¶ *See* also Jaumann, *Wied. Ann.*, 55, p. 658, 1895.

** Hertz, *Ges. Werke*, 2, p. 289.

†† *Wied. Ann.*, 52, p. 440, 1894; *The Electrician*, Vol. XXXV., June 21, 1895, p. 272.

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70deg. has almost no discharging effect when its electric oscillations are normal to the plane of incidence.

By a precise prediction of this kind my discharge law receives a great claim to confidence. In the following it shall be utilised—

(1) For determining the direction of vibration of cathode rays, with reference to previous experiments by Lenard and myself (Chap. 2);

(2) For determining the direction of vibration of light in rarefied air, with reference to the measurements of Elster and Geitel (Chap. 5).

Simple Validity of the Discharge Law.—The whole range of discharge phenomena is open to explanation in various essential points. A complete insight into the nature of the discharge is certainly not afforded by the discharge law alone. It is all the more remarkable that this law may be so simply and smoothly applied to the remote optical experiments. This facility, this elimination of doubts, without further ado, is a sign that the present investigation has a good direction.

The excitation of discharge by variations of force is the simplest of all discharge phenomena, the first generalisation from them, and the point of departure for theory.

II.—Nature of Cathode Rays.

Occurrence of Interference Surfaces in the Blue Cathode Light.—Under this title I published in 1892 a Paper which is connected with what follows; I therefore take the liberty of quoting its most essential parts, especially as it is rather inaccessible.

(From the "Mittheilungen der Deutschen Mathematischen Gesellschaft in Prague, 1892"—abstracted in *Wied. Beibl.*, 17 :—)

"The cathode rays, according to Hertz, take no part in the discharge; they are more like rays of light emitted by the cathode, but light rays with special properties. E. Wiedemann considers them to be ordinary ultra-violet light. This would, indeed, explain their high absorption, but not the peculiar deflection phenomena, and it would be unintelligible how the cathode could emit parallel-rayed ultra-violet light. It is much more obvious to suppose that the cathode rays are longitudinal electric waves, or we might say *longitudinal light*. Such waves must indeed be emitted by the electrodes under the violent alternations of potential which they undergo. The high absorption of these rays may be a peculiar property of theirs, and for this reason natural light might not have any longitudinal components. Perhaps Hertz also inclines towards this assumption, since he compares the magnetic deflection of the cathode rays with the magnetic rotation of the plane of polarisation of light.* About this, interference experiments must inform us. In the following, a few experiments on this matter are described, which, however, do not imitate interference experiments of optics, but adapt themselves provisionally to the peculiar nature of cathode rays. A periodicity of cathode rays could not be proved, but the great influence exerted upon their interference by their coherence and their equal phase could. Possibly the wave length of these rays is very great.

"When I first made a minute observation of the discharge in a so-called electric egg—*i.e.*, between spherical electrodes in rarefied air—I observed, in the re-entrant angle in which the negative ball joins the stem, a conical surface shining much more brightly than the blue stratum, which surrounded the stem like a collar and bisected the re-entrant angle. This is produced by the interference of the blue stratum proceeding from the ball and from the stem. But it is curious that this interference and the greater luminosity thereby produced is limited to a well-defined surface of mean position. If a flat negative electrode is placed opposite a cylindrical one of parallel axis, a sharp parabolic interference surface is obtained. The interference surface between two flat surfaces inclined to each other is plane and bisects their angle. With more complicated cathodes these interference surfaces are found at all constricted places in the blue cathode light. Owing to their greater luminosity these surfaces appear to protrude beyond the blue strata. The position of the positive electrode in these experiments is almost irrelevant. These interference surfaces are strongly distorted by magnetic forces, and that just like cathode rays proceeding along them from the cathode. The cathode rays, proceeding normally from the two cathode surfaces, are therefore deflected together, and proceed along the interference surface.

"For the closer study of the phenomenon two elongated parallel plates 1cm. apart were used as a cathode, the positive plate being fixed equidistant from their ends and normal to the negative plates. The two negative plates cover themselves both within and without with the blue cathode light, but the inner layers are much narrower, brighter, and nearer to the electrodes. This may be due to the deflection of the cathode rays by the second cathode plate, which may be greater at higher pressures, just like the magnetic deflection. When the pressure is diminished these blue strata approach each other and finally coalesce, forming a well-defined plane limiting surface, which finally remains alone and accurately bisects the space between the two plates. The cathode rays run parallel to the cathodes in this interference plane, but emerge from between them in all directions.

"From the negative pole of an influence machine provided with a spark gap, two wire connections are brought to the cathode plates. In this case the interference plane is quite sharply defined even when the wires are many metres long, but only when the wires are perfectly equal in every respect. With quite small differences of length, say 10cm., the plane is considerably broadened out. With still greater differences the whole space between the plates is filled with light, which finally collects about the plate connected with the shorter wire. Hence the electric rays produced by the spark gap and approaching through the wires must arrive at the cathodes with exactly equal phases in order that the cathode rays may form the interference surface. If the two cathode plates are joined by a long loop of wire and the negative conductor of the machine is joined by a sliding contact, the great sensibility of the interference surface for any displacement of the contact from the middle of the loop is very evident. If we may judge from this sensibility concerning the wave lengths in the wires which produce the cathode rays, we must regard them as varying from 0·5m. to 1m. I have sought other points along the wire loop distant by whole wave lengths, and therefore equally as suitable as the centre, but have not succeeded in finding such points, evidently because it is waves of very different wave length which produce the cathode rays." The *broadened* interference surface observed after a slight displacement of the contact from the centre corresponds, we may say, to a spectrum of interference surfaces belonging to cathode rays of different frequencies.

Cathode Rays in the Axis of Symmetry.—I shall first mention the obvious reasons for regarding the cathode rays as longitudinal electric waves.

First and foremost we have the strong occurrence of the cathode rays in the axis of symmetry of discharge space. Their intensity is greatest there and decreases outwards. These are, therefore, longitudinal or scalar, if only from considerations of symmetry (at least along the axis, *i.e.*, essentially). The latter alternative is excluded, since they were recognised long ago as *electric* waves (E. Wiedemann, Hertz).* A radial or tangential transversality may, of course, occur at their bounding surface without being essential.

I can only understand E. Wiedemann definitely, and Helmholtz (in the letter referred to) questioningly, attributing transversality to the cathode rays if we imagine them to be phenomena of irregular and varying transversality like natural light, but do not consider this either as sufficient or advisable.

Necessary Presence of Longitudinal Electric Waves.—It is quite a special property of the Maxwell-Hertz equations that they do not admit of longitudinal waves. Almost any modification of them makes longitudinal waves appear as possible.

Now it is especially rarefied air which is so peculiar with regard to electric phenomena that it is impossible to regard Maxwell's equations as sufficient. The mere fact of discharge already contradicts them.

But with the invalidity of these equations there is room afforded for longitudinal waves, and these will actually occur when the necessary limiting conditions are given.

This necessary condition is given by the variations of electric force at the electrode surface, produced by the waves approaching along the wires. In fact, the cathode rays become much more vivid when a small spark gap is introduced, thereby increasing the intensity of the wire waves.

Frequency of the Cathode Rays.—The experiments referred to concerning the behaviour of interference surfaces when the sliding contact is displaced give a clear indication of the order of magnitude of the period of the cathode rays. The exciting wire waves have lengths of the order of magnitude of 1m., and therefore a period of 10^{-8} to 10^{-9} seconds. This is probably also the period of the cathode rays. This experimental deduction places me in the strongest antagonism to the assumptions of all other workers.

* As will be seen, I was the first, and I believe the only one who had reasons (1892) to explain the cathode rays as longitudinal electric rays. I am pleased to think that at that time I already stated that I conceived the idea on reading Hertz's work (*Wied. Ann.*, 19, p. 782, 1883). Hertz has never published anything concerning his opinion of cathode rays. Still, it has been recently proved that he considered them to be longitudinal electric waves (of Helmholtz's theory?). This follows from a letter by Helmholtz to Hertz, written in 1883 and published in the *Ges. Werke*, and from a passage in the manuscript of a lecture delivered by Hertz at Kiel in 1884, and now in the possession of his widow.

* After Hertz's views those of E. Wiedemann most closely approach my own. He was, as far as I know, the first to compare cathode rays with light. Further, he also (1884) searched for longitudinal electric waves, and regarded the positive stratified discharge as a longitudinal electric wave (*see* G. Wiedemann, *Electricität*, 4, p. 593). Quite recently (*Zschr. f. Electrochem.*, 8, 1895) he definitely abandoned the transversality of the cathode rays, and declared them to be vortex motions in the ether. This may be a basis for future agreement.

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E. Wiedemann regards them as ultra-violet light, and therefore attributes to them periods of 10^{-15} to 10^{-6} seconds. In that case the existing wire waves would have to have lengths equal to those of ultra-violet light, and this contradicts my experiment. Lenard goes so far as to attribute wave lengths of the order of magnitude of the molecules to them, as they are to be diffused by the molecules.

But with their ultra-violet nature the cathode rays also lose their transversality. For if they were transverse, without being ultra-violet, they would be ordinary light or Hertzian rays. But this they cannot be, since they have totally different properties.

The proof that cathode rays have the period of ordinary wire waves is therefore a further proof of their longitudinal character.

Experimental Proof of the Longitudinal Character of Cathode Rays.—This proof is founded upon the discharging effect of cathode rays, with the aid of the method developed in the first chapter.

About this Lenard* has made experiments which suffice for this proof, although they have not yet been sufficiently varied.

According to Lenard the cathode rays have a strong discharging effect. They are therefore electric waves of great amplitude. The cathode rays also have strong discharging effect when their direction is perpendicular to the electrode surface. *Hence the direction of their electric oscillation coincides with their direction of propagation.* They are rays with a great longitudinal component, and, therefore, from symmetry, essentially pure longitudinal electric rays.

(To be continued.)

* *Wied. Ann.* 51, p. 207, 1894.

PHYSICAL SOCIETY.

At an ordinary meeting of the Physical Society, held on February 28, 1896, Prof. John Perry, Vice-President, in the Chair, Sir D. Salomons showed some experiments with incandescent lamps. A large electro-magnet is excited by means of a continuous current, while an alternating current is passed through an incandescent lamp. On bringing the lamp near the magnet the filament is set in vibration, which, if the lamp is brought sufficiently near the magnet, are sufficiently intense to break the filament. The number and position of the nodes formed in the vibrating filament are found to be independent of the natural period of the filament, but depend on the frequency of the alternating current.

Prof. S. P. THOMPSON asked whether it was not found that the number of segments into which the filament is divided depended to some extent on the natural period of the filament.

Prof. AYRTON said that the magnetic leakage was very large with the arrangement adopted, and he would like to know whether this method was a more sensitive one for mapping out the field than those ordinarily employed. In an instrument designed by Prof. Perry and himself, an alternating current was passed through a wire stretched between the poles of a magnet, and the tension of the wire was altered till the vibrations set up were a maximum. The natural period of the wire, and hence the frequency of the alternating current, was then deduced from the tension, &c. In Prof. Ewing's magnetic curve tracer, on the other hand, the natural period of the stretched wire was made as different as possible from the period of the alternations which were to be observed, so that the natural vibrations of the wire did not influence the results. The author's arrangement appeared to him (Prof. Ayrton) to be intermediate between these two, and it would seem that the natural period of the filament would to a certain extent influence the results.

Prof. PERRY suggested that the lamp might be held in a very steady support, so that after the large vibrations due to the natural period of the filament had died out, the vibrations of the period of the alternations alone could be observed.

Sir D. SALOMONS, in his reply, said that the arrangement was not intended for making *measurements*. A lamp had been fixed in a steady clamp, and the current passed for many hours, but the character of the vibrations remained unaltered. He had found the vibrating filament useful for microscopic work where a surface rather than a line of light was required.

Prof. FLEMING read a Paper by himself and Mr. Petavel on

"An Analytical Study of the Alternating-Current Arc."

The first part of the Paper consists of an analytical study of the distribution of light throughout the various radiating regions in the arc when supplied with electric power of known constant amount, the periodic variations of the current through the arc and of the potential difference between the carbons being at the same time recorded. The power was measured by means of a bifilar wattmeter, while by means of a series of mirrors and a rotating disc carried by a sychronising alternate-current motor, the mean value of the light taken from any part of the arc was compared with the instantaneous value of the light taken from the same part of the arc, and taken at any assigned instant during the period. Thus the arc itself was its own standard, and difficulties due to slow variations in the mean light of the arc disappear. The facts observed may be summed up as follows:—The purple light of the true arc undergoes a periodic variation, and, as far as the eye can judge, is completely extinguished during a certain interval during the phase; it has equal maxima values during the period, at instants slightly lagging behind the instants of maximum power expenditure in the arc. On the other hand, the illuminative power of the carbon crater varies between a minimum value and two unequal maxima; the greater maximum occurring when the carbon is positive, and at an instant slightly lagging behind the instant of maximum power expenditure in the arc. The second part of the paper consists of a comparison of the efficiency of the alternate-current arc regarded as a light-giving agent as compared with that of a continuous-current arc taking the same mean power. Using two arcs, which may be regarded as typical of those used in practice, the mean spherical candle-power was compared for equal expenditure of power in the arcs, and it was found that for the alternating-current arc employed the total mean spherical candle-power was always less than that of the continuous-current arc. Lowering the frequency seems to decrease the efficiency of the alternating-current arc.

Prof. AYRTON said the behaviour of the alternate-current arc was of great interest, for the power supplied could not be measured by simply multiplying the current by the electromotive force, since the current lags behind the volts. The resistance, *i.e.*, the ratio of the current to the electromotive force, also lags; but the authors do not appear to have made any attempt to measure the true resistance. The authors were to be congratulated on the guarded tone they had adopted as to the bearing of these experiments on the question of the relative efficiency of the alternating and continuous-current arcs. In a previous communication, one of the authors had stated that the alternating-current arc must necessarily be a less efficient light-producing agent than the continuous-current arc. Although the last set of curves given in the Paper might appear to support this supposition, he (Prof. Ayrton) felt that the difference obtained was probably due to the fact that the alternating-current arc was not being worked under proper conditions. The quality of the carbons and the length of the arc have a most important influence on the efficiency of an arc. At present our knowledge is not sufficient to allow of our stating definitely whether or not an alternating-current arc can be made as efficient as a direct-current arc, but there is no doubt that it will be possible to get much better results than are at present obtainable.

Prof. S. P. THOMPSON said that when the fact of the existence of the difference in phase between the current and volts in an alternating arc was first published, he had made some experiments which showed that there was a lag and not a lead—*i.e.*, that the arc acted as if it possessed self-induction. The resistance also lagged, and he thought this lag might be due to a thermal lag. The temperature of the arc will lag behind the current both when it is increasing and when it is decreasing, and if the resistance of the arc depends on the temperature of the vapour in the arc then the resistance would also lag behind the current. It was not possible from *a priori* reasoning to say whether or no an alternating-current arc could ever be obtained of any efficiency equal to that of the direct-current arc. With suitable carbons, length of arc, current and volts it seemed to him that it might be possible to obtain an equal efficiency. The light-giving process in an arc is not merely an irreversible degradation of electric energy into heat, for the difference of potential between the carbons may be written $V = a + b l$ where a may be regarded as a back electromotive force and $b l$ as a true resistance. The first term of this expression does not vary with the length of the arc, l, but the second term does. Multiplying through by the current, C, the equation Watts expended $= C a + C b l$ is obtained. It is the first of the terms on the right-hand side which is a reversible effect, and corresponding to the power expended in driving the current against a back electromotive force, on which the light given out chiefly depends due to something occurring at the crater surface.

Mr. BLAKESLEY asked whether Prof. Thompson's idea of the light being due to the reversible part of the process was not a strong argument in favour of the direct-current arc?

Prof. AYRTON said that in two communications made to the Congress held at Chicago it was shown that even with direct-current arcs there was a certain length of arc for which the efficiency was a maximum. Mrs. Ayrton had quite recently found that the efficiency of arc lamp carbons altered with time. Prof. Thompson's suggestion as to a thermal lag was a valuable one.

Prof. FLEMING, in his reply, said that when comparing two agents where there were so many variables, it was practically necessary to restrict the investigation. In their case they had kept the mean power constant and had left the other variables to take care of themselves.

The Society then adjourned till March 13th.

Electricity on Board Ship.—It is stated, says the *Engineer*, that the Russian naval authorities have decided to substitute in the battleships "Sissoi Veliky" and "Navarin," as well as in the cruiser "Rossia," a telephone invented by Lieutenant Kolbasyeff for the speaking tubes now used. According to the *Novosti* these vessels are also to be fitted with the electric alarm bells invented by Captain Vassilyeff for showing the ship has been hulled by shot.

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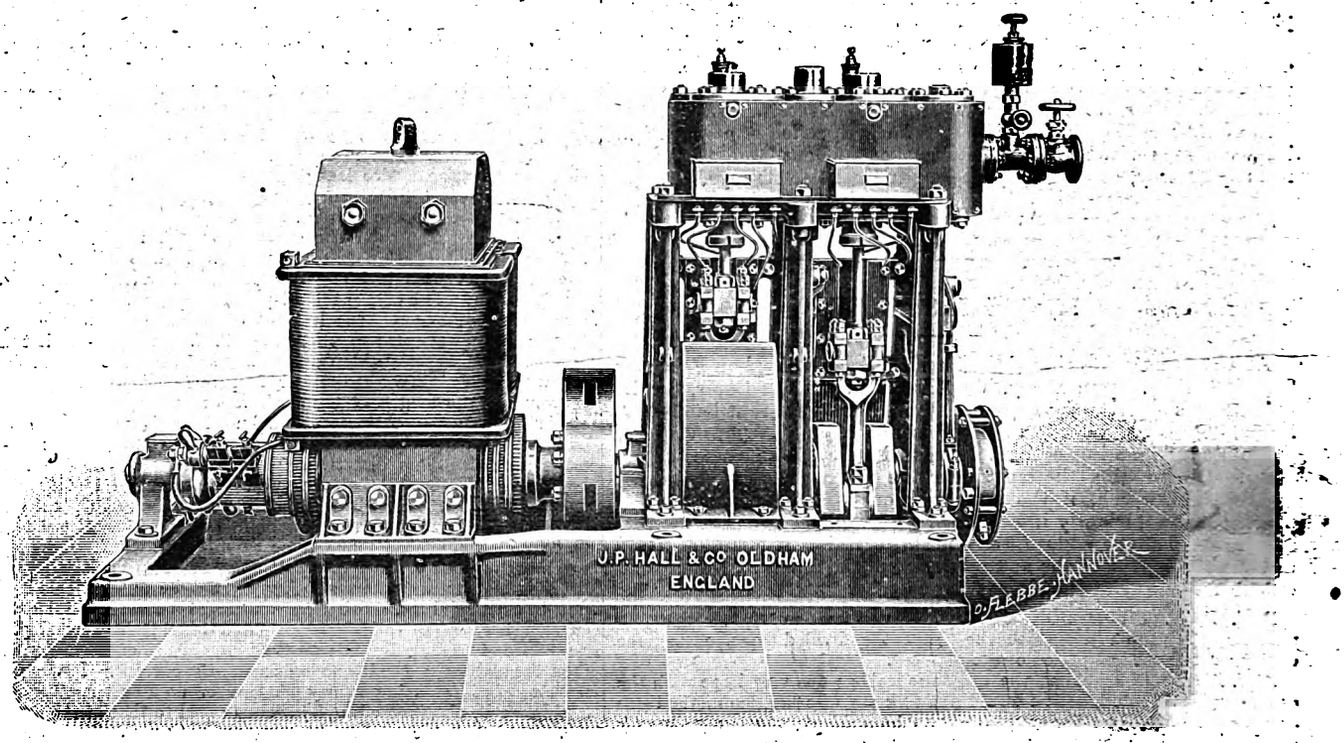
COMBINED COMPOUND ENGINE AND DYNAMO.

The accompanying illustration shows one of Messrs. J. P. Hall and Co.'s combined compound engines and dynamos specially constructed for ship lighting purposes. Three sets of these have just been completed to the order of Messrs. J. and G. Thomson (Limited), of Clydebank, for ss. "Kiev," the latest addition to the Russian Volunteer Fleet. We may also mention that this vessel has been fitted throughout with a complete system of electrically-driven fans, all the motors for which have also been made by Messrs. J. P. Hall and Co. The following description of the engines and dynamos will be of interest.

The cylinders are 5in. and 8½in., diameter by 7in. stroke, with the low-pressure valve between, and the engines are constructed to give 25 I.H.P. at 300 revolutions per minute, with 120lb. steam pressure when exhausting into the atmosphere. The moving parts are all as light as is consistent with strength, and the pistons, which are dome-shaped, are of steel, the cross-heads being of cast steel lined with magnolia metal. The connecting rods are of best forged steel of the ordinary marine type, with phosphor bronze bearings. The crank-shafts were also of forged steel, and each line of moving parts is separately balanced with weights forged on the crank-shafts, the cranks being placed on opposite centres, so that the engines are balanced as a whole and run with no variation without being in any way fastened down. The beds are made, as will be seen, with an extension for carrying the dynamos, the main bearings being cast on and truly bored in position and bushed with phosphor bronze bushes, the one at the flywheel end being double length to carry the weight of the armature and flywheel. The governors are of the firm's patent automatic type, which are so arranged that they vary the stroke of the eccentric from 2in. to 1in., and which from their design have very little friction and are very quick to take up any small variation in load, and the engines govern to within 2 per cent. with no load or full load.

The dynamos are slow speed, with drum bar armatures, and give 120 amperes at 100 volts, with a maximum temperature rise of 60°F. after six hours' run with full load, and the magnet coils are wound on strong sheet iron bobbins, with teak flanges carrying the terminals. The lubrication throughout is continuous, and ample provision is made for catching the waste oil, whilst the cylinders are provided with spring relief valves as well as ordinary drains.



The whole arrangement is exceedingly compact, and takes up comparatively only a very moderate space, so that it is specially applicable for lighting purposes on board ship where the above point is a matter of importance, and the firm are supplying a large number of these engines and dynamos to the leading ship-building establishments and electrical contractors. The firm also make other types of engines, dynamos and motors, both for direct and independent driving.

PARLIAMENTARY INTELLIGENCE.

LIGHT RAILWAYS BILL.

On the order for the second reading of the Light Railways Bill, in the House of Commons, on Monday evening last,

Mr. LOUGH moved, as an amendment, "That this House declines to sanction any scheme for the construction of light railways which will increase the burden of local rates or add to the weight of Imperial taxation." He said that under the Bill every facility was given to the locality to enter upon the construction of unproductive light railways, and there was no clause which protected the local rates from the charge that might be placed upon them by local authorities who were carried away with the prospects of these railways. The object of his amendment was to afford that protection. He contended that the assistance given by the Treasury under the Bill was given in a most pernicious form. Instead of proceeding in the way laid down in the Bill, which would result in imposing burdens on the localities, the Treasury ought to offer inducements to private speculators to construct lines where they were likely to prove an economical success. The first light railway enterprise in Ireland was under the Liberal Bill of 1883. Light railways were built under an extravagant guarantee of 5 per cent. to be given by the locality, and if the Treasury were satisfied that the railway would be kept at work it refunded the locality 2 per cent. Eighteen lines had been opened. They were 600 miles long, and, he believed, were the worst constructed railways in Europe. The service was irregular and unpunctual, and the rates high. The cost ranged from £2,600 to £6,000 a mile. The local ratepayers had to pay the interest on the whole of the capital, and this year there would be £90,000, or 6 per cent., interest to pay on £1,500,000 capital sunk in these lines. It was a wicked thing to plunge Ireland, at a time of agricultural distress into this mischievous speculation. Instead of plunging gaily into light railways for England they ought to repair the mischiefs which these railways had done in Ireland. A rate of 2s. in the pound was paid in Ireland for light railways which were positively dangerous to travel upon. As to leaving the matter to local authorities, local authorities in England were no more to be trusted than local authorities in Ireland. Under the Bill of 1889 to promote light railways in Ireland the cost of construction ranged from £4,000 to £9,000 a mile, and one line cost as much as £15,000 a mile. Let it not be thought that the £1,000,000 mentioned in the Bill would meet the expenditure. The House in reading this Bill a second time would open a little tap which it would never be able to close, and a hundred millions might ultimately have to be expended.

Mr. PERKS, in seconding the amendment, contended that the Bill in its present form would be of comparatively little use in securing the construction of cheap light railways in the rural districts, and unless substantially altered or amended in Committee the House ought not to pass it.

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Mr. SOUTTAR thought that if the financial clauses were altered in some particulars the Bill would become a good working measure.

Mr. GOLD said that if hon. members came from constituencies such as his, they would be unanimous in favour of State aid for these railways. In Essex there were at least 20 populous places and one large town distant from seven to ten miles from any railway station, and there were more than 16,000 acres out of cultivation. He thanked the President of the Board of Trade most heartily for the measure.

Mr. V. DAVIES strongly supported the Bill, and expressed surprise that a representative of one of the districts of the metropolis should be found opposed to it. He should have thought every representative of a great town or city would by means of this measure have been glad to have held out to agriculture the right hand of friendship. He trusted that the President of the Board of Trade would reconsider the financial part of the Bill, as it would be impossible for many places to pay 3½ per cent. for the money advanced.

Sir H. MEYSEY-THOMPSON pointed out that, with the sole exception of the United States, in every other country the State had an interest in the railways and contributed towards them. He suggested that the Railway Commissioners, the Board of Trade, or a similar body might be empowered to grant loans for the construction of light railways at 2½ per cent. and regulate these loans according to the circumstances of the district. His own belief as a railway director for the last 20 years was that these light railways would largely be made by the existing railway companies. The conclusion of railway experts was that it would be fatal to light railways if they were not of the same gauge as trunk lines, allowance being made for very exceptional cases in hilly districts.

Mr. WHITTAKER denied that agriculturists had suffered more than manufacturers, for anyone might see mills and factories lying derelict, but their owners did not come begging to that House for relief. The value of agricultural land to-day was as great as it was 50 years ago. The assessment under schedules A and B was in 1844 £40,000,000, and it was the same in 1894. Light railways would not effect an improvement; the cause of the evil lay much deeper than that.

Mr. BRYCE said that with regard to the financial proposals of the Bill, of course, nothing could be more popular than for a Minister to suggest Government grants in aid of such undertakings; but the House ought to take care that no improper demand was made upon the national purse. He thought that local authorities under proper safeguards might be allowed to subsidise undertakings of this character. As to the question of a subsidy from the Treasury, he thought no case had been made out to show that private enterprise would not deal sufficiently with this matter. He thought that the enormous difference in the cost of construction would encourage the great railway companies to take advantage of the measure. He would not go so far as to say that there might not be a case in which a particular class of industry might be entitled to special consideration by the State, but he did hold that the drawback to plans of this kind was that they necessarily tended to excite jealously between town and country. Another objection to subsidy by the State was that people would not make railways without a subsidy if they thought they could get one, and those of the railway companies who had been intending to make branch lines would probably hold their hands when they thought there was a chance of getting a subsidy. The policy of making grants from the Treasury was open to the objection that it subjected that Department to pressure from members and others advocating the claims of their particular localities. In countries where that policy had been adopted this pressure had been a source of much annoyance, and had been known to lead to something approaching jobbery. He hoped, therefore, that the provision respecting free grants would be expunged from the Bill. He feared that the million which the Treasury was to be authorised to advance would not go very far, and that the expectations raised by the Bill would be greatly in excess of the benefits conferred. By establishing this precedent they might be preparing serious difficulties for themselves in future years.

Mr. RITCHIE said it had been stated that the effect of the Bill would be to discourage private enterprise. Well, the main trunk railway system of this country was almost complete, and yet we were face to face with the fact that large areas of country were without any communication whatsoever, to the enormous disadvantage of those who were engaged in agricultural pursuits. The first consideration of a railway company before making a branch railway would be whether it would pay. If it would not pay, the branch railway certainly would not be made. He hoped that local authorities and landowners in agricultural districts would have regard to other considerations, that they would think of something more than mere return of interest, and would keep in view what was likely to contribute to the well-being of the locality. He hoped that under inexpensive conditions some lines would return a moderate rate of interest; but they could not look forward for the present to such a rate of interest as would induce private enterprise to embark in them. In Belgium, where there were a large number of such railways, the average rate of interest was 3 per cent. He doubted whether they would get private enterprise in this country, either in the shape of existing companies or private contractors, to make railways at a possible return of 3 per cent. and a probable return of something much less. Some hon. members had urged that 3½ per cent. was too high a rate of interest, and had mentioned that Consols only paid 2½ per cent. But there was a vast difference between advancing money on Consols and on the security of a light railway. The Treasury lent this money at 3½ per cent. practically without security, because the railway could not be of great value if it did not pay; and the Treasury only stipulated for the same rate of interest as the local authority. If the time should arrive when the local authority considered that 3½ per cent. was an onerous rate of interest, the Treasury would be only too glad to have its loan repaid. He had not, as the hon. member for Islington suggested, held up the Bill as a panacea for agricultural depression, but he did think the measure would do something to improve the agricultural industry. There were now large areas in the country from which agriculturists could not get their produce to a market without a large expenditure of money, which made their return almost *nil*. There were hundreds of thousands of acres of land far away from a railway station which must derive enormous benefit from the operation of the Bill. The State, local authorities, and landowners would be benefited, and he did not think the Bill would have that effect upon the rates which the hon. gentleman imagined. He trusted local authorities would take into account what was for the benefit of the community over which they presided, and he believed that in the end they would reap their reward by a condition of things greatly improved upon that which now unhappily existed.

Mr. LOUGH asked to withdraw the amendment, but it was negatived without a division.

The SPEAKER then put the motion for the second reading.

A division was challenged, but the cries of "No" were not persisted in, and the second reading was ultimately agreed to without a division.

THE WORCESTER WATER-POWER STATION.

The following Report of the Borough Electrical Engineer (Mr. E. T. Ruthven-Murray) to the Worcester Electricity Committee is of general interest:—

GENTLEMEN,—In order that you may better realise the result of last year's working, I have analysed the return and accounts in such a manner that a comparison may be made between our own figures and those published by other electricity supply stations, and in making these comparisons the charges for interest and sinking fund have been excluded.

Taken as a whole, our total costs figure of 2·97d. per unit sold is decidedly satisfactory, although it is higher than I anticipated. Nevertheless, if the average price obtained, 3·163d., were not so extremely low, we should have made a substantial profit.

Undoubtedly the figure in the costs which looks out of proportion is that of 1·06d. per unit sold, for fuel; and in the reduction of this figure I see most hope of lowering the generation in the future.

There are several reasons why this figure is so large, and pre-eminent is the fact that the available water power did not come anywhere near its calculated value, with the result that from the end of May until the end of November it was necessary to run a portion of the day on steam only. About Midsummer there was so little water in the Teme that as much as 75 per cent. of a total week's running hours were done on steam power. As the engines at the works are all of 286 I.H.P., we had no choice but to run these at the very low load which was the maximum that could be obtained, and at a load factor so small that high efficiency and low consumption of steam, and, therefore, of fuel, was impossible. A condenser was thought unnecessary when the works were equipped, but this omission is now made good, and will, I have no doubt, effect an economy in the steam consumption of the engines of upwards of £0 per cent.

Before it became necessary to run by steam power in the daytime, we were using Staffordshire coal entirely, but in consequence of repeated complaints about smoke, you instructed me to burn Welsh smokeless coal when found necessary, which, being considerably more expensive is an important factor in the cost of fuel. The reason for so much coal being used was to keep running for the electric pumping plant at the waterworks. I estimate that no less than 400 tons of coal were used entirely to keep one motor running during the summer. As the price we received from the Water and Sewerage Committee was only 1d. per unit it will be seen that over the whole year our costs show a higher figure than this for coal alone, and instead of making anything out of the day load found by these motors, you have actually lost money by having them on circuit.

During the summer the contractors were engaged in replacing the coils of the alternator armatures with others of improved type, and to test them it was necessary to run the machines for many hours continuously. As no water power was available steam had to be used, and testing accounts for some 80 tons of coal.

It is authoritatively stated that the past summer was one of unusual drought, therefore we may not be so short of water during the coming season.

We have recently improved the figure for cost of engine-room stores, by alteration of the lubricating arrangements on the machinery at the works. Of the figure 0·267d. per unit, 0·156d. is engine-room stores. The figure of 0·111d. for carbons is not a true result of the year's working, as the carbons used during the few months of last year were altogether omitted, and have been added here. We are now purchasing carbons at about 22 per cent. less than we were during last year, and in the next report the figure of 0·267d. per unit will be materially reduced.

The next figure of 1·038d. per unit for wages at works is low for the character of the station, and cannot be reduced except in so far as it will be from the larger output we may expect this year. It is apparent that this will fall proportionally as the output rises; the same remark applies to the figure for repairs and maintenance, which I do not anticipate will much increase. The figure which includes legal expenses, management, and insurance, may be altered other than proportionally, although the figure for rates, taxes and rents should share in the reduction from increased output.

Turning from costs to revenue, the most striking item is that of the average price obtained, which, excluding revenue derived from meter rents, property rents, &c., only amount to an average of 2·73d. per unit, a figure without parallel in the annals of the electricity supply business. The figure, including revenue from other sources, 3·16d., is lower than any

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recorded. The waterworks motors are again mainly responsible for these figures. They were supplied with 103,644 units, for which we receive the sum of £431. 17s. This number of units bears the relation of 41·9 per cent. to the total output of 246,912 units. For the remaining 51·1 per cent. (143,268 units) we received £2,386. 8s. 2d., or an average of 3·99d. per unit, a figure above the lowest on record of other stations.

Bearing in mind the unusual difficulties we have had to engage with and overcome during the past year, our results cannot but be considered satisfactory. The number of lamps we have taken on is very gratifying, amounting to an increase of over 200 per cent., and I have no doubt, from information received, that we shall have a large accession of small consumers, from whom we derive a much better revenue per lamp than from most of the larger ones during the year.

THE MUNICIPAL ELECTRICAL ASSOCIATION.

The formation of the above Association was brought by Mr. John H. Rider before the meeting of municipal electrical engineers held in Westminster in July last to discuss the new Board of Trade Rules, and was warmly approved. It was felt that there were numerous important matters affecting the interests of municipal electrical undertakings on which intimate discussion and probably united action would be desirable, the following, among several others, havin been suggested :—

Board of Trade Regulations.

Wiring rules and the powers of municipalities in relation to their enforcement.

The repayment of loans.

The appropriation of profits.

The rating of electricity works.

The relation of electrical undertakings to other public services, such as gas, water, drainage, &c.

Matters of interest and importance concerning mechanical, electrical, and commercial questions.

The meeting also decided to appoint a committee of five to prepare a draft constitution for the proposed Association, and the following gentlemen were elected by ballot for that purpose :—Mr. Sydney W. Baynes, Mr. A. B. Mountain, Mr. John H. Rider, Mr. C. H. Wordingham and Mr. Arthur Wright. This Committee held a meeting on the following day, and appointed Mr. W. L. Madgen hon. secretary *pro tem.*, feeling that his services would be of value during the period of organisation, as he had taken a keen interest in the subject—being, in fact, the originator of the movement. The Committee completed its work in good time, and a draft of the proposed prospectus and constitution was sent out with a notice convening a general meeting for November 18th, at the Westminster Palace Hotel, Victoria-street, S.W.

This meeting was held in due course, the following gentlemen being present :—Mr. Arnot (Glasgow), Mr. Appelbee (Cardiff), Mr. Barnard (Hull), Mr. Vesey-Brown (Sunderland), Mr. Cottam (Hampstead), Mr. Christie (Londonderry), Mr. Edgcome (Kingston-on-Thames), Mr. Ellis (Southport), Mr. Gay (Islington), Mr. Gibbings (Bradford), Mr. Giles (Blackburn), Mr. Hesketh (Blackpool), Mr. Hope-Johnstone (Bedford), Mr. Jeckell (South Shields), Mr. Mitchell (Dewsbury), Mr. Mountain (Huddersfield), Mr. Ruthven-Murray (Worcester), Mr. Price (Portsmouth), Mr. Faraday Proctor (Bristol), Mr. Rider (Bolton), Mr. Stewart (Derby), Mr. Thursfield (Burnley), Mr. Wilmshurst (Halifax), Mr. Wordingham (Manchester); Mr. Wright (Brighton) in the chair. Letters of regret were received from Mr. Blackman (Aberdeen), Mr. Copland (Newport), Mr. Couzens (Exeter), Mr. Hamilton Kilgour (Cheltenham) and Mr. Talbot (Nottingham).

After full discussion the prospectus and constitution were passed as amended (with the exception of one or two points in the latter which stand over for consideration at the first convention), and it was decided, on the proposition of Mr. Arnot, that the municipal electrical engineers then present constitute themselves into the Municipal Electrical Association.

The following are the terms of the prospectus, describing concisely the motive and objects of the Association :—

(1.) The object of the Municipal Electrical Association is to promote the interests of municipal electrical undertakings, and to that end to bring municipal electrical engineers into relation one with another.

(2.) This Association will endeavour to promote the interests of municipal electrical undertakings, without regard to the source from which dangers threatening such interests may arise.

(3.) To secure consistent and well-organised management, the constitution provides for an Executive Committee, one-third going out of office after each annual convention.

(4.) The annual meeting of the Association for the discussion of Papers, the election of the executive, and the transaction of other business, will be held in May or June in each year, at such places as the Association shall determine, and on such dates as may be determined by the Executive Committee.

The following gentlemen form the Executive Committee and officers for the first annual convention, to be held in London on June 10th, 11th and 12th of this year :—

President.—Mr. Arthur Wright.

Vice-Presidents.—Mr. William Arnot, Mr. C. H. Wordingham.

Committee.—Mr. C. S. Vesey-Brown, Mr. Albert Gay, Mr. John Hesketh, Mr. A. B. Mountain, Mr. H. Faraday-Proctor, Mr. John H. Rider.

Hon. Treasurer.—Mr. G. H. Cottam.

Hon. Secretary.—Mr. Wm. L. Madgen.

Mr. Wright, Mr. Arnot and Mr. Wordingham, the President and Vice-Presidents for the year, are in charge of three of the most important municipal electric undertakings in the country, and, with the above-named Committee, are thoroughly representative of municipal electrical work. It was, on the proposition of Mr. Hesketh, seconded by Mr. Rider, unanimously carried that Mr. Madgen be asked to continue the honorary secretaryship until the convention, at which an official (probably a member) will be appointed. We understand that it is not improbable the convention of 1897 will be held in Manchester, and that of 1898 in Glasgow; but as to this nothing has yet been decided. In the meantime, however, steps are being taken by the Committee to make the first gathering a success.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d., abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations issued February 6th.

NEW BOOKS AND EDITIONS.

The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices :—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

'THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

TENDERS INVITED.—The Corporation of Sunderland invite tenders for steam engines, continuous-current dynamos, water-tube boilers, fuel economiser, water-softening plant, and cast-iron tank. Tenders must be sent to Mr. Fras. M. Bowey, Town Clerk, not later than 5 p.m. on Friday, the 13th instant.

——— The Corporation of Bangor require tenders for the construction, supply and laying down of the necessary plant and mains for the installation and supply of electric current within the borough. The contracts are split up into two sections. Tenders must be sent in to Mr. W. H. Pritchard, Town Clerk, Bangor, by the 18th instant.

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TENDERS INVITED.—Tenders are requested by Mr. George White-Fraser, consulting electrical engineer, of 18, Imperial Loan Building, Toronto, Canada, for generators and motors to a total capacity of about 1,000 H.P. of each, in various sizes. The machinery is to be installed in a large paper mill in Canada. Tenders should be forwarded promptly.

——— The Manchester, Sheffield and Lincolnshire Railway Company invite tenders for the supply, during the twelve months ending April 30, 1897, of various stores, including telegraph materials, wire, signal stores, fog signals, screws, rivets, asbestos packing, &c., &c. Tenders must be sent in by 10 a.m. on Tuesday, March 17th, to Mr. Oliver S. Holt, Secretary, London-road Station, Manchester.

——— Tenders are required for fitting up electric bells at the Infirmary of the Pontefract Union. Tenders by 4 p.m. to-day (Friday) to the Clerk (Mr. W. S. Wood), Union Offices, Pontefract.

——— The Rathmines and Rathgar Town Commissioners require tenders for the erection of telephones, &c. Particulars of the Township Engineer, Town Hall, and tenders by the 14th instant to Mr. F. P. Fawcett, secretary, Town Hall, Rathmines, Ireland.

——— The Police Department of the Corporation of Glasgow require a compound-wound dynamo for their sewage purification works at Dalmarnock. Tenders by the 14th instant to the Clerk, Mr. J. Lang, City Chambers, Glasgow.

——— The municipal authorities of Ecija require tenders for the concession for the electric lighting of the town for 20 years. Tenders to El Secretario del Ayuntamiento de Ecija (Seville), Spain, by the 10th inst.

——— Tenders are invited by the municipal authorities of Zamora for the concession for the electric lighting of the public streets for 20 years. Tenders to El Secretario del Ayuntamiento de Zamora (Leon), Spain, by the 30th inst.

——— The French authorities invite tenders for the supply of a quantity of telegraph paper, from 10mm. to 16mm. wide in 14 lots. Tenders to the Direction Générale des Postes et des Télégraphes, 103, Rue de Grenelle, Paris, by the 24th inst. Tenders are also required by the same department for the supply of eight lots of telegraph instruments. Tenders by the 25th inst.

——— The Erfurt Direction of the Prussian State Railways requires tenders for the supply of 52,000 arc lamp carbons. Tenders to the Königliche Eisenbahn Direction, 23, Bahnhof-strasse, Erfurt, by the 11th inst.

——— Tenders are required for lighting the suburban districts of Bucharest by some system which will not necessitate the employment of underground pipes. The districts are at present lighted by 3,265 oil lamps. The contract is for a term of five years, from April 13th, and specifications may be inspected at the offices of the Agence Havas, 96, Queen-street, Cheapside, E.C. Tenders to the Mairie by the 14th (26th) inst.

TENDERS ACCEPTED.—At the last meeting of the Blackpool Town Council, it was decided to approve the Electric Lighting Committee's decision to accept the tenders of Messrs. John Fraser and Son for boilers and condenser, Messrs. Tinkers (Limited) for steam pipes, &c., and Messrs. S. Z. de Ferranti (Limited) for a 300-kilowatt alternator and two 55-light rectifiers.

——— The Paving Committee of the Rochdale Corporation have accepted the tender of Messrs. Simpson Bros., for the supply of the electric lighting plant required at the sewage works, Roch Mills.

——— The Derby Town Council have accepted the tender of Messrs. J. Davis and Son for fixing electric bells and telephones at the Asylum, and connecting the porter's lodge by telephone with the main building, at £69.

——— The tender of Messrs. J. Brown and Co., of Sheffield, has been accepted by the Hampstead Vestry for the supply of two additional boilers (Ellis and Eaves' fire tube marine type) for their electricity works, at £3,500. Tenders were also received from Messrs. Willans and Robinson (Niclausse type), Maudslay, Sons and Field (Belleville water-tube), and J. I. Thornycroft and Co. (water-tube). The tenders of Messrs. Doulton and Co. for stone-ware pipes and traps; J. Gibb and Co., for tools, engineering stores, &c.; Sir W. A. Rose and Co., for oils; and the Wigan Coal and Iron Company, for coal, have also been accepted.

——— The Rhondda District Council have accepted the tender of Messrs. Treharne, owners of the Fernvale Brewery, to supply electric current for lighting main roads from Bridgend Hotel through Pontygwaith.

SALES BY AUCTION.—The Official Receiver in the bankruptcy of Charles F. Fox has instructed Messrs. Houldsworth and Son, of Northgate Hall, Halifax, to sell by auction, on Wednesday next, March 11th, at the Electrical Works, 1, Pond-street, Halifax, the plant and stock-in-trade, which includes a number of machines, lathes, tools, &c., and electrical fittings. Some further particulars are given in our advertisement columns.

APPOINTMENT VACANT.—The Uganda Railway Committee require an officer to take charge of the erection of telegraphs. Salary £400 per annum. Applications to the Secretary of the Committee, Foreign Office, Whitehall, London, S.W. Some further particulars are given in our advertisement columns.

BANKRUPTCIES.—A petition has been presented in the estate of John H. Cox, electrical engineer, 46, Kelly-street, and 13, Nicolson-street, Greenock. The examination takes place on the 13th inst., at the County-buildings, Greenock. Messrs. W. B. Paterson and Co., Glasgow, are agents.

——— In the failure of Charles F. Fox, described as electrical engineer and contractor, of 1, Bond-street, Halifax, the following are amongst the list of creditors:—

Cox Walkers	£91	0	0
Manchester Edison-Swan Company	76	13	3
Northern Electric Wire Company	42	1	6
Beecroft and Wightman	11	0	0

Liabilities amount to £544. 6s., and assets £343. 14s.

——— The following are the principal creditors in the failure of George Isaac Reakes, lately trading as an electrical engineer under the style of G. Reakes and Co., Bishop-street, Cherry Orchard, Shrewsbury:—

Manchester Edison-Swan Company	£232	0	0
Beanland, Perkin and Co.	36	0	0
Slade, Templeton and Co.	16	4	1
General Electric Company	16	0	0
Evered and Co.	13	18	6

LIQUIDATIONS.—At an extraordinary general meeting of the shareholders of the Morecambe Electric Light and Power Company (Limited), on February 27th, it was decided to wind up the Company voluntarily. The Chairman (Mr. W. B. Hodgson) said the meeting was called in consequence of the petition recently presented for the compulsory winding up of the Company by the Bank of Liverpool; but the petitioners intimated that they would not proceed with their petition in the event of the Company deciding to go into voluntary liquidation. It was decided to appoint Mr. C. R. Compston, of Lancaster, as liquidator. The non-success of the undertaking is attributed to insufficiency of capital and to the result of proceedings by residents in the vicinity of the generating station for nuisance and other unforeseen difficulties. The District Council recently decided to purchase this Company's undertaking.

——— Creditors of the Automatic Electric Light Syndicate, Limited (in voluntary liquidation), must send in particulars of their debts or claims to the liquidator (Mr. J. M. Tourtel), 22, Long-lane, Aldersgate-street, E.C., by April 10th.

——— Creditors of the Electric Novelty Syndicate, Limited (in voluntary liquidation), are requested to send in particulars of their debts or claims to the liquidator (Mr. Geo. F. Haskins), 18, Walbrook, E.C., by April 20th.

——— A meeting is to be held at Winchester House, Old Broad-street, E.C., on the 31st inst., at 2:30 p.m., to receive an account of the winding-up of the Johannesburg Lighting Company (Limited).

PRITCHETT ACCUMULATORS.—Messrs. Venner and Sillar, of 10, Delahay-street, Westminster, have been appointed by Messrs. Pritchett and Gold sole agents in Great Britain and Ireland for the Pritchett Accumulators.

BUSINESS CHANGES.—Mr. A. H. Rose has joined the firm of Rose and Bird (Limited), manufacturers of the "Radiant" Incandescent lamp, in the capacity of managing director, the position occupied by the late Mr. J. A. Bird. The offices of the firm have been removed from Newgate-street, to Albany-buildings, Victoria-street, Westminster, S.W.

BERGHANSEN'S POLE FINDER.—Mr. R. Simon, of Zulla-road, Nottingham, sends us a copy of a recent report by Prof. W. Robinson upon this handy instrument, particulars of which were given in our issue of December 20th last. Prof. Robinson's report is to the effect that the pole finder is "quick in action and very sensitive, giving a good deposit of red-coloured crystals in less than a minute with a cell of two volts pressure." The weight of the pole finder is 2oz. and its length 3¼in. A large number (over 1,000) have already been sold.

NEW CATALOGUE.—An excellent and very complete catalogue of electrical apparatus and accessories reaches us from Messrs. Dorman and Smith, of Ordsal Works, Salford, Manchester, copies of which can be obtained at the London offices, 94, Charing Cross-road, W.C., or at 56, George-square, Glasgow. The illustrations are well executed, and are designed to afford the trade every facility in selecting their requirements. Nearly 200 examples of apparatus, fittings and accessories are shown, including switchboards, a variety of switches, a considerable variety of lamp-holders, suspension holders, reflectors and shades, cut-outs, distributing boxes, wall sockets (including new designs for concentric work), socket connectors, ceiling roses and suspension pendants. In mill and ships' fittings for the electric light a good selection is presented.

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The whole of the goods included in the list are actually manufactured by the firm. Useful information regarding all the apparatus is given, and these particulars are accompanied in all cases by prices. The catalogue is well arranged, clearly printed, and in fact a very useful and timely publication.

CATALOGUES.—In our February 14th issue we noticed Section A catalogue and price list from Messrs. P. R. Jackson and Co. (Limited), of the Salford Rolling Mills, Manchester. We have now to acknowledge the receipt of Section B, dealing with piston, pump and packing rings, in the manufacture of which this firm holds a high reputation. Particulars of a large variety of these rings is given in the list.

THE NEW ELECTRIC SUPPLY STATION AT BUDAPEST.—A detailed description of this station, compiled by M. Etienne de Fodor, the Director of the Company, has just been published in brochure form. It contains 22 splendid illustrations and three tables of useful data, and is printed on fine paper. In *The Electrician* of July 26, 1895, we gave a description of this station.

"ARCHITECTURE."—Under this title a monthly magazine of architectural art has recently been started, and the second number, which has just come to hand, contains a quantity of excellent reading matter, accompanied by some exceptionally good illustrations. The publishing offices are at Talbot House, Arundel-street, Strand, and the price of the magazine is 1s.

BERLIN INDUSTRIAL EXHIBITION.—Amongst the features of this Exhibition will be the general assembly of the Union of German Railway Administrations, representing the railway companies of Germany, Austria-Hungary, the Netherlands, Roumania, Belgium, and the Berlin-Warsaw Railway; the Congress of the German Electrotechnical Society and of the Society of German Architect and Engineers, the German Society of Mechanics and Optics and of the German Photographic Association. The important question of the selection of a competent jury has been discussed, and it has been decided that exhibitors in the different sections are to appoint the judges to whom the granting of awards will be entrusted.

ABERDEEN.—The question of the extension of the electricity station was under consideration by the Gas and Electric Lighting Committee at its last meeting. It was pointed out that before next winter it would be necessary to put down additional plant, and very large extensions would be required at an early date. In the meantime it was thought desirable to obtain another 300 H.P. engine. It was resolved to obtain a report as to purchasing a new engine, and generally on the whole question of extensions. The report is to be presented at an early meeting of the Committee. ——The Harbour Board are making inquiries as to the cost of lighting the harbour electrically, and for the purpose of obtaining information a deputation from the Board recently visited Leith, where the harbour has been lighted electrically for some time. It is stated that the Board will, in the event of electric lighting being decided upon, take current from the Corporation.

ALLEGED EMBEZZLEMENT.—At the Blackpool Police Court, on the 27th ult., a man named Peter Bradley was charged with embezzling sums of money amounting to about £18 from his employers, Messrs. Sharp and Kent. It was stated that Bradley had acted as agent for the prosecutors, but had not accounted for the moneys which had been paid to him. The defence was that there was a dispute between the parties, and that the prosecutors were indebted to the prisoner in a much larger sum than the amount alleged to have been embezzled. The prisoner was remanded for a week.

ASTON.—Mr. Vaudrey has presented his report to the District Council on the condition of the electric light installation at the Baths, Free Library and Council Buildings. The report recommends the putting down of a new engine and dynamo, and these the Highways and Buildings Committee have now been authorised to purchase at an estimated cost of £350.

AYR.—A special meeting of the Town Council was held on Monday last for the purpose of considering a recommendation by Mr. R. Hammond, consulting electrical engineer to the Council, that new transformers be purchased at a cost of £630, those originally supplied being deemed too small for their work. An animated debate occurred, but it was resolved to delay decision in the matter.

BANGOR.—At the meeting of the City Council on Wednesday a long and acrimonious discussion arose on the minutes of the Electric Light Committee. The minority of the Council is doing its utmost to thwart and delay the introduction of the electric light, and a petition against the project has been presented to the Board of Trade. The Committee's replies to the statements contained in the petition have also been forwarded to the Board. The minutes were approved.

BELPER.—A discussion on the electric lighting question was initiated by Mr. Smedley ut the last meeting of the District Council. He moved that an application be made to the Board of Trade for a Provisional Order. The question was adjourned till the April meeting of the Council.

BLACKPOOL.—The Town Council on Tuesday last approved the proceedings of the Electric Lighting Committee recommending the application to the Local Government Board for sanction to borrow a further sum of £30,000 for extensions to the electricity works.

BRADFORD.—The Electricity Committee have decided to lay electric light mains on the west side of Manningham-lane as far as Queen's-road, and also in Little Horton-lane. The Committee have approved the specifications of plant required for the new electric supply works, and it was resolved to issue advertisements inviting tenders for same.

BRAY.—At the last meeting of the Town Commissioners the resident engineer at the electric light station (Mr. G. M. Harriss) presented a lengthy report on the condition of the plant, and recommended the Commissioners to make additions thereto. The question was allowed to remain in abeyance until an independent report has been obtained from a consulting electrical engineer, and Mr. R. Hammond has been appointed by the Commissioners to prepare a special report on the matter.

BRISTOL.—The Joint Committee of the Sanitary and Electrical Committees, recently appointed to consider the question of sanctioning the introduction of the overhead system of electric traction into the city have decided to obtain the opinion of an expert as to the most suitable system. The Electrical Committee are considering the advisability of extending the electric light mains to Stoke's Croft and North-street. The accounts of the Department for the year ended December 31st show a gross profit of £4,019. 19s. 10d., as compared with £456. 7s. 11d. in 1894. During the year 251,708 units were supplied to private consumers and 156,893 for public lighting.

BURTON-ON-TRENT.—At the meeting of the Town Council on Tuesday the Gas and Electric Lighting Committee reported that the accounts of the lighting department for the past year show a deficiency of £292. 0s. 5d. The total capital expenditure to date is £28,634. 12s.

CABUL (AFGHANISTAN).—According to an Indian exchange, Sir Salter Pyne, who acts in a consulting capacity to the Ameer on military and other engineering matters, is on his way home with presents for Her Majesty and with appointments in his pocket for British electricians to proceed to Cabul to instal the electric light, not only in the palace but in the streets of the city. It is further stated that the work is to be entirely carried out with British plant and material.

CAMBERWELL (LONDON).—The Special Electric Lighting Committee have presented their report on the application of the County of London and Brush Provincial Company for a Provisional Order for the district. The report sets forth the terms upon which consent should be given, and gave rise to a lengthy discussion at the last meeting of the Vestry, some of the members contending that the application should be opposed. Eventually the Committee's recommendations were agreed to.

CARDIFF.—The tenants of the Royal Arcade are anxious to avail themselves of the advantages of the electric light, and the owners of the arcade have, for some time past, been negotiating with the Lighting Committee for a supply of electric current. The chief obstacle in the way of introducing the light is the cost of repaving the arcade after the laying down of the electric light main. The Public Works and Lighting Committees have each offered to contribute a quarter of the cost of the pavement, and it is hoped that this concession will get over the difficulty with the Arcade Company, as there is likely to be a considerable demand for current from the tenants, several of them having already sent in applications.

COLCHESTER.—The Town Council has received a letter from the commanding officer of the Royal Engineers (Eastern District) to the effect that the War Department would be prepared to take current for the electric lighting of the block of officers' quarters, the officers' mess and the recreation buildings in the new barracks. Before coming to any decision as to lighting the whole of the barracks by electricity, the result of experiments being made elsewhere must be awaited.

COMMISSION OF SEWERS.—At the last meeting of the Commissioners of Sewers, in reply to a question as to when the experiments in the electric lighting of the side streets would be commenced, Mr. Voysey (the electrical inspector) said it depended upon the City of London Company. The apparatus was complete, and the experiments would be commenced in about six weeks.

CORK.—The Cork Electric Tramways Company (Limited) have decided to apply to the Lord Lieutenant in Council, under the Tramways (Ireland) Acts, for an Order in Council authorising the construction, working and maintenance of tramways in the city and county of Cork. The Company intend to reserve power to adopt electricity or other mechanical power on the proposed tramways.

DERBY AND ASHBOURNE TRAMWAY.—It is stated that the Bill for the construction of an electric tramway between Derby and Ashbourne at an estimated cost of £31,000 has been abandoned.

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DUBLIN.—The accounts of the Electric Light Department for the year *1894* were submitted at the last meeting of the City Council. The Electric Light Committee reported that, after paying out working expenses, interest, &c., and putting aside £1,846 for sinking fund purposes, there was sufficient profit to pay a dividend of 6 per cent. on the capital expenditure. It was stated that there was considerable difficulty in keeping pace with the demand for current. The Committee have at present applications from 80 customers for an equivalent of about 6,000 8 c.p. lamps, which they were unable to supply. After a lengthy discussion the accounts were approved, but the Committee were asked to show a little more alacrity in the presentation of their reports.——The Corporation have considered the report of the Committee of the whole Council on the Bill of the Dublin Southern District Tramways Company, and with regard to wayleaves, &c., for their proposed system of electric tramways, and also a report as to certain proposals by the Dublin United Company. The first report recommended that the scheme of the Southern Company for the construction of about 13 miles of tramway be approved, and that the rent be fixed at £4,000 per annum. Mr. Alderman Meade moved the adoption of the first report. After a five-hours debate it was decided to postpone the further consideration of the matter for six months. A further amendment approving the construction of No. 1 line of the Southern Company from Haddington-road to O'Connell Bridge was carried.

DUNDEE.—The National Telephone Company have under consideration the question of making certain alterations to and improvements in the telephone exchange at Dundee, including the introduction of the twin wire system. The Company require that the town trunk wires should be placed underground.

EALING.—The District Council have decided to have plans, &c., prepared for the extension of the electricity works. At the last meeting of the Council the Chairman stated that the demand for current had been much greater than was at first anticipated, and they would shortly have to put down additional machinery at the generating station.

ECCLES.—A long discussion arose at the last meeting of the Town Council on the minutes of the Town Hall and Electric Lighting Committee. Extracts were given from Mr. W. H. Preece's recent report to the Swansea Town Council, and the Committee recommended the Council to proceed with their joint electric lighting and refuse destructor scheme. Alderman Spary was in favour of postponing the matter, as he said they would shortly have the tramways on their hands, and the question of electric traction should be considered in conjunction with the electric lighting and dust destruction schemes. The minutes were eventually approved.

EDINBURGH.—Notice of motion has been given for the next meeting of the Council that it be remitted to the Electric Lighting Committee to consider whether it was not desirable to have the consulting electrical engineer appointed a permanent official of the Corporation to advise on all points in regard to installation, and to report.——Recommendations by the Cleaning and Lighting Committee that no action should be taken in regard to the electric lighting of the remaining public thoroughfares in the city as defined by the tramway routes, and that also no action should be taken for lighting by electricity the West Port, were discussed at the last meeting of the City Council, and a compromise arrived at in the first case, and in the second a direct negative was approved. At the next meeting further extensions of the electric lighting mains will be discussed.——The Town Council have considered a letter from Messrs. Walter Dixon and Co., electrical engineers, of Glasgow, on the subject of adopting a system of electric traction on the tramways, hut have decided to take no action in the matter, and the Tramways Committee's report was approved.

FAREHAM.—A special meeting of the Town Council was held last week for the purpose of further considering the electric lighting question. In compliance with a request from the Board of Trade, the Council have passed a resolution undertaking within three months of taking over the Electric Lighting Company's plant to place the wires underground. It has been decided to engage Mr. E. Manville to prepare a report on the present condition of the plant and as to necessary extensions, &c. The Council have accepted the offer of the Capital and Counties Bank to lend £6,681 at 3 per cent. for 20 years for electric lighting purposes. The 17th inst. has been fixed as the date for the completion of the purchase of the Fareham Company's works, and a satisfactory arrangement has been come to as to the payment of interest on the purchase money from the date of the original contract to purchase, and also as to costs in the recent action. All's well that ends well.

GLASGOW.—The National Telephone Company have applied to the Corporation for leave to lay their wires underground. The matter has been referred to the Finance Committee.

HANLEY.—At the special meeting of the Town Council on Wednesday the General Purposes Committee recommended that, as from 1st January last, the charges for electric current be as follows:—5d per unit to general consumers, 4d. for places of worship, and 3d. for motive power purposes; and that, in lieu of the discount of 5 per cent. hitherto allowed, an abatement of 1½d. per unit be made on accounts paid within 21 days from the end of the quarter. The recommendations of the Committee were confirmed, with the exception of that relating to discounts.

HALIFAX.—The Markets Committee have decided to wire the new markets for the electric light. The work is to be carried out under the supervision of the Borough Electrical Engineer, Mr. T. P. Wilmshurst. It has also been decided to wire the Town Hall. The Lighting Committee have decided to recommend the Town Council to apply for sanction to borrow a further sum of £20,000 for electric lighting purposes.

HAMPSTEAD (LONDON).—The Vestry have decided to lay additional electric light mains to Shoot-up-Hill and Adamson-roads. Messrs. J. Brown and Co. have been requested to estimate for pumps, blow-off tank, pipes, &c., required for the electricity works.

KING'S NORTON.—At the meeting of the Board of Guardians on Tuesday the House Committee reported that they had invited tenders from six firms for the electric lighting of the new infirmary and workhouse.

LECTURES.—At a recent meeting of the Midland Institute Scientific Society, at the Technical School, Dr. Sumpner (principal of the school) lectured on "Some Curiosities of Magnetism." The lecturer said it was a curious fact about engineering industries that they seemed entirely dependent on the existence of a few substances. In the electrical industries copper had to be used for conductors, and nothing but carbon would do for glow lamps and arc lamps; lead, though the heaviest and least convenient of ordinary metals, had to be used for secondary batteries, while no metal but iron would at all do for dynamos and motors. All substances except iron, nickel and cobalt were so alike in magnetic properties that they differed among themselves to a much less extent than the stature of ordinary persons, but to represent the magnetism of iron in the same way they would have to imagine a race of men as tall as the Matterhorn. A number of experiments with magnetic needles were shown illustrating the behaviour of iron when subjected to magnetic forces. Magnetism was far more wonderful than the new X-rays, for it could traverse both flesh and bone, while the X-rays could only get through flesh. Dr. Sumpner was thanked for his lecture.

——— An interesting lecture on "Recent Improvements and Applications in Electrical Machinery for Power-Transmission Purposes" was delivered by Mr. Walter Dixon, at Gordon's College, Aberdeen, on Tuesday evening last.

LEEDS.—The City Council have approved the minutes of the Highways Committee, recommending the adoption of the overhead trolley system of traction for the entire tramway system of the city.

LIVERPOOL.—A complete system of telephonic connection between the Dale-street Central Police Office and the various police stations in the city has been established. The head constable, by way of experiment, has adopted the "individual" system of signalling in case of the outbreak of fire, the occurrence of an accident, or the need of police assistance in any way. The National Company have fitted up at the Dale-street detective office instruments which afford immediate communication with a number of points by special connection with the ordinary telephonic circuit. Under this arrangement, as necessity arises, a constable unlocks the box containing the apparatus, say at the Haymarket, and conveys his message to the head office. Here there is a recorder, upon which is printed in cipher the exact locality whence the message originated and the nature of the assistance required.——The Lighting Committee have decided to recommend the City Council to apply, under the Liverpool Electric Supply (Transfer) Bill, for powers to increase the amount to be borrowed to £500,000 in order to provide capital for extensions.——At the meeting of the City Council on Wednesday it was decided to approve the report of the Finance Committee, which recommended that the public buildings be lighted electrically at a cost not exceeding £5,500.

MACROOM (CORK).—A meeting of the most influential inhabitants was recently held, when it was decided to take steps to put the town under the Town's Improvement Act, the ultimate object in view being the introduction of the electric light.

MAIDSTONE.—The proposed transfer of the Maidstone Provisional Order to Mr. Thomas King was again discussed at the last meeting of the Council. Some time ago the Electric Lighting Committee presented a report recommending the transfer, but at a recent meeting of ratepayers a resolution deprecating the suggested sale was passed. Mr. Alderman Ellis now moved the adoption of the Committee's report, and said that Mr. King had increased his original offer for the Order by £250. Mr. Cox moved an amendment that the report be referred back. Mr. Morling, in seconding, suggested that the Council should employ an electrical expert who would be able to advise them as to the best course to pursue. He thought that the Council would be able to supply

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electric current at a much cheaper rate than a company, and this was an important matter to private consumers. After an animated discussion, the amendment was carried by 12 votes to 8.

MANCHESTER SHIP CANAL.—In the course of his remarks at the Ship Canal Company last week, Mr J. K. Bythell, the Chairman, said that among the works to be finished during the current year, and included in the capital expenditure of £48,620, was a new electric lighting installation.

MORECAMBE.—A meeting of ratepayers to consider the question of the proposed purchase of the Morecambe Electric Light and Power Company's undertaking by the District Council was held last week. The Clerk stated that the Board of Trade had already intimated their willingness to consent to the transfer of the Company's Provisional Order. The total cost of an installation for public and private lighting was estimated at £16,000, inclusive of £3,950 to be paid for the mains. A resolution approving of the Council's decision to purchase was duly passed.

MUCH WOOLTON.—The Urban District Council have decided to oppose the application of the Liverpool District Lighting Company for a Provisional Electric Lighting Order, and have resolved to take the necessary steps to obtain an Order to enable the Council to supply electric current.

NEWMARKET.—The Board of Trade have written to the District Council for their observations on the application of the Newmarket Electric Light Company for a Provisional Order. The Council have instructed the Surveyor to prepare a report on the matter.

NORTHAMPTON.—The Directors of the Northampton Electric Light and Power Company have decided to make reductions in the price of current, and to adopt the Wright system of charging.

NOTTINGHAM.—At their meeting on Monday the Town Council considered the report recently presented by the Electric Lighting Committee, an abstract of which appeared in our last issue. The report recommended the Council to borrow an additional sum of £40,000 for electric lighting extensions. The Chairman of the Electric Lighting Committee (Sir John Turney), in moving its adoption, said that it was absolutely necessary to considerably extend their supply station and to put down additional plant. The increase in the demand for electric current was most gratifying, and had exceeded their anticipations. In conclusion, he said they could not afford to lose any time, as he had that morning seen a letter to the Electric Light Committee from the builders of the engines employed at the station (Messrs. Willans and Robinson), stating, in effect, that owing to the constant flow of orders during the past few months, the capacity of their existing works was taxed to its fullest extent. He, therefore, asked that the Committee should be allowed to proceed with the work immediately. After a brief discussion this course was approved, and the Committee's report adopted.

RIPON.—A long discussion on the electric lighting question took place at the last meeting of the City Council. For the guidance of the Gas Committee, it was decided to instruct the Town Clerk to obtain from the Dean and Chapter information as to the number of lights they would require in the event of their deciding to light the Cathedral electrically.

SALFORD.—At their meeting on Wednesday the Town Council decided to apply to the Local Government Board for sanction to borrow an additional sum of £5,000 for electric lighting purposes.

SOUTH AFRICAN EXPORTS.—For the week ended February 22nd, goods classed under the heading "Electrical" were exported from this country to South Africa of the value of £3,650, made up as follows:—Cape Town, £613; Algoa Bay, £127; East London, £5,429; Natal, £481.

ST. GEORGE (BRISTOL).—The District Council have consented to the proposal of the Bristol Tramways Company to extend their electric tramways along the road at the parish boundary between Euston-road to Barton Regis Union.

ST. GILES (LONDON).—The new public library is to be wired for the electric light. The contract for the fittings, &c., has been placed with Messrs. S. Pontifex and Co., of Coleman-street, E.C.

ST. HELENS.—The Corporation have approved the plans and specifications of the buildings for the electric light works, and the engineer has been instructed to obtain tenders.

STAFFORD.—The Gas and Electricity Committee reported at Tuesday's meeting of the Town Council that they had entered into an agreement with the County Council for lighting the Council buildings, the Judge's House and Eastgate House electrically at an annual charge of £175, the County Council paying at the rate of 8d. per unit for current supplied over 1,300 units per quarter, and the lamps not to exceed an equivalent of 1,200 8 c.p. The Committee's minutes were approved.

THEATRE LIGHTING.—It is proposed to fit up the Folly Theatre, Manchester, for the electric light.

TIPTON.—The electric light has just been installed at the Rattlechain Brickworks. Incandescents are used for interior lighting, but the large marl hole and wharf are illuminated by means of two 2,000 c.p. arcs. The contract was executed by a local electrical engineer, Mr. J. Oxham.

TRAIN LIGHTING.—The Waterford and Limerick and Western Railway of Ireland is making some experiments as to the suitability of the electric light for train lighting, and Messrs. J. Stone and Co. have been employed to fit up one of the carriages on the line.

WAKEFIELD.—The Electric Light Committee have decided to recommend the Council to at once proceed with their electric lighting scheme. The Council have already obtained sanction for borrowing the necessary money, and tenders have been accepted for plant, &c.

WELLS.—At the last meeting of the Town Council it was decided to apply to the Local Government Board for sanction to borrow £10,000 for the establishment of electric light works in the town.

WEST HAM.—An attempt made by Mr. Alderman Smith to delay indefinitely the consideration of electric lighting matters was rejected at the last meeting of the Town Council. This course, however, does not place electric lighting matters in this district on any more satisfactory basis.

COMPANIES' MEETINGS AND REPORTS.

Telegraph Construction and Maintenance Company (Limited).

The thirty-second ordinary general meeting of the members of this Company was held on Tuesday, at the offices, Old Broad-street, under the presidency of Admiral Sir George H. Richards, K.C.B., F.R.S.

The SOLICITOR (Mr. Chapman) read the notice convening the meeting, and other routine business having been disposed of,

The CHAIRMAN said: I have no doubt that you will have seen from the report that it is comparatively an unusual one, as it is rather a meagre record of work done during 1895. I daresay that those who were here will remember that at our last annual meeting, and again at the July meeting, I shadowed forth that there were no great works in progress, and that prediction has been realised. As a matter of fact, there has been really very little submarine telegraph work carried out during 1895, and I think I am correct in saying that a great part of what has been done has been executed by this Company. This, to a certain extent, is satisfactory to us all; but our share in the work has been, as you will see by the report, a few hundred miles of cable for the Japanese Government, which we have sent to Japan, and a few hundred miles for different companies. We have also made several repairs in existing lines of cable, and our ordinary guttapercha work has been fairly good, and compares favourably with that done in the previous year. Still, this has not enabled us to pay you the dividend which we have done for a great many years, and we regret that as much as you can. We are, however, proposing to-day to pay you a dividend of 10 per cent., which, added to the interim distribution already paid, makes 15 per cent. for the year, or £1. 16s. a share. Like other companies, we must sometimes expect to have a lean year, and we have had one in the period under review; but I am able to tell you that as far as the Company's position goes, it is entirely sound financially, and very healthy. We only want work. We are not very often, as you know, without work, and I think I may say that our prospects of work for this year are better. We have great hopes that that will prove to be so. I am glad to tell you also that all our works, factories, machinery and ships are in good order, and we were never in a better position to carry out work than we are in now. I do not know that I can give you any further details. These are the facts, and I think I had better now move the first resolution. If any gentleman has any questions to put to me afterwards I shall be very pleased, as far as I can, to answer them. I will now move—

"*That the report and accounts of the Directors to December 31, 1895, submitted to this meeting, be and the same are hereby received and adopted, and that a dividend of 2½s. per share, in addition to the 12s. per share interim dividend paid on June 30, 1895, be paid on all shares of the Company for the year ended December 31, 1895, and that such dividend be paid free of income tax.*"

Sir ROBERT G. W. HERBERT, G.C.B., briefly expressed his pleasure in seconding the resolution.

Gen. TREVOR inquired where they got their dividend of 15 per cent. from for the past year. He made out that the earnings were between 5 and 6 per cent on the capital.

The CHAIRMAN: 15 per cent. is on the paid-up capital of £448,200.

Gen. TREVOR said that in addition to the share capital there were debentures amounting to £150,000 and the reserved fund of £50,000, making altogether £640,000. That was their trading capital, and on this they had made a profit of £32,500, which was nothing like 15 per cent. He only wanted to know where the rest came from.

The CHAIRMAN: Our profit is made out of the work done. The money you speak of consists of reserves which we are empowered to make for certain purposes, and which it is essential for a Company of this kind, which has many risks, to possess. That money is your security. On the other side it is amply met by good securities, showing the prosperity of the Company.

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Gen. TREVOR inquired whether he was correct in stating that the earnings for the past year had been under 6 per cent. on the capital.

Sir ROBERT HERBERT: That is after charging 5 per cent. on the debentures.

Mr. GEORGE W. CAMPBELL: A certain amount is taken from the profit and loss account of last year. The balance brought from last year's account has been reduced in order to make up the dividend.

Mr. WHISH said the debts owing to the Company amounted to the large sum of £318,000 odd, and it was to be hoped that they were good, sound debts.

The CHAIRMAN: There is not the least doubt about them. They are perfectly good, as are also our securities. You have your accountants and your auditors here, and I am sure that they will testify to that if necessary. You have, however, always accepted our word in these matters. We have no reason whatever for keeping anything from you except what we must keep from you as a trading company, because we cannot make everything public regarding our affairs. He then put the motion, which was carried. Subsequently he proposed the re-election as Directors of Mr. James Pender and Sir Robert Herbert.

Mr. CAMPBELL seconded the motion, which was carried unanimously.

Mr. GIBSON afterwards proposed, and Mr. HEWAT seconded, the re-election of the auditors, Mr. John Gane and Mr. P. A. Glegg, and the resolution was carried unanimously.

Gen. TREVOR then proposed a vote of thanks to the Chairman and Directors for their attention to the Company's affairs.

Mr. CROFT seconded the motion, which was carried unanimously.

The CHAIRMAN: We are much obliged to you for the confidence you continue to maintain in us.

The proceedings then terminated.

Chelsea Electricity Supply Company (Limited).

The annual ordinary general meeting of the Company was held on Wednesday at their central station, Cadogan-gardens, under the presidency of Mr. J. Irving Courtenay.

The SECRETARY (Mr. S. J. Cluer), having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, I assume that the Directors' report and the audited accounts for the year 1895, which have been circulated among the shareholders, may be taken as read, and I shall therefore proceed at once to make a few remarks on the principal points of interest in the Company's affairs during the year under review. We have, as you will have seen in the report, issued £60,000 Four and a-Half per Cent. Debenture stock, and the remaining 3,723 Ordinary shares have also been placed. Only a portion of this is additional capital, because we have redeemed the whole of the Six per Cent. Debentures, amounting to £36,900. The greater part, however, of the shares and Debenture stock was not paid up until the latter part of the year, and most of the fresh capital expenditure (£41,176. 4s. 6d.) was made during the same period, so that the normal return on this new capital could not possibly be earned in 1895. In July last we lowered the charge for current by 25 per cent., and consequently the increase in revenue may not seem so large as might have been expected. Notwithstanding this reduction, the increase over the previous year in net revenue from £3,991. 11s. 5d. to £6,414. 16s. 5d. enables us to recommend the same rate of dividend on the Ordinary shares, *i.e.*, 5 per cent., as that paid last year, although the sum required for this dividend, together with the interest on Debentures, exceeds that distributed for 1894 by nearly £3,000. We propose to carry forward £1,114. 16s. 5d. to next account. We have again reduced the cost of production. We have also had a considerable increase (over 10,000) in the number of lamps supplied, and I may add that this increase still continues, even to a larger extent than last year. We look for an improvement in the yield per lamp fixed owing to the growing though slow adoption of the electric light in the shop district. This brings me to the question of capital expenditure. An increase of lamps means additional mains, plant, and machinery, and we have not only largely increased our plant, but have already begun to provide for the increase of customers expected during the present year, and thus be ready for next winter. The continued expansion of the business creates a recurring need for fresh capital, for we only raise additional capital, and increase our plant and mains, from time to time as wanted. We have during the past year completely altered and equipped the new generating station in Manor-street, called the Cheyne-walk station, and a new storage station for the supply of the Fulham-road district is in course of erection, and will shortly be completed. There have been added to the plant at the generating station in Manor-street five steam boilers and eight engine dynamos of 150 H.P. each and one of 90 H.P., and six continuous-current transformers, each having a capacity of over 2,000 lights, are installed in our sub stations. We have laid street works for a distance of about 8,000 yards, the cases in which have a capacity for accommodating about 40,000 yards of mains, the conductors actually laid during the year having a length of about 29,000 yards. It is a very difficult matter in a thickly-populated neighbourhood to obtain land where it is wanted and when it is wanted, on which to make extensions, or to build new stations. The Directors have, therefore, been looking ahead, and have secured the freehold of a large plot of land surrounding and including the land on which our Cheyne-walk generating station stands. The fact that the Company owns the freehold of this land cannot but be advantageous. You will have seen from the reports in the newspapers that an injunction has been granted against the Company in respect of the generating station here in Cadogan-gardens. I hope we shall shortly be in a position to deal with this troublesome matter in a manner that will put an end to further litigation. I may here remark that electric lighting companies have had hard measure dealt out to them by the legislature. Perhaps it is to some extent their own fault, because those who took a leading part as their representatives at the time did not forsee the oppressive use that would be made of certain clauses in the Electric Lighting Acts. The electric light supply companies carry on a *bonâ fide* and necessary industry to the great benefit of the public, and with as yet only moderate returns to their shareholders for the risks they have run. They have statutory duties to fulfil, but they are, in my opinion, without adequate legal protection, and are considered as fair game to be shot at; the alternatives generally presented to them being either to purchase peace at any price the occupier of adjoining property chooses to demand, or to run the risk of being forced to discontinue the full use of premises upon which a large capital has probably been spent. The attention of Parliament will, I learn, be soon directed to this most important question. The companies only ask for fair treatment. They do not object to pay liberal compensation, if, in spite of every effort on their part, any real annoyance should be caused to their neighbours, but they will ask to be protected by Parliament against being coerced into paying unreasonable sums. There have been during 1895, from several causes, exceptional duties and responsibilities of a most anxious character thrown upon the managing engineer, Mr. Frank King, our resident engineer, Mr. Percy Still, and the staff, and I cannot permit this occasion to pass without expressing our thanks and appreciation of the manner in which they have discharged those duties. You will see from our net revenue account that we have written off all the expense incurred in connection with the proceedings I have mentioned above. We have also placed £1,047. 6s. 7d. to a reserve fund, and carried forward £1,114. 16s. 5d. In view of all the circumstances and the difficulties with which the Company has had to contend, and still has, in carrying on its business, I consider the general result to be satisfactory, and it is evident that its financial position has been greatly strengthened since our last meeting. With these observations I will move:—

"*That the report of the Directors and the statement of accounts for the year 1895, now before the meeting, be and they are hereby adopted; and that the payment of a dividend of 6 per cent. on the Preference share capital and of 5 per cent. on the Ordinary share capital for the year 1895 be and is hereby approved, payable forthwith.*"

The DEPUTY-CHAIRMAN (Major-Gen. Webber, C.B.), in seconding the motion, observed that the career of a Company like the Chelsea, once it was established on the lines which experience had recommended for continuance, would be a very simple matter indeed but for the various conditions which surrounded its development. The one to which the Chairman had alluded had given him and the Directors considerable anxiety during the year, not as to their power to overcome the difficulty that arose, but on the very point which the Chairman had mentioned—namely, that electric light companies were entirely inadequately protected from those who wished to take advantage of the situation which the law ought never to have created. The *modus operandi* of the Company was so distinctly laid down and assured, he might say, from a technical and engineering point of view, that there was nothing to describe on the present occasion which they were not already aware of from information which had been given to them in past years. The Chairman had not said a word too much respecting the admirable work done by their officers, but Mr. Courtenay had not alluded to the very admirable work which he had himself done during the past year. It had rarely been his (the speaker's) lot to meet anyone who, filling such a position as Mr. Courtenay did in the Chelsea Company, gave so much of his valuable time, and in a way which was of enormous benefit, to the Company as their Chairman did.

The CHAIRMAN then invited discussion, but no question being asked, he put the resolution, which was carried unanimously. He afterwards proposed the re-election as a Director of Mr. Nugent Daniell.

Mr. G. N. MARTEN seconded the resolution, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. MARTEN, Mr. Emile Garcké was also re-elected to his seat at the Board.

General MACKENZIE, in proposing the re-election of the auditors, Messrs. Cooper Bros. and Co., said he desired to take that opportunity of expressing on behalf of a considerable number of shareholders their gratification with the admirable report which the Board had been able to present. They were in no degree anxious that the Directors should increase the dividend so long as they maintained the present good position and extended the valuable business of the Company.

Mr. FRANK KING seconded the motion, which was carried unanimously.

The CHAIRMAN: That concludes the business. I have only to say how gratified we all feel that we are able to present a report so good as to warrant the remarks made by General Mackenzie, and to tell him that the Board will bear in mind the remark which he made on his own account and that of other shareholders—that what is desired is not that we should pay you large dividends, but fair and moderate dividends, and to consolidate the position of the Company.

The proceedings then terminated.

Hove Electric Lighting Company (Limited).

The fourth annual meeting of this Company was held on Wednesday at Cannon-street Hotel, Colonel A. J. Filgate, R.E. (Chairman), presiding.

The SECRETARY (Mr. F. R. Reeves) read the notice calling the meeting.

The CHAIRMAN said: The report is a very full one, and gives a fair exposition of the Company's work and present position, which I trust you will consider satisfactory. The total capital expenditure up to December 31, 1895, amounted to £57,472, against £48,828 at the close of 1894, and since the accounts were made up our capital commitments have been

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further augmented by about £2,000. We have been obliged, as stated in the report, to obtain a new Crompton-Willans set of 250 H.P., thus increasing our dynamo horse-power to 700; and two new boilers aggregating 380 H.P., increasing our nominal boiler power to 780. This addition was necessary, as our resident engineer found it difficult to contend with the heavy demand thrown on the generating station last December. We have also erected an economiser by the use of which we hope to effect a saving on our coal bill, which is at present a large item. With these additions to our plant we shall be able to meet a heavier demand for current than has yet arisen, and, indeed, the station as at present equipped will be sufficient to meet all the demands on it for some time to come. Before long we shall probably have to increase the copper in some of our mains, and at an early date the question of extending the mains to streets not at present touched will have to be considered. Our policy in regard to extensions is to go anywhere within reasonable limits where a fair demand is likely to be forthcoming. I am glad to say the condition of the capital account is much more satisfactory than it was. During the past year we have issued £8,595 of share capital at a premium of 5s. a share. Practically the whole of the capital outlay during 1895 was met by the shares issued in that year, but we also placed during 1895 £7,500 of Four and a-Half per Cent. Debentures at 103. Our loans have been diminished from £10,000 to £3,100, and we have been able also to reduce the interest on them from 5 per cent. to 4 per cent. We have determined to exercise our option of paying off the Five per Cent. Debentures on July 1st next. The existing holders have agreed to accept £7,250 of Four per Cent. Debentures in exchange for their present holdings of Five per Cent. Debentures. Further applications for £400 of the new debentures have been received, and the balance we shall be able to place when the money is wanted. Turning to the revenue account, I may say that since January 1, 1895, the number of our customers has increased from 228 to 276, and the number of lamps on the system from the equivalent of 16,124 8 c.p. lamps to 18,900. The units consumed in 1895 were 162,428, compared with 107,218 in 1894, an increase of over 50 per cent.; the gross revenue has increased from £3,916 to £5,663, or by 44 per cent.; the expenditure has increased from £2,673 to £3,101, or by less than 17 per cent.; and the net revenue has increased from £1,243 to £2,562, or by nearly 106 per cent. These satisfactory results are due to the work done by our resident engineer at Hove, and to the care and attention of our secretary, to both of whom our thanks are due. Including the small balance brought into the accounts from last year, the amount on the credit side of the net revenue account is £2,577, which is reduced to £1,539 after charging against it the amount required for interest on the debentures and loans, and here I may remind you that we may hope in future to see a reduction in the proportionate amount required for interest on our debentures and loans. In dealing with the balance at the credit of net revenue account, which is sufficient to pay a dividend of 5 per cent. on the share capital, we have to give due consideration to the stability of the Company, and to provide for contingencies which may happen at any moment. In the first place we have to provide for the gradual liquidation of the preliminary expenses, and we have come to the conclusion that it is desirable to write off £134 under this head, leaving the amount to be dealt with in future £1,500. In all well-managed electric light companies it has become an axiom that a good reserve fund should be built up, and we have decided to recommend that £200 be credited to reserve out of last year's revenue, in addition to £460 realised by premiums on shares and debentures, making the total amount £660. With the remaining balance we recommend a dividend on the share capital at the rate of 4 per cent. per annum, carrying forward £152. In making these proposals we think it desirable to state that we hope to be able to recommend the payment of an interim dividend next autumn and in future years. In order to meet the wishes of our customers we have decided to adopt as from January 1st of this year the method obtaining in Brighton of charging by the "demand meter" system, which regulates the rebates or discounts allowed to customers in accordance with the actual consumption calculated on the maximum number of lamps in use at any one time. It is too soon yet to express any opinion as to the result of the change, but we trust it will lead to an increased consumption of current, so as to compensate the Company for any loss arising from the alteration. No doubt further modifications of the system of charging will have to be considered hereafter; but in the meanwhile the shareholders' interests will receive every consideration. The consumption of electricity is still increasing, and although not so rapidly as desired, it may be of interest for you to learn that the estimated net revenue for January and February of this year has amounted to £892, as compared with £714 in the same months of 1895. If this rate of increase can be maintained the accounts at the close of the current year should show satisfactory results. I think the figures I have placed before you are sufficient to show that the Company is likely to remain remunerative, and I may add that since the issue of this report we have received applications for shares to the amount of over £1,500, at a premium of 5s. per share. I now beg to move:—

"That the report of the Directors and the audited accounts and balance sheet to December 31, 1895, be and are hereby approved and adopted."

Col. H. WOOD, C.B. (Vice-Chairman), seconded the resolution, which was carried unanimously.

The CHAIRMAN then proposed:—

"That a dividend at the rate of 4 per cent. per annum for the year ended December 31, 1895, be declared and paid on April 15th next on the shares of this Company."

Mr. CARLETON F. TUFNELL seconded, and it was agreed to.

The CHAIRMAN moved the re-election of Mr. Tufnell as a Director, which was seconded by Col. WOOD, and carried.

The auditor (Mr. R. Payne, F.C.A.) having been reappointed, the proceedings terminated with a vote of thanks to the Chairman.

W. T. Henley's Telegraph Works Company (Limited).

The following Directors' report is to be presented at the 17th ordinary general meeting to be held at the Company's offices, 27, St. Martin's-lane, Cannon-street, E.C., on Friday next, the 13th instant, at 2 p.m.:—The accounts show a net profit of £21,823. 12s. 5d. After payment of debenture interest and income tax, and making an allowance for depreciation of plant, machinery, &c., there remains £17,342. 9s. 2d., to which must be added £1,600. 7s. 9d., the final dividend received from the International Cable Company (Limited), and £8,624. 9s. 3d. brought forward from last year, making a total of £27,557. 6s. 2d. Deducting from this £2,100, the interim dividend of 3 per cent. paid on the Ordinary shares on August 1st last, and £1,050, the half-year's dividend on the Preference shares paid in October, there remains a balance of £24,417. 6s. 2d. Of this sum the Directors have transferred £5,000 to reserve fund, and they propose the payment of the remaining half year's dividend on the Preference shares at the rate of 7 per cent. per annum, and a further dividend of 5 per cent., free of income tax, on the Ordinary shares (making a total distribution of 8 per cent. for the year, free of income tax, on the Ordinary shares). These payments absorb £11,050, leaving £13,367. 6s. 2d. to be carried forward. In the month of July last an issue of 3,000 Ordinary shares was made, and these were all subscribed for by the shareholders at par. The retiring Directors are Mr. Sydney Gedge, M.P., and Mr. Frederick Newton, who offer themselves for re-election, as do the auditors, Messrs. Ball, Baker, Deed Cornish and Co.

Oxford Electric Company (Limited).

The report of the Directors of this Company for the year ended December 31, 1895, to be submitted at the ordinary general meeting to-day (Friday) at 3.30 p.m., states that the revenue account shows a gross profit of £2,709. 8s. 3d. After providing for the full interest of 5 per cent. on the debenture issue and other interest, there remains a balance of £1,317. 9s. 4d., which, added to the amount brought forward from the previous year (£195. 4s. 8d.), leaves an available balance of £1,512. 14s. The Directors recommend that a dividend of 3½ per cent. be paid upon the Ordinary shares, which will absorb £1,152. 11s., leaving £360. 3s. to be carried forward.

The running of the plant during the year has given entire satisfaction, and current has been supplied to the public without the slightest interruption. Since the last report an equivalent of 3,797 8 c.p. lamps has been added to the system, and on December 31st there were 15,003 8 c.p. lamps connected. Fifteen colleges are now connected to the mains, and the Directors hope that the increase in the number of lights during 1896 will be equally satisfactory.

A new 150 H.P. engine and 100 unit dynamo of the same type as those already in use have been installed at the generating station, and various additions made to the machinery and plant during the year. In anticipation of an increase in the demand for current, the Directors are considering the expediency of enlarging the works at Osney and establishing additional sub-stations in various parts of the city. To provide for these extensions the Directors propose to issue 914 Ordinary shares of £5 each.

A new contract for the public lighting of the city has been entered into, the number of public lamps increased from 16 to 32, and the candle-power from 1,200 to 2,000 per lamp.

All the plant has been maintained in efficient order, and the expenditure for coal per unit of current delivered has been reduced to 0·55 of a penny.

The retiring Directors are Alderman Buckell, J.P., and L. A. Selby Bigge, Esq., M.A., who, being eligible, offer themselves for re-election, as does the auditor, Mr. W. S. Carver.

Birmingham Electric Supply Company (Limited).

The annual report of the Directors, to be submitted at the ordinary general meeting on Thursday next, the 12th inst., states that the net profit, including the balance of £1,001. 11s. 9d. brought forward, is £6,570. 11s. 8d. Out of this the Directors recommend the payment of a dividend of 4 per cent., absorbing £3,629. 9s. 9d., placing £1,920. 9s. 11d. to depreciation reserve fund, and £250 to the general reserve fund, carrying forward £770. 12s. On making this appropriation, the total reserves and undivided profits of the Company will amount to £9,463. 18s. 6d. There has been a steady increase in the Company's business during the past year, the total number of 16-c.p. lamps, or their equivalent, on order on December 31, 1894, being 12,138, and on the same date in 1895, 18,199. The number now stands at 19,401. The expenditure on capital account during the year amounted to £50,537. 2s. 1d. Considerable additions have been made to the plant and machinery at the Dale End Works, and included in the capital expenditure are the buildings and partial equipment of the Company's new stations at Edgbaston and Newhall-street, as also the underground mains that have been laid through a considerable portion of the Company's new Parliamentary areas. The Directors state that the two new stations are now in full working order. Although current was not available in the Edgbaston district till October last, the orders already received from that district are encouraging. The demand for current in the jewellers' district, both for lighting and power purposes, is also most satisfactory. In consequence of the reduced scale of prices adopted by the Board last year the number of customers has been considerably increased, and, although there was at first a slight falling off in the revenue, the result justifies the policy adopted. The increase during the year in the

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use of motors has been considerable, and the Directors think that this will in time become an important addition to the Company's resources. In order to cope with the demand in the future, additional plant has been ordered for the Dale End station, and generating plant is also in hand for the Newhall-street depot. The registered capital of the Company has been increased from £100,000 to £200,000, and in October last 10,000 shares were issued at a premium of 5s. per share, and the premium of £2,500 had been applied to writing off preliminary expenses (£1,685. 2s. 4d.), writing off expenses incurred in the recent registration and issue of new capital (£154. 10s.), and the balance (£660. 7s. 8d.) towards the reduction of the charge on account of the Company's Provisional Orders. The retiring Directors are Messrs. H. Buckley and F. W. V. Mitchell, who offer themselves for re-election, as do the auditors, Messrs. Sharp, Parsons and Co.

NEW COMPANIES, STATUTORY RETURNS, &c.

COLONIAL LIGHTING SYNDICATE (LIMITED).—This Company has been registered at Edinburgh, with a capital of £2,000, in £50 shares, to contract for, and obtain rights and concessions for the supply of electric or other artificial light in any of the cities, towns or districts within any colony or dependency of Great Britain.

STANLEY MORRISON AND CO. (LIMITED).—This Company was registered on February 25th, with a nominal capital of £20,000, in £5 shares, to acquire and take over as a going concern the business carried on by Arthur Stanley Morrison at 24, Duke-street, Aldgate, London, and to carry on the business of manufacturers of and dealers in india-rubber, asbestos, gutta percha, electricians, telegraph and electrical engineers and contractors, submarine and other cable and telegraph instrument manufacturers, wire drawers, and contractors for the laying down and maintenance of submarine and land cables, telegraphs and telephones. The subscribers, with one share each, are: E. Burford Morrison, J. H. Morrison, C. E. Morrison, A. H. Morrison, S. H. Motion, F. B. Hooper and F. A. Scott. The first Directors are A. Stanley Morrison and Basil Gee.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The annual return of this Company, made up to February 4th, has been filed. The nominal capital is £1,300,000, in £20 shares, and 60,710 of these have been taken up.

EASTERN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to February 6th, has been filed. Out of a nominal capital of £4,700,000, 469,989 shares of £10 each have been subscribed for and allotted. The full amount has been called, and £4,699,890 has been received.

ELMORE'S AMERICAN AND CANADIAN PATENT COPPER DEPOSITING COMPANY (LIMITED).—The annual return of this Company, made up to January 13th, has been filed. The nominal capital is £200,000, divided into 65,000 Priority and 35,000 Deferred shares of £2 each; 44,788 of the former and all of the latter have been taken up, and the Deferred shares have been issued as fully paid. The full amount has been called on the Priority shares, and £86,044. 15s. has been paid.

ELMORE'S WIRE MANUFACTURING COMPANY (LIMITED).—The annual return of this Company, made up to January 14th, has been filed. The nominal capital is £300,020, divided into 133,500 Ordinary, 16,500 Preference and 10 Founders' shares of £2 each; 67,278 Ordinary, 15,000 Preference and 10 Founders' shares have been taken up, and the full amount has been called. £565 has been paid on 1,610 forfeited shares.

LINEFF ELECTRIC TRACTION AND LIGHTING SYNDICATE (LIMITED).—The annual return of this Company, made up to January 4th, has been filed. 11,431 shares have been taken up out of a capital of £15,000 in £1 shares, and of these 8,003 shares have been issued as fully paid. The full amount has been called and paid on the remaining 3,428 shares.

NEWCASTLE AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this Company, made up to February 25th, is filed. 5,000 shares have been taken up out of a capital of £100,000 in £10 shares, and £8 per share has been called.

ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to February 18th, is filed. The nominal capital is £200,000, divided into 19,980 Ordinary shares of £5 each, 20,000 Preference shares of similar value, and 100 Founders' shares of £1 each. All of these shares have been taken up, the full amount has been called, and £200,000 has been paid.

YORKSHIRE HOUSE-TO-HOUSE ELECTRICITY COMPANY (LIMITED).—The annual return of this Company, made up to February 18th, has been filed. The nominal capital is £100,000, divided into 19,900 Ordinary and 100 Founders' shares of £5 each. 18,848 Ordinary and 100 Founders' shares have been taken up, and the latter have been issued as fully paid. The full amount has been called on 10,000 Ordinary and £2 per share on 8,848 (payments in advance of calls).

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver, 1 3d. per oz. (March 5th). Consols (2½ per cent.) 109¼—109⅜ for money, 09¼—109⅜ for account; 2½ per cent. 105⅝—106 (March 5th). Stock xchange Settling Days: Consols, March 30th; Stock and Shares Connuation Days, March 10th and 25th; Ticket Days, March 11th and 26th; ay Days, March 12th and 27th; Mining Share Carry-over Days, March 9th nd 24th.

BELL'S ASBESTOS COMPANY (LIMITED).—The Directors of this Company have declared a dividend at the rate of 3 per cent. per annum, after acing £1,000 to reserve and carrying forward £2,200.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—Notice is given that the transfer books of this Company will be closed from the 18th to the 24th inst. inclusive, preparatory to the payment of an interim dividend of 3s. per share (equal to 6 per cent. per annum), free of income tax, for the quarter ended December 31st last. The dividend is payable on the 25th inst.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended March 1, 1896, were £946, against £953 in the corresponding week of 1895, a decrease of £7. The total receipts for the half-year amount to £8,860, against £8,941 in the corresponding period of 1895, a decrease of £81.

COMMERCIAL CABLE COMPANY.—Mr. Clarence H. Mackay has been elected a director in place of the late Mr. J. W. Mackay, junr. The Directors have declared the usual quarterly dividend of 1¾ per cent., payable on April 1st next. The transfer books of the Company will be closed from the 20th inst. to April 2nd. The annual report of this Company states that the gross earnings amounted to $1,961,597; earnings from interest to $48,140, an increase of $3,939; net earnings to $1,215,308. an increase of $204,870; and the net surplus amounted to $515,308, an increase of $204,870.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The estimated amount of the traffic receipts of this Company for the month of February s £2,461.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of February amounted to £69,711, against £67,342 in the corresponding period last year.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of February, 1896, amounted to £48,233, and to £34,213 in the corresponding period of last year.

GREAT NORTHERN TELEGRAPH COMPANY.—The numbers are published of 100 1883 Debentures (Series B) of this Company, which have been drawn for payment on the 1st inst, at the offices of Messrs. C. J. Hambro and Son, 70, Old Broad-street, E.C. The traffic returns of this Company in February last were £22,000, and the total receipts for the period from the 1st January to 29th February, £44,400, against £41,000 and £44,400 in the corresponding months of 1894 and 1895 respectively.

ISLE OF MAN TRAMWAYS AND ELECTRIC POWER COMPANY (LIMITED).—The annual meeting of this Company was held at Douglas, on Friday last. The Chairman (Mr. A. Bruce), in moving the adoption of the report and accounts, referred to the satisfactory character of the balance-sheet and the gratifying results of the past year's working. The cost of working the horse section of their lines was 50 per cent. of the gross receipts, while the electrical section only cost 34 per cent. The report was then unanimously adopted, and the retiring Directors (Dr. Farrell and Mr. W. J. P. Pittar) were re-elected. An extraordinary general meeting of the shareholders was afterwards held, when resolutions approving the purchase of the Snaefell Mountain Electric Railway for £72,500, and increasing the capital of the Company to £175,000, were passed.

LIVERPOOL ELECTRIC SUPPLY COMPANY (LIMITED).—The ordinary general meeting of this Company was held on Friday last at the Exchange Station Salerooms, Liverpool. The Chairman (Mr. A. H. Holme) in moving the adoption of the report and accounts, said that the result of the year's working had justified the opinion expressed at the last meeting, that the Company was in a prosperous condition. They had largely increased their capital, and their number of lights. They had now nearly 40,000 lamps connected, an increase of 7,200 since January of last year. That would probably be their last meeting, as the Royal Assent would shortly be given to the Bill for the purchase of their undertaking by the Corporation, and within 42 days of that event the Corporation would pay them £8. 2s. per share. In reply to a shareholder, the Chairman said that the whole of the profit of the undertaking now went to the Corporation, less 6 per cent., which they were empowered to divide, and he concluded by moving that a dividend at this rate be declared for the half-year ended December 31st last, which was agreed to. Mr. A. H. Holme and Sir David Radcliffe, the retiring Directors, were re-elected.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 1st inst. amounted to £1,056. The amount for the corresponding week last year was £934. Increase £122.

SANITAS COMPANY (LIMITED).—At a meeting held last week the Chairman, Mr. F. H. L. R. Moll, announced that the business done by the Company during 1895 had been very satisfactory. New articles had been introduced, and had met with an excellent reception from the trade and the public. He asked the shareholders to approve of a dividend equal, with a bonus of 9d. a share, to 13¾ per cent. per annum. Mr. C. T. Kingzett, Managing Director, explained to the meeting some details of the business, and pointed out that the increase in the demand for Sanitas preparations had necessitated considerable extension of plant at the works.

STOCK EXCHANGE NOTICE.—Application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to, £200,000 Four per Cent. First Mortgage Debentures (Nos. 1 to 2,000) of John Fowler and Co., Leeds (Limited).

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended February 28th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,624.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half-month ended February 29th are £2,681, against £1,947 in the corresponding period of 1895.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Feb. 26.		Price Wednesday, Mar. 4.		Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending Feb. 29. Highest	Lowest
			TELEGRAPHS.								
£1,012,880	Stock	18/0	Anglo-American ... xd	46	48	46	48	5 4 2	Jan., Apr., July, Oct.	46½	..
£2,993,560	Stock	36/0	Do. Preferred ... xd	87	88	87	88	5 13 8	" "	88	87
£2,993,560	Stock	5/0	Do. Deferred ...	7½	7⅝	7½	7⅝	..	..	7⅝	7⅝
£178,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	100	104	100	104	3 17 6	Jannary and July ..	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid) ...	10⅛	10⅜	10⅛	10⅜	..	..	..	..
180,000	£10	3/0	Brazilian Submarine ...	14	14⅛	14⅛	14⅛	4 14 11	Mar., June, Oct., Dec.	14 1/16	14
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	110	114	111	115	4 7 9	June and December	..	..
10,000,000	$100	8⅓	Commercial Cable Capital Stock ...	160	170	160	170	4 3 0	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine ... xd	12½	13½	12½	12½	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent. ... xd	20½	21½	20½	21½	4 15 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid) ...	4	5	4	5	4 0 0	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent. ...	10	10½	10	10½	4 15 8	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each ...	104⅞	107⅞	105⅞	108⅞	4 3 11	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877 ...	9	9½	9	9½	4 4 8	Jan., Apr., July, Oct.	9⅜	9⅛
400,000	10	2/6	Eastern ...	17	17½	17	17½	3 14 4	" "	17⅝	17
70,000	10	6%	Do. 6 per Cent. Preference ...	18	18½	18	18½	3 4 10	" "	18⅝	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	128	131	129	132	3 1 2	May and November	131	130
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899 ...	105	108	105	108	4 13 0	February & August	..	..
250,000	10	2/6	Eastern Extension ...	17⅜	18⅛	17⅜	18⅛	3 16 9	Jan., Apr., July, Oct.	18⅛	..
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock ...	128	131	128	131	3 1 2	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900	100	104	101	105	4 16 2	January and July ..	103½	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb.,1900	100	104	101	105	4 16 2	" "	104½	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) ..	105	108	105	108	3 14 3	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.) ...	112⅞	115⅞	112⅞	115⅞	3 10 4	May and November	..	..
180,227	10	1/6	Globe Telegraph and Trust ...	10	10½	10	10½	3 18 6	Jan., Apr., July, Oct.	10½	10⅜
180,042	10	6%	Do 6 per Cent. Preference ...	16⅞	17½	16⅞	17½	3 9 7	" "	17⅝	17½
150,000	10	5/0	Great Northern ...	22½	22⅞	22½	22⅞	3 14 9	Jan., April, and July	23	22⅞
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue .... x i	104	107	102	105	4 15 3	March & September	..	..
17,000	25	12/6	Indo-European ...	46	49	46	49	5 2 0	May and November	48½	47
37,548	10	..	London Platino-Brazilian ...	..	..	..	..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures ... xd	107	111	105	108	5 11 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942..	108	111	108	111	3 12 7	" "	..	..
11,889	8	4/0	Reuter's ...	5	6	5	6	..	April and October..	..	..
3,881	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent. ...	132	137	132	137	4 7 7	" "	133	..
15,609	10	2/0	West African Telegraph ...	5⅛	6⅛	5⅛	6⅛	..	January and July ..	..	..
£238,300	100	5%	* Do. 5 per Cent. Debentures (red.) ... xd	102	105	101	104	4 13 2	March & September	104½	101
30,000	10	2/0	West Coast of America ...	1	2	1	2	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902 ...	94	99	94	99	8 4 1	June and December	97½	..
88,321	10	1/3	West India and Panama ...	1	1½	1	1½	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference ...	10½	11	10½	11½	5 6 8	May and November	10⅝	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference ...	9	10	9	10	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108	111	108	111	4 10 11	June and December	..	..
64,248	15	3/0	Western and Brazilian ...	8⅜	9½	8⅜	9½	5 5 8	May and November	9⅜	9⅛
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred ...	6½	7	6⅞	7	..	—	6⅞	6⅞
33,129	7½	1/6	Do. Deferred Ordinary ...	2⅜	3½	2⅜	3½	..	—	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	102	106	102	106	5 13 9	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910 ...	102	106	102	106	5 13 9	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds....	113	118	113	118	6 0 11	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.) ... xd	104	107	105	106	5 14 3	March & September	..	..
			TELEPHONES.								
44,000	5	2/6	Chill Telephone (fully paid) ...	3⅛	3⅜	3	3⅛	..	—	—	—
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance ..	1/16	1/16	1/16	1/16	..	May and November	—	—
171,504	£1	5/15	Oriental Telephone and Electric (fully paid) ...	1/16	1/16	1/16	1/16	..	Yearly ...	..	..
484,597	5	3/0	National ... xd	6⅝	7	6⅝	6¾	4 0 0	June and December	6 11/16	6⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref. ... xd	16	18	16	18	3 6 8	" "	17½	17½
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid).. xd	16	17	16	17	3 10 7	" "	16½	16½
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref. ... xd	6⅜	6⅝	6⅜	6⅝	3 12 9	—	6⅝	..
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.) ...	104	107	104	107	3 5 9	January and July ..	106½	106½
58,000	5	3/0	United River Plate ...	3½	3⅝	3½	4	..	" "	3⅝	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.) ...	93	98	95	100	5 1 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	10/0	City of London Electric Lighting (fully paid) ..xd	14½	15½	14	15	3 6 8	—	15	14½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid) ... xd	16	17	16	17	3 10 7	—	17	16½
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.) ...	134	138	134	138	3 13 0	June and December	..	..
19,900	£5	..	Electricity Supply Co. for Spain ...	..	..	..	..	..	—	—	—
£30,000	£5	3/0	Charing Cross & Strand Electricity Supply Corp. x i	6½	7½	6½	7½	..	—	6½	6
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900 ...	..	..	..	..	..	—	—	—
23,175	£8	..	County of London & Brush Prov. Ord. (fully paid).	8	9	8	9	..	—	—	—
10,000	£10	9½d.	Do. Pref. (£8 paid) ...	10	11	10	11	..	—	—	—
8,322	£5	..	House-to-House Electric ...	..	..	..	..	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	..	..	..	..	..	—	—	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid) ...	..	..	..	..	..	January and July ..	—	—
45,000	£5	3/0	Liverpool Electric Supply (fully paid) ...	7⅞	8½	7⅞	8½	3 13 10	—	—	—
111,000	5	..	London Electric Supply ...	..	..	..	..	..	—	—	—
49,900	£10	3/0	Metropolitan Electric Supply (fully paid) ...	12	12½	12⅛	12⅜	2 7 0	—	12½	12½
£150,000	Stock	4½%	* Do. 4½% Debs. ...	115	118	110	119	3 16 1	June and December	..	..
6,452	£10	4/0	Notting Hill Electric ... xd	8½	9	8½	9	..	—	8½	..
..	..	..	Rand Electric ...	1/16	1/16 prem.	1/16	1/16 prem.	..	—	—	—
19,980	£5	5/3	St. James and Pall Mall ...	9⅝	10½	9⅝	10½	..	—	10	..
20,000	£5	7%	Do. 7 per Cent. Preference ...	9	9½	9	9¾	3 13 8	—	..	..
19,900	5	4/6	Westminster Electric Supply (fully paid) ... xd	9½	10	9½	9⅝	4 12 4	—	9½	9⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	2	1/6	Brush Electrical Engineering ...	1	1⅛	1⅛	1⅜	5 3 8	—	1	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative ...	1⅜	1⅝	1⅜	1⅝	3 8 7	—	1 11/16	1½
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures ... xd	112	115	110	113	3 19 8	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref..	2½	2¾	2½	2¾	..	January and July ..	..	..
80,261	5	1/6	Edison and Swan United ... xd	1⅝	2	1⅝	2	..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock ...	103	106	103	106	4 6 6	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	—	—	—	—	..	..	—	—
110,000	2	..	Electric Construction ...	1⅜	1⅝	1⅜	1⅝	..	..	1 3/16	1⅛
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref. ...	2⅜	2¾	2⅜	2⅝	5 1 10	..	..	..
91,195	2	..	Elmore's Patent Copper Depositing ...	¼	⅜	¼	⅜	..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid) ...	¼	⅜	¼	⅜	..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works ... xd	20⅝	21⅛	19⅝	20⅝	4 17 7	February & August	21	19⅝
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896 ...	103	106	103	105	4 7 5	March & September	..	..
15,995	£10	..	International Okonite Ordinary ...	..	..	..	..	..	—	—	—
16,000	£10	..	Do. 8 per Cent. Preference ...	..	..	..	..	..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid) ...	..	..	..	..	..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance ...	38	39	38	41	4 7 9	March and July....	41½	39
£150,000	100	5%	* Do. 5 per Cent. Bonds ...	102	105	102	105	4 15 8	January and July ..	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)..	..	..	..	..	..	—	—	—
41,098	£5	..	Do. Preference (fully paid) ...	..	..	..	..	..	—	—	—
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary ...	15	16	15	16	3 15 0	—	1 1/16	1
£80,000	10	7/0	Do. 7 per Cent. Preference ...	16½	17⅜	16½	17⅜	3 19 9	—	..	..
£50,000	Stock	4½%	Do. 4½% Mort ge Debenture Stock ... xd	109	112	107	113	4 2 0	—	—	—
			RAILWAYS AND TRAMWAYS.								
£680,000	Stock	1½%	City and South London Railway Con. Ordy. ...	40	42	40	42	2 19 6	May and November	..	..
7,650	10	5%	Do. 5% Perpetual Preference ...	14¼	15	14¼	15	3 6 8	.. ..	14½	14
£10,171	Stock	4%	Do. 4% Perpetual Debenture ...	130	132	130	132	3 0 7	May and November	131½	..
37,500	£10	3½%	Liverpool Overhead Railway ...	13⅜	13⅞	13⅜	13⅞	2 1 8	—	—	—
10,000	10	5%	Do. 5% Preference ...	15⅜	16	15⅜	16	3 2 6	—	—	—
145,000	Stock	4%	Do. 4% Debenture ...	113	114	114½	116	3 10 2	January and July ..	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but not or redemption.

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NOTES.

In an article to be found in another column, Mr. W. C. Fisher deals a deadly blow at a very ancient electrical tradition. Time was when we were all taught to regard the Clark standard cell as an extremely delicate organism, to be handled with all the nervous solicitude due to an invalid. Mr. S. Skinner somewhat disturbed this belief in his Paper in the *Phil. Mag.* of September, 1894 (see *The Electrician*, September 28, 1894, p. 644), entitled "The Clark Cell When Producing a Current," where he showed, amongst other things, that using large cells with an exposed zinc area of about 95 sq. cm. and of a very low resistance, the electromotive equanimity of the standard was not upset when it was producing 0·01 ampere. And now Mr. Fisher's experience goes to prove that not only is a properly-made Clark cell, *i.e.*, one *not* made according to Board of Trade specification, none the worse for any amount of knocking about, but that short-circuiting—that once fatal disease—has lost its terrors. The curves of electromotive force given in Fig. 35 show in a striking manner the highly-beneficial effect of slight charging upon the rate of recovery of a severely short-circuited cell. It is also interesting to learn that a Clark cell, like many other organisms, is all the better for plenty of hard work. We think most of Mr. Fisher's results will be entirely new and decidedly useful to the majority of users of Clark cells.

Considerable interest will probably be evinced by electrical engineers, in the fact that the Brush Electrical Engineering Company have recently placed upon the market a vertical high-speed enclosed steam engine. The earlier type of Brush engine is well-known in this country, especially in provincial supply stations; but we may mention that it is neither an enclosed nor strictly a high-speed type, and in the majority of instances is rope-geared to the dynamos. The new engine, which it is intended to couple direct, exhibits therefore an important departure from the former practice of its makers. It is constructed to the designs of Mr. J. S. Raworth, by whom the earlier engine was also designed, and though built to run at high speeds it is equipped with Corliss valves and automatic expansion gear. Naturally enough, trip gear has not been introduced, the valves being actuated by positive motion. In this, however, the makers discover nothing but advantage, for the throttling of the steam at very low loads with such a valve gear is claimed to give higher economy than a sharper admission. We wish the newly-born engine a long and prosperous life, and await with interest the results of the trials which life inevitably has in store for it.

Whatever a practical steam engine builder has to say about the development of steam engines is entitled to respect, and on this account electrical engineers will welcome the opinions expressed by M. H. Lindley in his Paper on "The Development of Electric Lighting Engines," an abstract of which we print this week. The Paper bristles with practical information, chiefly in respect of the *minutiæ* of engine building; but we fail to discover in it any really philosophic or exhaustive account of the causes which have led to the development of that special type, the electric light engine. Mr. Lindley notes the adoption of moderate and high-speed engines in preference to the older type of mill engine, but he attributes it to such comparatively minor matters as the smaller cost of the former, and the universal adoption of white-metal bearings; and he scarcely so much as mentions the main reasons—viz., the avoidance of gearing while still retaining a high-speed dynamo, the higher steam economy per useful horse-power consequent on the better thermodynamic conditions, the use of single action, and the more compact and convenient sub-division of plant into units of manageable and economical power. There is unconscious humour, moreover, in the reason which Mr. Lindley has given for not dealing with the high-speed engine in detail—the electric light engine, *par excellence*, we had thought. "It is impossible to deal in any other than a general manner with this type," he says, "without simply describing A's or B's engine," which would no doubt be too good an advertisement for A or B.

Although it cannot be said, even by the most inveterate optimist, that the time devoted to the discussion of the Papers read by Messrs. Mavor and Bathurst before the Institution of Electrical Engineers in November, 1895, was time particularly well spent, so far as the advancement of the house-wiring question is concerned, three dreary evenings will not have been spent in vain if they serve to call attention to the character and method of discussion permitted. While the Papers themselves were, perhaps, not the best possible type of "curtain raiser" for a good session, both of them bristled with points of attack. All this,

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however, was of no avail; the critics faced the points boldly, and—passed on. And the want of relevancy and practicality was not redeemed by any exhilarating display of wit; a portentous solemnity pervaded the proceedings worthy of the sad deliberations of a coroner's jury.

WHY was this so? Are our brilliant young consultants always so careful of each other's feelings? What is the nett result of the two Papers referred to, and the prolonged discussion to which they gave rise? We have a catalogue of the merits of conduit and concentric wiring, and of the demerits of wood casing: both lists, having been compiled by interested parties, require—editing, to say the least. Then we have placed on record in the discussion opinions as to the iniquities of insurance companies, bad habits of workmen, arrangements of working staff, &c., &c., all of which may be very interesting, but scarcely relevant to the question at issue. But granting that this may pass, why should three full evenings have been spent on the subject? It is clear that two things are necessary if the Institution is to do any real work at its meetings. Men not practically acquainted with the subject under discussion should be discouraged from speaking, and the time limit should be rigorously enforced. Given speakers who really have something pointed to say, they will not find much difficulty in saying it in ten minutes. Verbosity should be snuffed out by an automatic electric time bell, if the President finds it a task too delicate to undertake himself. At any rate he might extinguish irrelevancy.

THE holophane globe is certainly decidedly less cumbersome in appearance and less costly and more effective than the average scientific dodge for diffusing and distributing the light of the glow lamp or similar luminous source. At the same time, "Holophane" (Limited), the advertisements of which have during the past few days spread themselves over many columns of *The Times*, does not, it seems to us, possess a very substantial foundation. The manufacture and sale of holophane globes might, no doubt, prove a profitable adjunct to a well-established glass-globe business, but it is no more capable of supporting all by itself an entire company with a capital of £100,000 than a new form of thermometer would be. The vendor, not the inventor *bien-entendu*, is to be paid £80,000 for all the patents covering this little invention, excepting those relating to France and the United States. Considering the precarious nature of patent property, we doubt if any patent ever existed or ever will exist genuinely worth that sum *before* it has passed through the fire of the law courts right away up to the House of Lords, The easy assumption that the British public is going to absorb 663,400 holophane globes per annum is amusing. The holophane globe is undoubtedly a praiseworthy device; but, like the baby in "Midshipman Easy," it is "only a very small one," and we are sorry to see it made an excuse for extracting so much money from the investor.

THE Canadian Society of Civil Engineers have adopted a "code of engineering ethics"; whether they will observe the code is quite another matter, though doubtless it will find a place in every Canadian engineer's Molesworth. This engineering decalogue, or rather endecalogue, is drawn up in a style which has a faint flavour of Sandford and Merton, "Advertising with a view to attracting business should," we are gently told, "where resorted to, be as far as possible free from egotistic or self-laudatory references, and expressed in language not derogatory to the dignity of the profession"; a flower of rhetoric worthy of the Rev. Mr. BARLOW. Again, in the eleventh commandment it is ordained that "The Civil Engineer whose advice is sought in respect to the usefulness, practicability and cost of a work should, before expressing his opinion, obtain reliable information. . . . ." After which one almost expects to find the list of truisms winding up with the Quaker's warning "Friend, thou had best not eat peas with thy knife." No doubt Canadian civil engineering practices, like English electrical engineering practices, are in some need of regulation by ethical considerations, but a string of platitudes will not effect much in this direction. It is the unwritten law given by the example of the leaders of a profession that the minor professional lights fear to infringe.

WE publish this week an analytical table of the 1895 accounts of a number of electric supply undertakings doing business in London and in the provinces. This table will be added to as further accounts are forthcoming, and the table, with the additions, will be issued at regular intervals until the analysis is complete. When we first commenced this work, in 1892, the extent of the electric supply industry did not warrant more than one issue a year. To-day, with over one hundred concerns in operation, more frequent publication becomes imperative.

Cable Interruptions and Repairs:—

	Date of Interruption.	Date of Repair.
Zanzibar—Mombasa	Mar. 6, 1896	Mar. 9, 1896.
Puerto Plata—Martinique ...	Dec. 19, 1895	—

The Royal Society.—The Croonian lecture, "Observations upon Isolated Nerve: Electrical Changes a Measure of Physico-chemical Change," was delivered yesterday by Dr. A. D. Waller, F.R.S.

The Zipernowsky Transformer Patents in Italy.—The Siemens v. Zipernowsky transformer patent case was heard before the Court of Appeal at Florence last week. Judgment has been reserved.

New Anglo-German Cable.—The Silvertown Company has secured from the Post Office the contract for a new four-cored cable, some 230 miles in length, to be laid from the Norfolk coast to the Island of Borkum. The manufacture of the cable has already been commenced.

Electric Railway over the Rhine.—The construction of an electric railway between Düsseldorf and Crefeld, crossing the Rhine at Golzheim, has just been decided on. A company has been formed with a capital of £600,000. The line will be about 12 miles long, and the whole distance will be covered in 24 minutes. Trains to be run at intervals of 20 minutes.

Erratum.—In our description, last week, of the Bristol municipal electric supply station the horse-power of the "G G G S" Willans engines coupled to the 88-kilowatt alternators was stated in one place to be 100 H.P., and elsewhere in the article as 150 H.P. The former figure is obviously too small for the kilowattage, and we understand that the engines are rated by the builders at 150 H.P. each.

The Accumulator Industry in France.—The sole right to manufacture and sell the Muller and Tudor accumulators in France has just been acquired by the Société Industrielle des Moteurs Electriques à Vapeur (Système Heilmann). The

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accumulators have hitherto been made by the Hagen Accumulator Company of Hagen, Westphalia, but will now also be manufactured at the Heilmann Works, in France.

Electric Rock Drills.—Electric rock drills are being adopted at the iron ore mines of the Hernadthal Hungarian Iron Industry Company at Krompact. Six drills are at first to be brought into use, and the generating plant, which is being put down by Messrs. Siemens and Halske, of Vienna, will comprise a semi-portable engine and boiler, and a 16-kilowatt continuous-current dynamo.

Manufacture of Bronzes and the Factory Act.—*Engineering* announces that the Secretary of State for the Home Department has issued an order under the Factory and Workshops Act, 1895, declaring that processes in the mixing and casting of brass, gun metal, bell metal, white metal, delta metal, and phosphor-bronze are dangerous or injurious to health, and therefore come under the provisions of the Act relating thereto.

Electric Emergency Lighting in Budapest Theatres.—To do away with the not very pleasant oil lamps which are now in use in theatres in case of emergency, the leading theatres of Budapest have obtained permission from the local authorities to displace the same by electric lamps. These lamps will be quite independent of the main lighting plant, and will it is hoped come into action when this latter breaks down.

Car Motor Ventilating Device.—To afford ventilation to entirely closed motors, the Philadelphia Electric Railway has adopted a very simple arrangement. From a ventilator on the car roof the cold air goes down through a pipe in the corner of the car, and feeds into the motor cases. From the cases it is discharged through one of the hot air escapes in the sides of the car. Which of the two holes is to be closed is determined by the direction the car moves.

City and Guilds Central Technical College.—We have received a copy of the Programme of the City and Guilds Central Technical College. Particulars are contained in it of the various departments of mathematics, engineering, physics and chemistry, and of the examinations, scholarships, &c., pertaining to the institution. The full course in electrical engineering extends over three years, and is under the direction of Prof. W. E. Ayrton.

The Telephone on the Continent.—Dalziel's agency states that arrangements are being completed for extending the existing through telephone service between Paris and Marseilles on to Cannes, Nice, and Monte Carlo, and that negotiations are pending between the London and Paris Postal Departments, so that the London and Paris telephone may be connected with the French inland trunk wires. It is also asserted that the French Government is seriously considering the practicability of telephone communication between Marseilles and Algiers.

The Pacific Cable.—A *Times* cablegram, dated Ottawa, March 5th, states that the Canadian Government have been informed that the conference between Mr. Chamberlain and the colonial representatives regarding the details of the Pacific cable scheme will take place at the Colonial Office the week after Easter. The Canadian delegates will be appointed in time to enable them to be present at the gathering. If the state of public business should enable him to leave Canada, Sir Mackenzie Bowell will be one of the delegates and Mr. Sandford Fleming the other.

Electric Traction in Rome.—The Rome Tramways Company is so satisfied with the successful result of the electric traction system started last September as regards economy of working and increase in receipts, that it has resolved to adopt electric traction on the whole of its network, and has presented a petition to this effect to the Municipality of Rome. At the same time a request has been made for permission to build five new lines to be worked electrically. The Naples Tramways Company has also petitioned the municipality of that town to grant a concession for the electric working of the entire tramway system, amounting in all to some 40 miles of double track. This is at present partially worked by horses and partially by steam.

Deodorising Gas Engine Exhaust.—A device for deodorising gas engine exhausts is described in the *Chemical Trades' Journal* as consisting of a box divided into two compartments by a perforated partition, on which bone black is spread in a moderately thick layer. The exhaust gases from the engine enter into the lower compartment at the extreme left, pass through the perforated dividing wall and superimposed layer of absorbent in the upper compartment, and thence escape into the open air through a pipe at the upper right-hand side. Thus the ammonia and fœtid hydrocarbon gases are absorbed by the bone black, and whatever liquid offensive particles may be in the products of combustion are retained by it mechanically. Water of condensation collecting in the lower compartment may be drained off through a drip pipe.

The Penetrating Qualities of the Arc Light.—In the first number of the *Photographische Rundschau* for 1896, Herr Schmidt, of Munich, describes some experiments he made about a year ago with regard to the penetrating quality of the arc light. He found that the light from an arc lamp passes more easily through certain substances than sunlight. A wooden board 2mm. thick was placed before a photographic plate, and an exposure of only 10sec. to 12sec. sufficed to attack the plate. Indiarubber, bone and ebonite proved less transparent with a thickness of 2mm., an exposure of half an hour was required to cause the same effect as through wood. Celluloid was found, however, nearly opaque. A 43-ampere continuous-current arc lamp was employed, the photographic plate being placed about 16in. from it.

Argon.—The recent discovery of argon in atmospheric air, by Lord Rayleigh and Prof. Ramsay, aroused such great interest that it has been resolved, says *Nature*, on the repeated request of the "general public" to prepare a volume containing an account of the methods of extracting the new gas from air, and of its properties, explaining, where necessary, in popular language, the basis of the reasoning employed in drawing conclusions relative to argon. But the whole history of the determination of the gases in air is so closely related to this recent discovery, that it would hardly have been possible to present the subject in its entirety without a preliminary sketch of the discoverers and their work. The little work, which has been written by Prof. Ramsay, and will be published by Messrs. Macmillan and Co., therefore treats of all the progress made in this branch of chemistry.

A Telephone System for Guernsey.—Two public meetings were held in Guernsey last week—on March 4th at St. Peter Port, and on March 5th at St. Sampson's—to consider the introduction of a telephone exchange system into the island. Both meetings were addressed by Mr. A. R. Bennett, who recommended that the work should be a popular one, undertaken either by the States of Guernsey or by a local co-operative company approved by the States. A representative of the National Telephone Company was present, and explained the terms on which his Company would open a Guernsey exchange; these were, however, rejected as too onerous. Ultimately it was unanimously resolved (1) that it is expedient to introduce a telephonic exchange system into Guernsey with the least possible delay, and (2) that a committee be appointed to consider the whole subject and to take the necessary steps to secure the establishment of an exchange by the States or by a co-operative company under the protection of the States. A committee consisting of 17 leading inhabitants, including several members of the Guernsey legislature, was elected, partly at the St. Peter-Port and partly at the St. Sampson's meeting. The committee held its first sitting on March 6th, and decided that the States should be recommended to apply immediately for a licence to telephone the island in terms of Clause 19 of the Treasury Minute of August 7, 1894. A telegram notifying the desire of Guernsey to manage its own telephone system, and the intention to apply for a licence was ordered to be despatched to the Postmaster-General.

Interior Lighting by Diffused Reflection.—We recently had an opportunity of inspecting the fine example of interior electric lighting on the diffused reflection system which has been carried out at the Union Bank of Australia in Cornhill by Messrs. Henry F. Joel and Co. to the designs of Mr. Goymour Cuthbert, A.R.I.B.A., and under the supervision of Mr. Hugh Erat Harrison. The magnificent main hall, which

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is 72ft. long by 53ft. wide by 20ft. high, and is in the usual classical style affected by banks, is lighted by 91 groups of three 25 c.p. glow lamps suspended 6ft. from the ceiling in bronze dish-shaped fittings, made reflecting on the inside by a dull coating of tin. To those accustomed to the alternations of glare and gloom characteristic of so much of our modern public building lighting, the beautifully uniform illumination attained in the main hall of the bank leaves at first an impression upon one's mind, or rather upon one's retina, of uniform dullness. A few minutes, however, suffice to educate the eye up to the standard of this ideal mode of preventing injury to the human visual organs, and the sufficiency of the illumination is attested by the fact that the smallest print can be read with ease at the level of the bank desks. What special arrangements have been made for keeping the ceiling clean we do not know; the reflecting fittings are, however, arranged so that they can be easily dusted. The solid opaque bottoms of the basin pendants present a somewhat heavy and gloomy appearance, and we should have thought a little obscured glass might have been used with advantage here. All concerned, including the bank officials, are, however, to be congratulated on this bold and praiseworthy departure from the bad and beaten track of lighting by direct dazzlement.

Monopoly in Scientific Discoveries.—At the discussion on Mr. A. A. C. Swinton's Paper on "Röntgen's Photography of the Invisible" at the Society of Arts, last week, Prof. Dewar, chairman of the meeting, made the following remarks:—

". . . It was stimulating to the cultivation of real science to have a brilliant discovery like this (probably the most remarkable which had been made within the last half century; seeing that it had been rendered practically useful within less than three months of its publication), generally appreciated. They could see no end to the future work in abstract science which it opened up. It had, at the same time, stimulated a kind of criticism to which, perhaps, Mr. Swinton would be exposed, but which, in his opinion, ought not to be entertained. That was the view that a scientific discoverer had some kind of monopoly for an indefinite period of time in his discovery, and that his position was similar to that of an inventor. He should not have been surprised if this view, which had recently been promulgated in the scientific journals, had led to a kind of injunction being asked against their friend. He could not understand that position. There was no monopoly in science, and he felt convinced, though he had not the honour of knowing Prof. Röntgen himself, that he would not regard this widespread interest in his work as in any way detracting from his merits, but rather as adding new laurels to the value of the original investigation. He was sure Mr. Swinton would be the last man to do anything else than exhibit the marvellous fertility of Röntgen's discovery. To say that any investigator, if he locked the door of his laboratory and cultivated his own garden—as had been suggested—for a permissible period, could have done as much in three months as had been done in this case through publicity, would be simple nonsense. He could not but think that such ideas rather suggested that, instead of having regard to the real objects of science, there was too much consideration being given to the personality of the investigator. Now the merits of the investigator had often very little to do with the importance of the discovery. That was one reason why there could be no such thing as monopoly. Look at the antecedent work involved in Prof. Röntgen's discovery. On the one side you had the heredity from Faraday, who first suggested lines of force, to the great development made by Maxwell, to the work of Varley, and to that of Crookes. On the other hand, you had the work of Hertz, Lenard, and Röntgen. There were three Germans who had cultivated this field, and at least four Englishmen who had done admirable work. We, therefore, had our own share in the development of Röntgen's discovery, and every step had been necessary to the ultimate achievement. Of course, they always felt that somebody else might have discovered something, and that it was a pity he missed it; but really one man could not expect to monopolise everything, and there was plenty yet to be found out."

Röntgen Rays.—The *Comptes Rendus* for February 17th contains, as usual, numerous communications on the subject of Röntgen rays. M. R. Swyngedauw has a communication on the subject of the lowering of the sparking distance. Prof. Righi has a summary of the communication which appeared in full in *The Electrician* of last week. Prof. J. J. Borgman and M. L. Gerchun present, in an expanded form, the information contained in their telegram published in *The Electrician* of February 14th. MM. L. Benoist and D. Hurmuzescu present a Paper in which they state that they have verified that Röntgen rays are propagated in air according to the law of inverse squares. They also state that the Röntgen rays are heterogeneous. They base this statement on the fact that they find the coefficient of transmission for a 0·1mm. thickness of aluminium to be about 0·85, and they go on to say that such a value is absolutely incompatible with the very sensible transparency that Prof. Röntgen observed for a plate of aluminium 15mm. thick, if we assume that the coefficient is independent of the Crookes tube employed, and if it does not increase with the thickness traversed—that is to say, if X-rays are not subjected when passing through aluminium to selective absorption, which is a proof of heterogeneity. If the value 0·85 were constant, the total transparency of a sheet 15mm. thick would be represented by 26×10^{-12}. MM. Benoist and Hurmuzescu then carried on experiments with increasing thicknesses. They found that the coefficient increased from 0·85 for sheets not exceeding 0·6mm. thick, to 0·9 for sheets exceeding 1mm. They next employed different Crookes tubes under identical conditions, and found that the coefficient of transmission varied from 0·85 to 0·78. Another communication was made by MM. Auguste and Louis Lumière describing some experiments carried out by them with a view of ascertaining the amount of absorption which Röntgen rays undergo when passing through sensitive films. After ten minutes' exposure they found that photographic effects were produced through a packet of 250 sheets of gelatino-bromide-silver paper; they further found that 300 sheets of paper without the bromide emulsion exercised the same absorptive effect as 150 sheets of sensitised paper. They then experimented with photographic plates having different degrees of sensitiveness for white light in the ratio of extent of 1·8 to 30, and they found that within the limits of their experiments this ratio was exactly the same for Röntgen rays. Amongst the many communications to the Académie des Sciences there is one dated Liège, February 13, 1896, emanating from a M. de Heen, which commences as follows:—"In order to take date, I have the honour of informing you that according to my latest experiments the X-rays of Lenard and Röntgen do not emanate from the cathode, but from the anode." The last communication of any interest is one from M. G. H. Niewenglowski, in which he states that he has discovered that phosphorescent bodies have the same property of assisting the transmission of solar light as phosphorescent sulphide of zinc has in regard to Röntgen rays, a phenomenon which was recently pointed out by M. Charles Henry (see *The Electrician* of February 21st, p. 537).——MM. Able Buguet and Albert Gascard, in a note in the *Comptes Rendus* of February 21th, state that the natural diamond is far more transparent to X-rays than the imitation variety, and the same holds good for natural jet. In the same issue MM. Darieux and de Rochas briefly describe some experiments made with the eyes of freshly-killed pigs, which go to show that the media of the eye, so perfectly transparent to light, are but very slightly so to X-rays.

Contemporary Electrical Science.—In the *Physical Review* we find an advance paper by W. D. Bancroft upon the chemical potential of metals, *vulgo*, electromotive forces of cells. He finds that the potential does not depend upon the concentration of the solution, or upon the positive ion of the electrolyte. It may be described as a function of three things—the metal, the negative ion of the salt, and the solvent medium (usually water). Mercury and platinum acquire potentials of an opposite sign to those acquired by other metals with the same negative ion.—A very handy water battery is described in the same periodical by Austin and Thwing. Strips of copper and zinc are bent into a peculiar shape round a set of fixed pegs. A copper-zinc couple run downwards side by side, then bend away from each other, and then down again. This makes a kind of shoulder, and the lower ends can be immersed by springing a homœopathic vial on to the elastic couple and dipping the whole in water. A large number of such cells are placed side by side; the upper parts of the strips are bent again and soldered together, the junctions being mounted in a board and insulated with wax. One board can carry several hundred cells, and they may be filled by dipping the whole into a trough of water.—There is a paper on Sahulka's effect in the *Wiener Berichte*, 104, by F. Gold. The effect consists in a continuous current observed in an arc between iron and carbon poles fed with an alternating current. It flows from iron to carbon, and may be demonstrated by a magnetic needle. The arc has evidently less resistance in the iron-carbon direction than in the contrary. With a steady continuous current the arc is longer if the current flows from carbon to iron than if it flows from iron to carbon.

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THE CROMPTON POTENTIOMETER: ITS USE AND CAPABILITIES.—V.*

BY W. C. FISHER, ASSOC.MEM.INST.C.E.

The Clark Standard Cell.

As in the potentiometer method all power, E.M.F., and current measurements are dependent upon the Clark cell as a standard of comparison, it is necessary that some description of its behaviour under *practical* everyday conditions and treatment should be given; for whilst much has been said and written with reference to it from a laboratory standpoint, the writer is unaware of its having been dealt with as a workshop standard, liable at all times to accidents, ill usage, and careless treatment, such as the endeavours, not by any means rare, of the sceptical "new assistant" to measure its voltage with a low-reading voltmeter, followed by his triumphant ejaculation —I knew it!—or, I thought so!—as the needle swings gracefully back to zero.

One is so accustomed to hear the Clark cell spoken of with bated breath as a kind of delicate organism, to be handled with the greatest care, never turned upside down or shaken, and duly provided with insulated terminals to prevent even such chance leakage as may take place through the fingers, that one hesitates to assert anything to the contrary; yet for all *practical* purposes and use all such precautions are unncessary and, more like its sister cell the secondary battery, the more it is

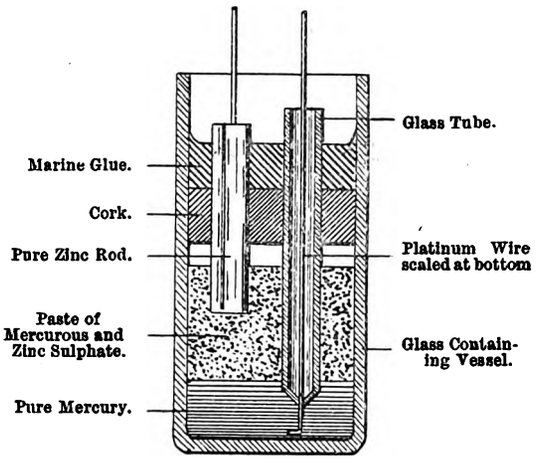

FIG. 26.

actually *worked* the more efficient and reliable it becomes. To many this may appear a strange statement, but it has been proved repeatedly—to those who have met it with incredulity—that the terminals of a properly-constructed Clark cell may be coupled together with an inch or two of thick copper wire, and yet in a very short time the cell returns to its full value, such time being entirely dependent upon the duration of such treatment. This recovery may also be accelerated to such an extent that a cell so coupled up for 24 hours, and which would normally require 36 hours to recover completely, may be brought up to value sufficiently accurate for all practical purposes in an hour or two, or even less; that such is the case will presently be shown. Before doing so, however, a brief description of the forms in use might be of interest to some.

The Board of Trade, in adopting the Clark cell as a standard of E.M.F., gave it the value of 1·434 Board of Trade volts, at 15°C., and in their specification of such a cell require it to be made up in the form shown by Fig. 26, and accentuate certain points in manufacture to which attention should be paid. The cell is sufficiently explained in the figure, yet constructed in this manner, and carrying out strictly the instructions given in the specification, the results attained are somewhat disappointing, and as such disappointments have been heard of from more than one quarter, it would seem as if there were something wrong somewhere. Fig. 27 gives a curve of the variation in value of 12 cells taken at random out of a batch of about 50 made up to the Board of Trade specification. The full line curve representing the values some 24 hours after construction, the dotted line being the values six days later at a different temperature, the extreme variation, as will be seen, being in each case nearly 1 per cent. After repeated trials with varying and uncertain success all attempts at manufacture were given up, and since that date the writer's experience has been entirely with cells made by Messrs. Muirhead, the original makers of this standard. Moreover, owing to the quantity of loose mercury introduced in the official cell, it is not advisable naturally to unduly shake or invert it in any way on account

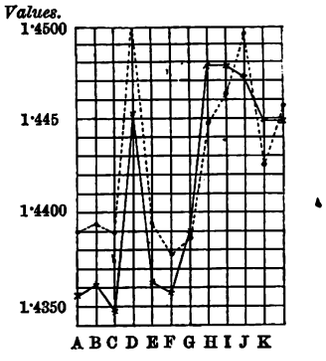

FIG. 27.

of the disarrangement so caused, and this is a distinct disadvantage, for such standards to be of any use must be capable of standing a certain amount of rough usage; they cannot always be carried in one's waistcoat pocket. After repeated trials it is unquestionable that Messrs. Muirhead's improved cell, shown in Fig. 28 (which is self-explanatory), where you have but a globule of mercury retained by surface tension and the surrounding paste within the spiral of platinum wire shown, will stand without injury the most brutal treatment. Whether submitted to all the tenderness usually displayed by the average railway employé, or sent by parcel

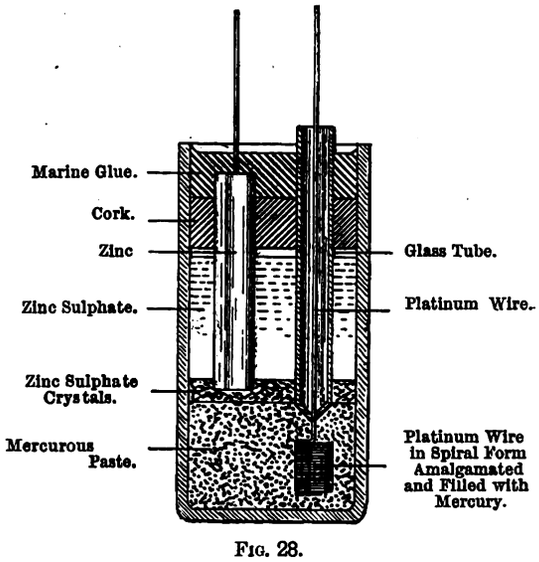

FIG. 28.

post to places as distant as the Transvaal and Australia, the writer has never known one case in which any cell failed. Twice or thrice cells have been returned on account of the mercury in the thermometer having lodged at the top—evidence of a more than usually severe bump. This put right the cells went their third journey uninjured. It might be interesting to mention that in the case of the cells sent to the Transvaal, four cells were sent to Pretoria by parcel post, with instructions to test immediately on arrival. This, by the kindness of the recipient, was done, with the result that the variation between three of the cells was inappreciable, the fourth was out considerably but showed signs of rapid recovery with the

* For previous articles see *The Electrician*, November 29th, December 6th (1895), January 17th, and January 31st (1896). *Copyright.*

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result that within 48 hours of their arrival little or no difference in all four cells was observable.

The writer should mention that Fig. 28 represents the cell as first constructed by Messrs. Muirhead, the form is now slightly altered, the platinum spiral being flattened and placed at right angles with the glass tube, in which it is sealed at the top as well as the bottom.

With reference to variation in value of Muirhead-Clark cells, Fig. 29 gives a series of curves showing the variation in a batch of 12 cells delivered. The curves are of interest, especially when compared with those of the official cells shown in Fig. 27, and which are to the same scale, each horizontal line indicating $\frac{1}{1000}$th of a volt.

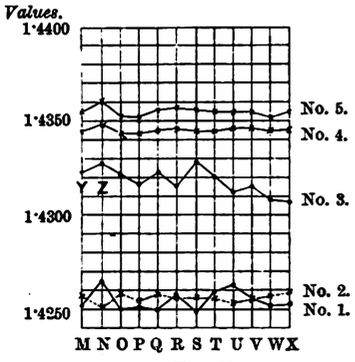

FIG. 29.

Curve No. 1, shown in Fig. 29, gives the variation immediately on delivery, without temperature corrections, showing a maximum variation of $\frac{1·5}{1000}$ths of a volt, and a mean variation of about $\frac{0·7}{10000}$ths. Curve No. 2 represents the value of the same cells after 24 hours' rest, the maximum variation being about $\frac{8}{10000}$ths, and a mean variation of very much less, especially if the chief delinquent N be omitted. Curve No. 3 shows the values of the same cells—with the exception of M, N, which were sold, and for which two others Y, Z were substituted—in the midst of the experiments about to be described. Curve No. 4 was taken six days after the conclusion of all experiments and Curve No. 5 14 days after same. In this last case there were several slight discrepancies due to a different and less steady galvanometer being

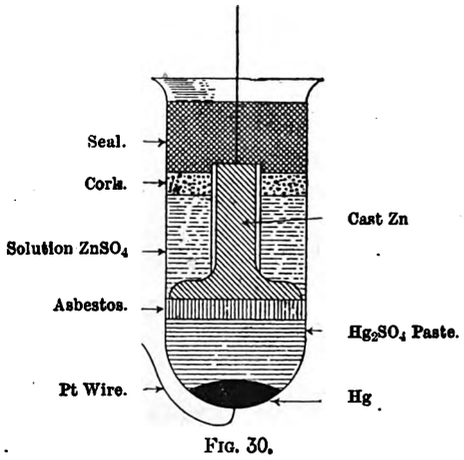

FIG. 30.

employed, which, if corrected, would tend to render the curve more even and in character with No. 4.

From these curves it will be seen that under exceptionally trying circumstances the maximum variation only amounted to $\frac{1}{500}$th volt. Under ordinary conditions the curves speak for themselves, and it is a matter of conjecture as to what the small variation shown is due, for whilst Messrs. Muirhead assure the writers that absolute cleanliness and purity is observed as specified for the official cell, there is no particular care and dexterity required in manufacture, and it is very seldom that they have cells which vary too much above or below normal value.

Prof. Carhart in America recently devised an improved cell, shown and explained by Fig. 30, the English cells having in his opinion three defects. The zinc is in solution of varying density, and therefore attacked at the higher levels. To prevent this he protects the zinc by a glass sleeve after it leaves the lower stratum of saturated solution. In the second place the cell is not portable, and this he overcomes by confining the mercury by ramming the paste upon it by means of a flat zinc with a piece of asbestos interpolated. And thirdly, he objects to the use of cork. An account of the behaviour of this cell would be interesting; also whether Prof. Carhart has found any unsteadiness through the use of the asbestos, which he prefers to cork, as from the writer's experience of it in another direction, he should hesitate about its introduction into a standard cell of the Clark type even after severe chemical treatment.

The specific gravity difficulty mentioned by Prof. Carhart would be simply got over in the cell shown in Fig. 31, which was devised by the writer to reduce for particular reasons the internal resistance of the standard. In it the old grid form zinc of the gravity Daniel cell is taken as a model in combination with Muirhead's spiral of platinum. In it the question of variation of specific gravity is overcome by want of depth, but the expense in manufacture, especially if the platinum spiral be

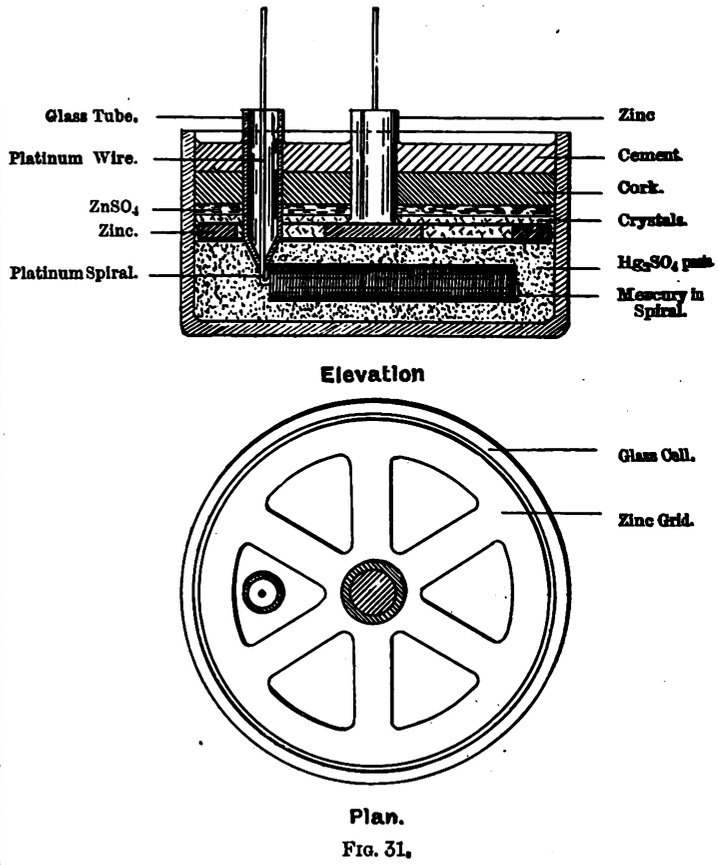

FIG. 31.

made of any size, is against its universal adoption. It is possible this might be overcome by the use of a compound wire, say platinum with an iron core, but experiments have not been made in this direction.

Since this article was written, Dr. Hibbert, of the Polytechnic, has brought before the writer and submitted for test nine standard cells of *one* volt. So far as preliminary tests go they promise well. Their agreement with each other is remarkably close, their temperature coefficient is negligible, their internal resistance low, and their recovery to full value after charge and discharge is accomplished in very much less time than that taken by the Clark standard. If successful in passing the higher temperature and time tests they will certainly supply a want as the missing full volt standard.

When we view the behaviour of the Clark cell under any but general electrical treatment the results are certainly astonishing, and effectually destroy the ancient traditions already mentioned. The marvellously quick recuperative power of the Clark cell was first brought to the writer's knowledge six years ago, when, owing to the accidental twisting

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together of the wrong pair of leads, a cell was short-circuited, and in accordance with ancient tradition, believed to be spoilt accordingly. A very few minutes after, through habit in the use of switches, it was brought into circuit and found to be none the worse. Somewhat in doubt, it was checked and found to be but imperceptibly out. To avoid any mistake, it was deliberately short-circuited, with the same result: a steady creep up to full value. Since that time short circuits have been taken no notice of, the cell, after several trials, being relied upon to come up to value in from 10min. to 15min., and there being always one cell in reserve, this time was a matter of no moment.

Shortly after this it was noticed that recovery could be accelerated by a slight charging of the exhausted cell, but no definite experiments were made until recently, when, at the

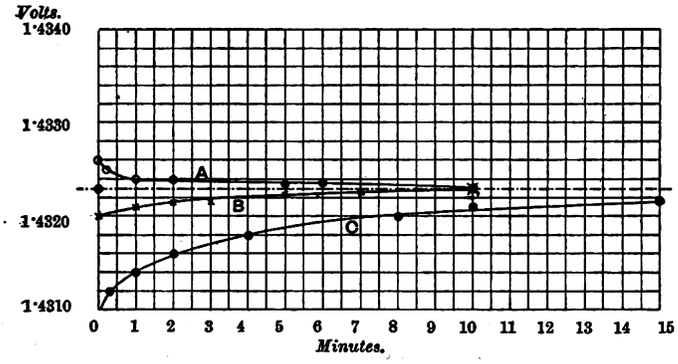

FIG. 32

suggestion of Mr. A. P. Trotter, actual recovery curves were taken under varying circumstances, which effectually placed beyond dispute the facts the writer has already mentioned. The experiments were made with the cells, the variation curves of which are shown in Fig. 29, and some of the results obtained are herewith given as briefly as possible

I. Fig. 32 gives three recovery curves corresponding to the following treatment of the same cell. (A). After a 1min. charge at an E.M.F. $\frac{1}{100}$th of a volt in excess of the cell value, the cell volts rose in value from 1·4323 to 1·4326 volts, or $\frac{3}{10000}$ths of a volt, and gradually fell, reaching the original value in 10min. or so. (B). After a 1min. discharge due to a want of balance of $\frac{1}{100}$th volt, the value of the cell fell to

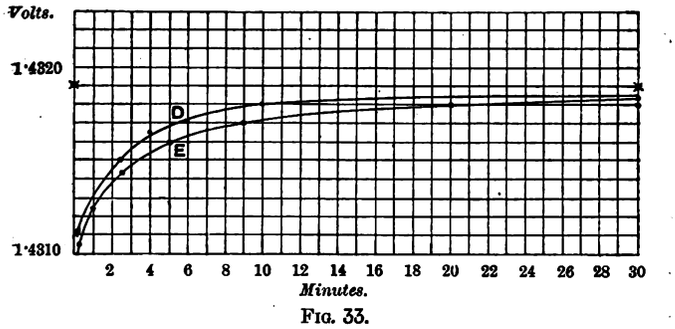

FIG. 33.

1·432, the recovery with time subsequently being gradual throughout until full value was again reached in 10min. (C). The cell was connected up to a low-reading voltmeter of about 500 ohms resistance for a period of 1min.; its value fell from 1·4323 to below 1·431. The early part of the recovery was rapid, afterwards becoming more slow, full recovery taking place in 30min. from disconnection of voltmeter. The last readings are not shown upon the curve.

II. Fig. 33, D. After 30sec. short circuit through 2in. of No. 18 copper wire, another cell fell in value from 1·4319 volts to below 1·431, and gradually recovered in 30min.; before it had fully recovered, it was again treated in similar manner when E indicates its recovery, at the same time showing the accumulative error or lag. In the case of tests F, G, H, I, and J of a similar nature, and curves of which are not given, this repeated lag by neglected full recovery was more pronounced and regular.

III. Fig. 34, K. A 5sec. discharge through wire above mentioned of another cell was the cause of a fall in value from 1·4343 to 1·434 with gradual recovery as shown, a second similar treatment followed by one of 30sec. duration was productive of curves L and M, which were again repeated by repetitions of 5sec. and 30sec. discharges, K—apparently the maiden effort—not being again repeated. N is the recovery curve common to four successive discharges of 30sec. duration of the same cell, but at a different temperature, full recovery being allowed between each discharge.

IV. Fig. 35, O. A cell had its terminals connected with a few inches of wire (No. 20) for 20 hours, in which time it fell from 1·4331 to 0·17 volts; its recovery was very slow at first, and continued so, until it got to 0·5 volt—the average rate being 0·03 volt per hour. After this it rapidly rose at an average rate of 0·1 volt per hour, until approximating full value was

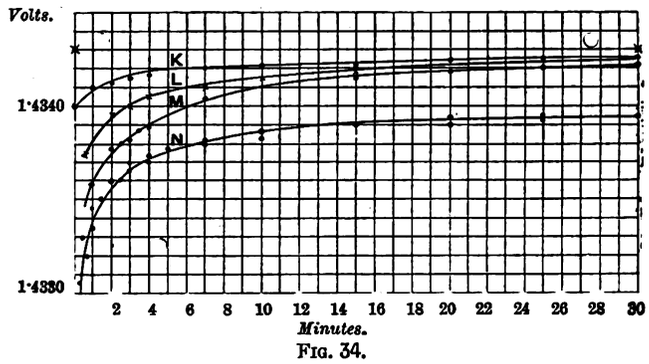

FIG. 34.

reached, the whole occupying about 24 hours; and it should be mentioned that 48 hours after this severe test, the difference between this cell and its partner in the case was $\frac{7}{10000}$ths of a volt, as compared with $\frac{1}{10000}$th before the test, and to which value it again gradually settled down after 48 hours rest. In this curve the time is indicated in hours at the top.

P. Another cell treated in similar manner for 20 hours had a constant potential of 1·4 volts placed on its terminals, and it was so charged, with the result that, as shown by the curve,

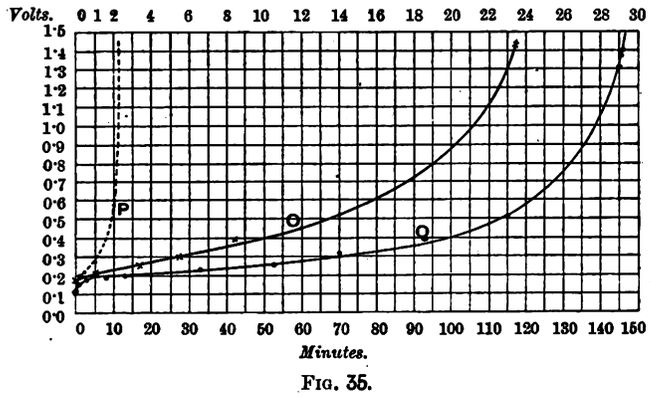

FIG. 35.

it reached its full value in 2½ hours. This curve is shown enlarged by Q, the time being indicated by minutes at the foot. The value of this cell, compared with its companion before test, was 1·4327, and 24 hours after commencement of recovery it stood at 1·4325 at same temperature, a difference of $\frac{1}{5000}$th of a volt.

Ordinarily a cell takes 8½ to 9 hours to rise from 0·5 of a volt to full value; charged at 1·4 volts, the time so occupied is less than 30min.

The following short experiments are also interesting:—

1st cell, after 5sec. short circuit, fell from 1·4319 to 1·4311;
" after 10sec. $\frac{1}{20}$th volt excess charge, its value rose to 1·4319 again.

2nd cell, after 30sec. short circuit, fell from 1·4319 to 1·4308;
" after 20sec. $\frac{1}{20}$th volt excess charge, it had risen to 1·4319 again.

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These are but a few of the results obtained from a large number of tests made, and have been a source of surprise to many who have been accustomed to treat their cells with all due traditional respect. Apply rough theory to the subject, the only conclusion one can come to is that the instant the cell commences to do work the internal resistance goes up enormously, so automatically cutting off the possibility of great injury. Ordinarily the cells have an internal resistance of about 750 ohms or less when in a healthy condition. This runs up very much after discharge; the full extent is not known, and it is difficult to ascertain, the cell commencing recovery at once, giving no time for test. Such tests as have been made prove the resistance to be at least double, even after a comparatively slight discharge, and with no tendency to materially increase after a heavy one. Apparently the internal effect is of a skin or filmy nature, which the vitality of the preponderating mass of material speedily overcomes. It is possible that the following experiment, shown the writer by Mr. Higgins, the engineer of the Exchange Telegraph Company, about 1884-5, may throw some light on the subject. If a shallow vessel of about 2in. or 3in. diameter be taken, and mercury placed therein, and a solution of sulphate of zinc be added, an attempt to produce a standard cell electrolytically is productive of great commotion upon the surface of the mercury, films of sulphates form only to break up, showing the metallic gleam beneath, and fly hither and thither in a curious and interesting manner. Whether anything akin to this takes place on a small scale when the ordinary cell is recuperating, and whether, as it would seem, this is accelerated by a slight charge, it would be of interest to know for certain.

As showing the effect of idleness and work upon such cells, the following may be of interest: one of the successful cells made to the Board of Trade specification, and which had been in enforced idleness for several years, was found upon test to have an internal resistance of *10,400* ohms; a preliminary short circuit and recovery reduced this to 7,500 ohms, a 30 seconds discharge *reduced* this to 1,300 ohms, which rose with recovery of cell to 6,100 ohms; a second discharge of 60 seconds duration again *reduced* the internal resistance to 2,400 ohms, which again rose with recovery to 4,000 ohms. It was still further reduced by other tests, but left to itself for a few days its internal resistance gradually rose, 14 days after its value being 8,600 ohms. The recovery curves of this cell were at first most erratic, but gradually assumed the characteristic recovery curve common to the others; its value also improved, being low before tests it gradually rose, and even after the 14 days rest it was 50 per cent. nearer the value of the standard.

The writer has to thank Mr. Henry Lea, C.E., for permission to publish the following extract in corroboration of the above. Mr. Lea, as is well known, is the electrical inspector to the city of Birmingham:—

"Two of the cells (I, J) have been in regular use ever since the test room was started (five years). Occasionally they have been deliberately short-circuited by a No. 16 copper wire. K and L are two months old. No. 456 (an occasional cell) is six months old, and used seldom. The Fitzgerald is new every time it is made up. A recent comparison gives the following result at 15°C.:—

I = 1·4341
J = 1·4339
K = 1·4341
L = 1·4340
456 = 1·4286
Fitzgerald ½hour old = 1·4340

"Comparisons of this kind have often been made here, and the results are generally the same."

In the above we have evidence again of two cells in constant use, or, as some would say, abuse, for five years, yet differing between each other but $\frac{1}{5000}$th, and from the standard but $\frac{1}{10000}$th of a volt. On the other hand, we have one idle for six months only, and differing from the standard by $\frac{1}{200}$th of a volt.

In further proof the following is given also as showing that the life of cells so treated is not shortened. The figures are those of two cells—K and L—made by Prof. Fleming in 1886 or 1887.

Nov. 1886-7	K = 1·4356	L = 1·4358	difference	0·0002
Jan. 1888	K = 1·4357	L = 1·4359	,,	0·0002
Feb. 1891	K = 1·4359	L = 1·4361	,,	0·0002
Jan. 1895	K = 1·43837	L = 1·43874	,,	0·00037
Jan. 1896	K = 1·4322	L = 1·4326	,,	0·0004
Feb. 1896	K = 1·4363	L = 1·43668	,,	0·00038

Prior to 1894 these two cells had been in constant daily use. Owing to other arrangements they have since been very seldom used, with the result that the discrepancy is increasing, whilst the internal resistance of K, which is least used, has gone up to 8,000 ohms.

It is possible that the potentiometer method of measurement itself, in producing constant minute charge and discharge, due to small differences of potential caused by depression of the key at points out of balance, is productive of good. But the writer must acknowledge to a feeling of doubt at one time as to whether one really had a true value or not, but by means of an increased sensibility in the galvanometer he has satisfied himself that, with ordinary care, it is quite possible to balance well within $\frac{1}{10000}$th of the value of the cell, for one automatically corrects any discrepancy produced by want of balance by instinctively shifting the point of contact to want of balance upon the other side, these very acts of see-saw eliminating the effects of each other, added to which is the fact that there should always be a second cell to fall back upon as a check.

THEORY AND CALCULATIONS OF ASYNCHRONOUS ALTERNATE CURRENT MOTORS.

BY A. HEYLAND (BUDAPEST).

(*Continued from page 581*).

III.—B. *Various Loads.*

After having investigated the conditions of *normal load*, it becomes of interest to ascertain how these conditions change with varying loads; in particular to inquire the status at *no load* and at *excess of load*. We have further to determine the *maximum excess of load* which the motor can bear.

The diagram Fig. 6B clearly depicts these relations if we regard the coefficient τ as constant, approximately equal to that τ which is valid for normal load. In doing so, we shall not introduce an error of any great consequence; for the permeability of the iron, and hence also τ, will vary little, as it is customary to work with low saturation. In perforated armatures, in which the stray lines are confined to the iron, the saturation may indeed attain higher values, and τ will decrease with rising current intensity. In the grooved armature, on the other hand, the lines experience their chief resistance in the air gaps between the teeth; the saturation will rise with the load and the permeability will diminish, but τ will be little affected. In any case, higher saturation will exercise a rather favourable influence; for at higher loads there will be less leakage than we should have for a constant τ. The actual conditions will hence be more favourable than those we have assumed for the calculations. It results that the hypothesis of a constant τ is justified.

(1) *Relations between the work expended* A_1, *the current intensities* I_1 *and* I_2, *and the power factor* $\cos\phi$, *as dependent on the constant quantity* τ, *and the maximum power factor f.*—Any variation in the load expresses itself, in Fig. 6B, by the movement of the point $C' C'' \ldots C^n$ (Fig. 10) on the circular path marked. In this figure—

$A C^n$ represents the primary current I_1;
$C^n C$,, ,, secondary current I_2;
$A C$,, ,, magnetising current I;
angle $C^n A B = \phi$, the difference of phase between K, the primary P.D., and the primary current I_1;
$\cos C^n A B = \cos\phi$, the power factor;
$K I_1 \cos\phi$, the primary work expended A_1;
$A A^n$, the projection of $A C^n$ on $A B$;

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$A\,A^n = I_1 \cos\phi$, the work primarily expended, measured in the scale $\frac{1}{K}$.

$I \cos\phi$ may also be represented by perpendicular $C^n c^n$ let fall from C^n on $A\,O_c$, so that also

$C^n c^n = I_1 \cos\phi$, the work primarily expended, measured in the scale $\frac{1}{K}$.

All these quantities vary when the point C^n describes its circle, and we can refer the variations to the angle $C^n\,O_c\,A$,

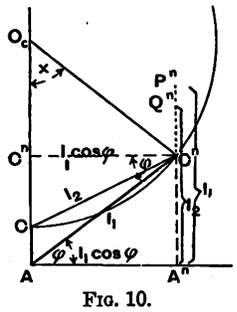

Fig. 10.

which we will call x. We can express all the terms introduced in the angle x, the radius $O_c C^n$, and the line $A\,O_c$. These two latter lines are connected by the equation (*see* Fig. 7)

$$\frac{O_c C^n}{A\,O_c} = \frac{O_c C}{A\,O_c} = f, \text{ the maximum power factor.}$$

To express the quantities as explained, we take the radius $=1$, and therefore $A\,O_c = \frac{1}{f}$, when we arrive at the following values:—

$$I_1 \cos\phi = C^n c^n = O_c C^n \sin x = \sin x, \quad . \quad . \quad (31)$$

$$I_1 = \sqrt{A\,O_c{}^2 + O_c C^{n2} - 2\,A\,O_c \cdot O_c C^n \cos x}$$

$$= \sqrt{1 + \frac{1}{f^2} - \frac{2}{f}\cos x}, \quad . \quad . \quad . \quad . \quad (32)$$

for which we may write:

$$\sqrt{1 + \frac{1}{f^2} - \frac{2}{f} + \frac{2}{f}(1 - \cos x)} = \sqrt{\left(\frac{1-f}{f}\right)^2 + \frac{2}{f}(1 - \cos x)}.$$

For higher loads and increasing x, the first term vanishes, and we obtain approximately

$$I_1 \equiv \sqrt{\frac{2}{f}(1 - \cos x)} = \frac{2 \sin \frac{x}{2}}{\sqrt{f}}. \quad . \quad . \quad . \quad (32A)$$

Further,

$$I_2 = C^n C = 2\,C\,O_c \sin\frac{x}{2} = 2 \sin\frac{x}{2}, \quad . \quad . \quad (33)$$

from which results that for higher loads the ratio

$$\frac{I_2}{I_1} \text{ tends to become a constant} \equiv \sqrt{f}. \quad . \quad (34)$$

Finally,

$$\cos\phi = \frac{I_1 \cos\phi}{I_1} = \frac{\sin x}{\sqrt{1 + \frac{1}{f^2} - \frac{2}{f}\cos x}}, \quad . \quad . \quad (35)$$

which, for higher loads, approximates

$$\cos\phi \equiv \frac{\sin x \sqrt{f}}{2 \sin\frac{x}{2}} \equiv \cos\frac{x}{2}\sqrt{f}. \quad . \quad . \quad . \quad . \quad (35A)$$

From I_1 and I_2 we derive $d a_1$ and $d a_2$ respectively, equal $I_1{}^2 W_1$ and $I_2{}^2 W_2$, *i.e.*,

$$d a_1 = \frac{2(1 - \cos x)}{f} W_1. \quad . \quad . \quad . \quad . \quad (32B)$$

$$d a_2 = 2(1 - \cos x) W_2. \quad . \quad . \quad . \quad (33A)$$

As the projection of $A\,C^n$ upon the base is a measure for the work expended, the system of polar co-ordinates can easily be transformed into one of rectangular co-ordinates. This is done in Fig. 10 by dropping a perpendicular from C^n, and cutting off

$$A^n P^n = A\,C^n = I_1$$

$$A^n Q^n = C^n C = I_2.$$

If we carry this out for various loads, the points P^n and Q^n will describe curves whose abscissæ represent the work expended, and whose ordinates the corresponding current intensities. By dividing the abscissæ by the ordinates of I_1, we obtain a third curve illustrating how the power factor $\cos\phi$ depends upon A_1,

$$\cos\phi = \frac{I_1 \cdot \cos\phi}{I_1}.$$

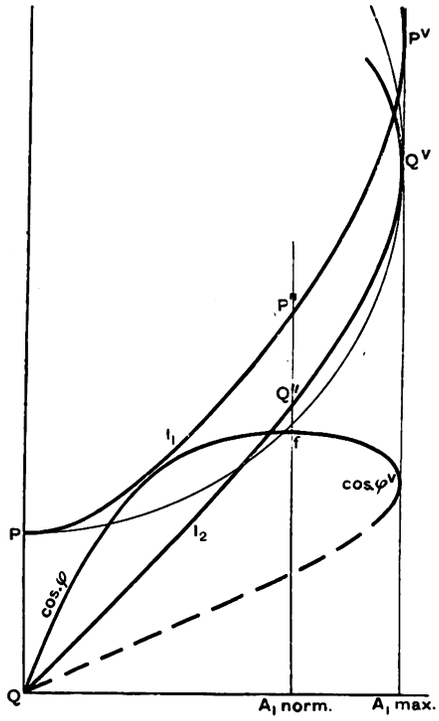

Fig. 11A.—Curves for I_1, I_2 and $\cos\phi$, depending on the work absorbed when $\cos(\phi_{\min.}) = f = 0{\cdot}7$.

In Figs. 11A, 11B, 11C, these three curves have been plotted in the manner explained for the three cases, maximum power factor $f = 0{\cdot}7$, $0{\cdot}8$, $0{\cdot}9$.

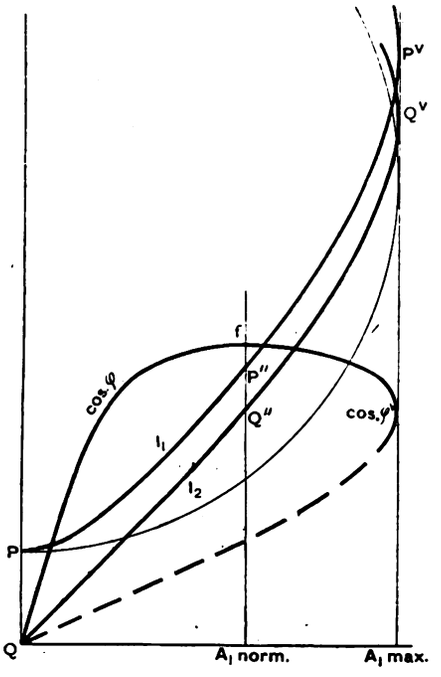

Fig. 11B.—The same for $f = 0{\cdot}8$.

We recognise the characteristic shapes with which practical load tests have made us familiar. The trend of the curves is determined by that f which stands for the case of normal load. We shall best understand the interdependence of these

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brittle materials, and rely for strength upon their great crushing resistance and high elasticity rather than upon toughness; but when well made and properly set at a moderate depth below the ground, neither material gives trouble from fracture due to vibration or crushing. Chemically speaking, stoneware is superior to cast-iron, since in the finished form as used for conduits stoneware is neither chemically acted upon nor physically disintegrated by the fluids which occur in town sub-soils. Clays have little action on cast-iron, but gravelly and porous soils and the sub-soils of streets carrying sewers and gas mains are decidedly corrosive of pipes of this material. The higher degree of smoothness in stoneware surfaces, as compared with cast-iron, or the extra cost of finishing off the interior and ends of a cast-iron pipe, will give the advantage to the former material in respect of the absence of abrading action on a cable. High insulating power is not a quality essential to a conduit, neither in the streets nor within houses; but the imperfect conductivity of stoneware, by comparison with the high conductivity of cast iron, constitutes a certain advantage in its use in most cases. The actual relative costs of stoneware and cast-iron conduits will not be an easy matter to settle in general terms, so much depending on the local facilities in obtaining the materials. In general, however, a stoneware

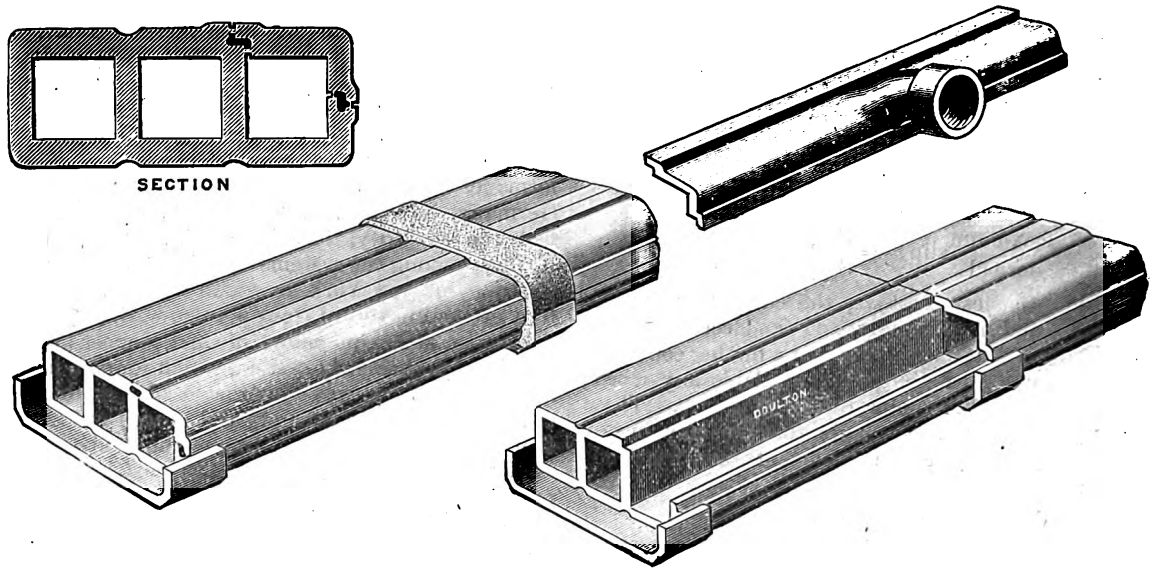

FIG. 1.—Details of Doulton Stoneware Conduit, Type "B 1," as used at Portsmouth.

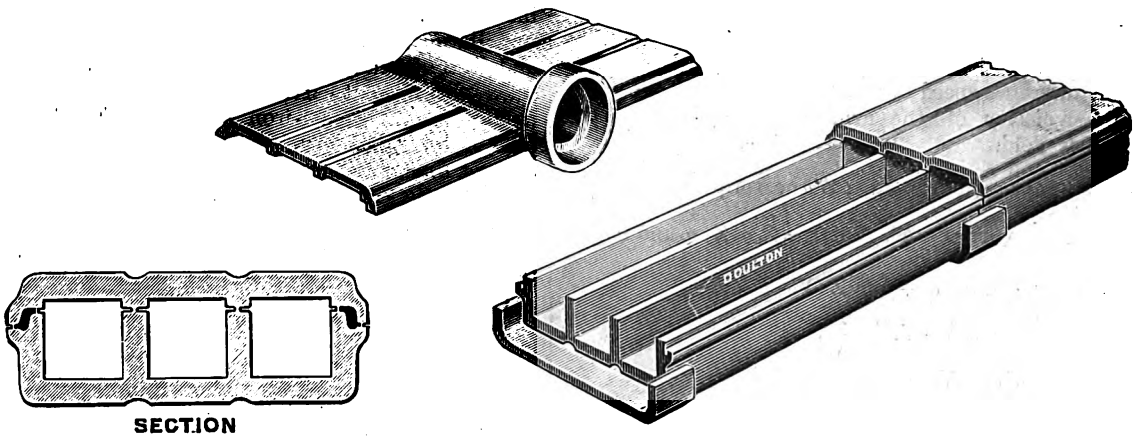

FIG. 2.—Details of Doulton Stoneware Conduit, Type "B 2," as used at St. Pancras.

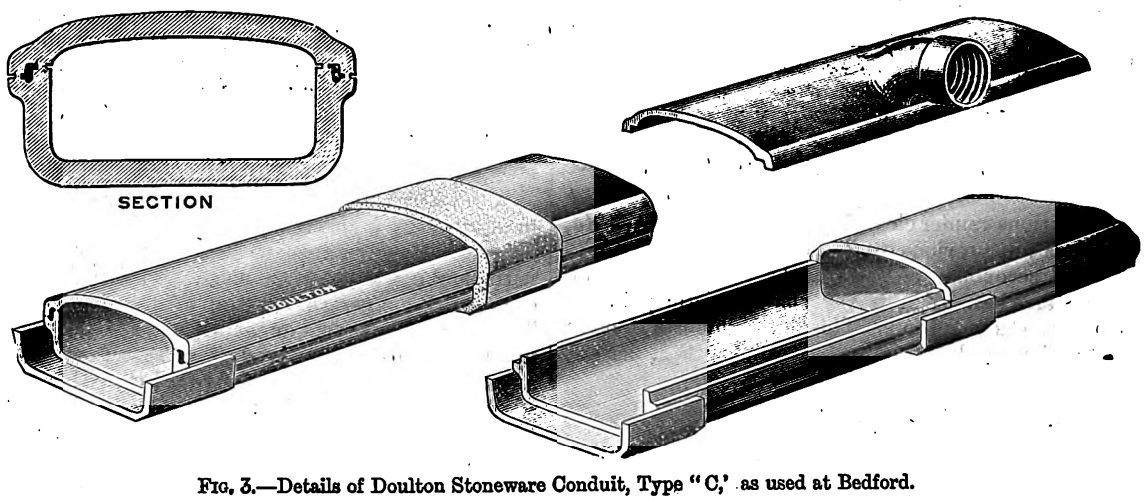

FIG. 3.—Details of Doulton Stoneware Conduit, Type "C," as used at Bedford.

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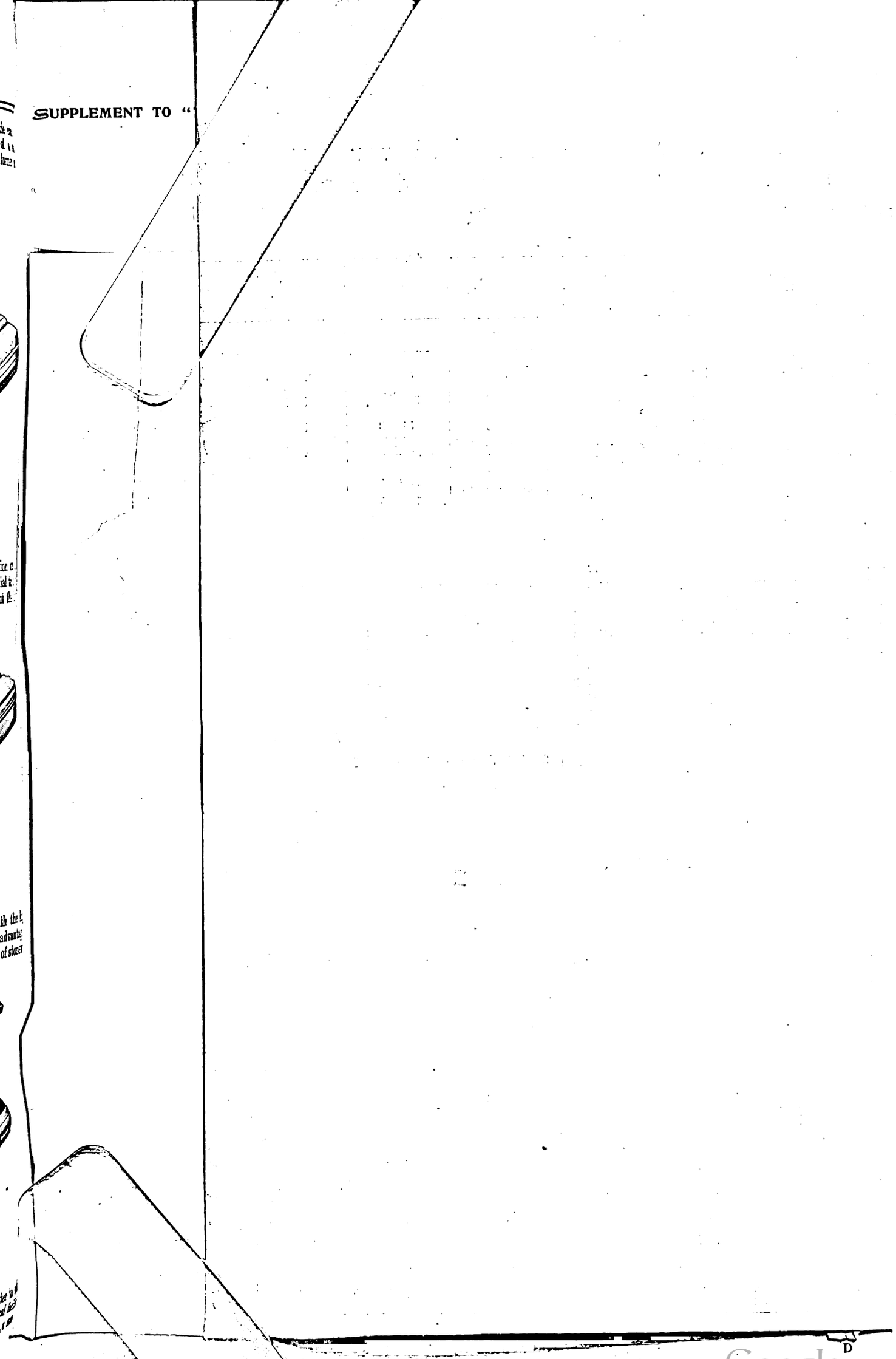

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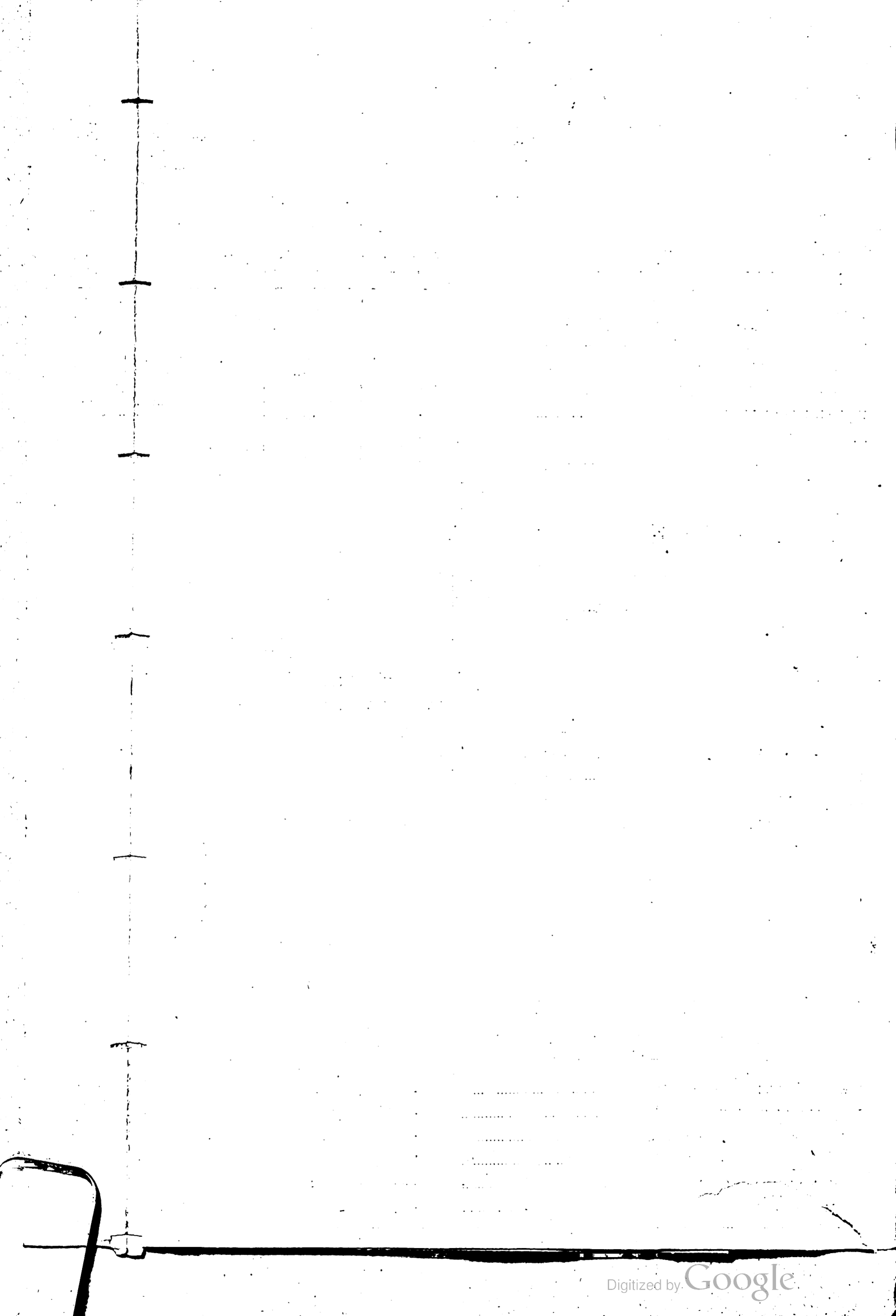
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conduit for a given set of cables, and for equal strength, will cost less and weigh less than a cast-iron pipe conduit. The following table gives the prices of cast-iron pipes and of various forms of stoneware conduit, as manufactured by Messrs. Doulton and Co., for electric supply mains :—

Type of conduit.	Price per yard.
	s. d.
Cast-iron socket pipe, in 9ft. lengths, 4in. diameter, 51lb. per yard	4 6
Ditto, in 9ft. lengths, 6in. diameter, 88lb. per yard	7 6
Glazed stoneware circular pipe, spigot and socket joint, 4in. diameter	2 0
Ditto, 6in. diameter	3 0
Doulton type "B 1" stoneware conduit (Fig. 1), as used at Portsmouth, with 2½in. by 2½in. ducts, including jointing chairs	2 6
Ditto, 4in. by 4in. ducts	5 4
Ditto, type "B 2" (Fig. 2), 2½in. by 2½in. ducts	2 6
Ditto, type "C" (Fig. 3), 6in. by 2¾in.	1 9

It must be borne in mind that the foregoing statements of the prices of various kinds of conduit do not necessarily give the relative costs of actually installing them, since so much will depend on the nature of the ground and of the route and the price of labour and extras. For instance, where the conduit has to pass under a vehicular way carrying heavy traffic, it will generally be necessary to place a stoneware conduit at a greater depth than one of cast iron, or to embed it securely in concrete; but even this consideration will be affected by the nature of the road, surface, &c. The costs of labour and of materials in jointing the conduits are a considerable item, and since the stoneware conduits are usually in 2ft. or 3ft. lengths, while cast-iron pipes are usually 9ft. in length, there will in general be many more joints of the former than of the latter in a mile run of conduit. However, a stoneware joint can usually be made more cheaply and quickly than a spigot and socket joint in 9ft. lengths of cast-iron pipe. The usual methods of making the joints are as follows. For a cast-iron pipe the spigot end is first pushed home into the socket, and jute drifted into the joint until it is rammed against the flange of the socket. The outer end of the flange is now luted up with a damp clayey rope, clay being plastered around the outside of the rope, so as to close the opening of the socket except at the top. The rope is next drawn out, leaving a clay stopping, and molten lead is poured into the annular space between the spigot and socket. When the lead is set, the clay is knocked off, and the metal drifted tightly into the socket, forming a perfectly tight joint. Messrs. Doulton and Co.'s stoneware conduits, except in the circular form, are generally jointed by abutting the ends on a stoneware chair, and then rendering the joint watertight with Portland cement.

It may be of interest to supplement the foregoing comparison between cast-iron and stoneware conduits with some particulars of the types of conduits, already referred to, which are used at Portsmouth, St. Pancras, Bedford, and in numerous other towns. Fig. 1 shows the type "B 1" of Doulton conduit used at Portsmouth. There are three separate ducts; the one on the left side of the conduit, as seen in the figure, is for the arc light mains; the centre duct is for the feeders; and the remaining duct, which can be covered with the house-service cover shown in the figure, is for the distributing cables. These three ducts are formed in one closed conduit; in the case of the distributing duct the upper portion is connected to the lower part by a thin connection, which can readily be severed by means of a chisel. In the type "B 2," shown in Fig. 2, and used on the St. Pancras three-wire system, the separation of the upper from the lower part can be made in the same manner, the whole of the upper part being removed and replaced by a house-service cover where required. These two forms of

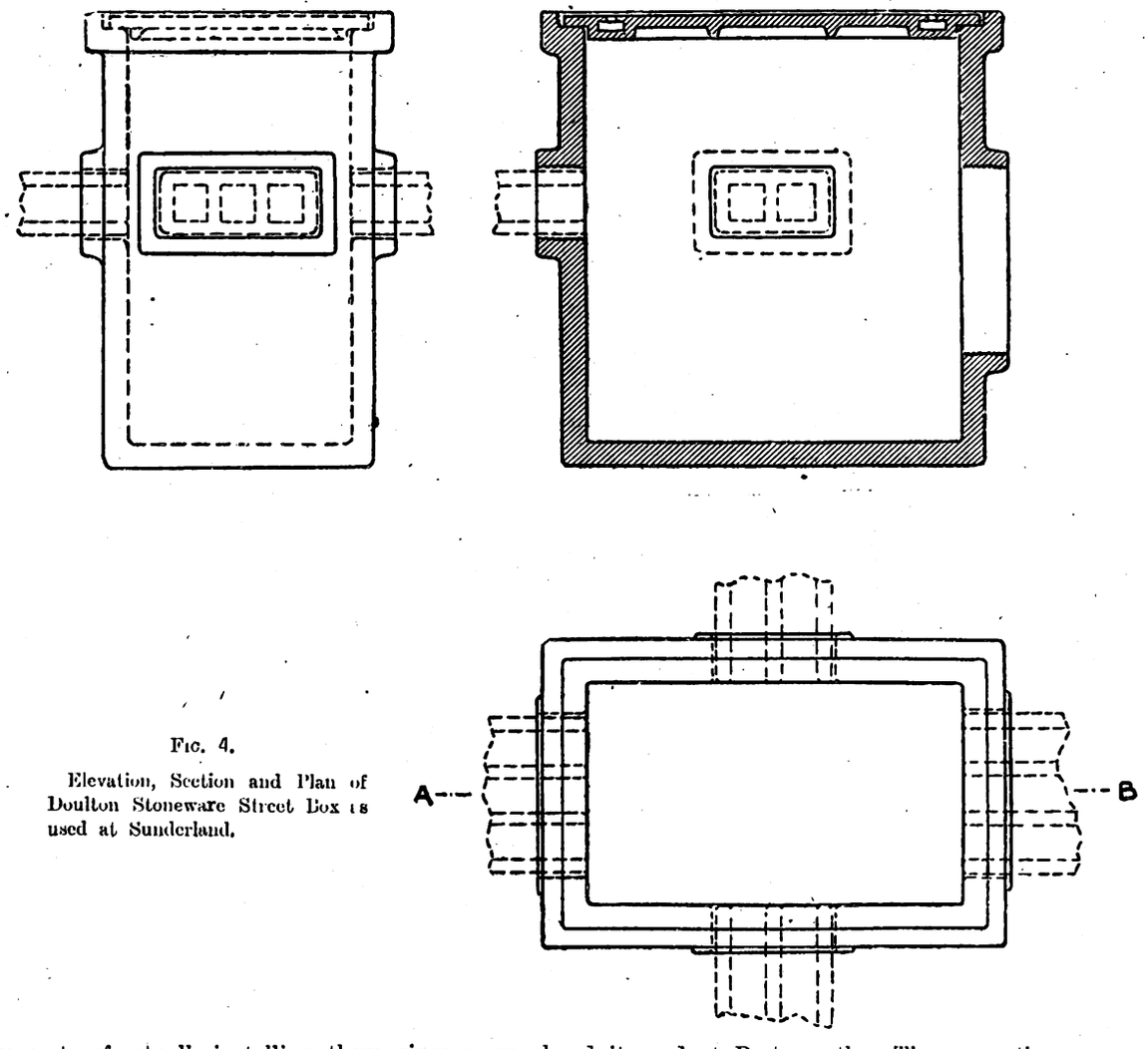

Fig. 4.

Elevation, Section and Plan of Doulton Stoneware Street Box as used at Sunderland.

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conduit provide separate ducts for the several cables, but where covered cables are used it is often cheaper and more convenient to carry them all in a single conduit, such as that shown in Fig. 3. This form is used at Bedford for the lead-covered low-pressure distributors, the high-pressure mains at that place being in cast-iron pipes.

The construction of street boxes and transformer chambers has not necessarily anything in common with the actual system of conduit used; nevertheless, the materials used in the one are often employed in the other, and a material which possesses qualities rendering it useful in a conduit should in general answer as well the purpose of a small street box. Stoneware and cast iron, more recently than brick and other built-up chambers, have come into use for this latter purpose. On the recently opened Islington system, cast-iron boxes are extensively used, while stoneware has found favour for this purpose at Sunderland. Details are shown in Fig. 4 of the type of Doulton stoneware chamber designed for Sunderland. The chamber or box, without its cover, is in one piece, which can quickly be lowered and set in the excavation. In the form shown there are four ways, but two-way and three way forms may also be used. Opposite entrances to the box are made, the one of larger area than the other. This is to enable a rise or fall in level of the conduit to occur at the box, as the conduit at the larger entrance may be set either at the top or bottom of the entrance, the remaining space being built up with brick. The boxes are fitted with airtight cast-iron cover plates, which are earthed over and covered with the ordinary paving of the footpath.

LONGITUDINAL LIGHT.*

BY G. JAUMANN.

(Continued from page 631.)

III.—Theory of Electric Phenomena in Rarefied Gases.†

Changes in Rarefied Air by Electric Actions.—The most remarkable property of rarefied air consists in the fact that small actions (variations of energy) produce great variations of properties (temperature, volume, &c.). This is due to the very small capacity of its unit volume for heat and for other forms of energy.

Now it may be supposed that from similar causes electric actions produce a strong change of state of rarefied air. The electric discharge is evidently connected with marked changes of properties of the medium during discharge, or perhaps before it, which cannot be reduced to mere changes of temperature.

I do not intend to make any supposition with regard to the nature of the state which is altered by electric force. But any change of state of the medium is accompanied by a change of its dielectric and diamagnetic constants. The special electric behaviour of rarefied air is due to the fact that electric actions indirectly alter its electric and magnetic constants, and this again reacts upon the course of these actions.

Maxwell's Equations for a Variable Medium.—Since the electric and magnetic coefficients ε and μ in Maxwell's equations are *variable* during the electric action in rarefied air, the equations assume the form

$$\text{(I.)}\quad \begin{cases} \frac{d}{dt}(\varepsilon X)=c_0\frac{d\mathfrak{N}}{dz}-c_0\frac{d\mathfrak{B}}{dy}, & \frac{d}{dt}(\mu\mathfrak{X})=c_0\frac{dZ}{dy}-c_0\frac{dY}{dz}, \\ \frac{d}{dt}(\varepsilon Y)=c_0\frac{d\mathfrak{B}}{dx}-c_0\frac{d\mathfrak{X}}{dz}, & \frac{d}{dt}(\mu\mathfrak{N})=c_0\frac{dX}{dz}-c_0\frac{dZ}{dx}, \\ \frac{d}{dt}(\varepsilon Z)=c_0\frac{d\mathfrak{X}}{dy}-c_0\frac{d\mathfrak{N}}{dx}, & \frac{d}{dt}(\mu\mathfrak{B})=c_0\frac{dY}{dx}-c_0\frac{dX}{dy}. \end{cases}$$

Here X, Y, Z denote components of electric force, $\mathfrak{X}$, $\mathfrak{N}$, $\mathfrak{B}$, those of magnetic force, ε and μ two variables having a simple relation to the electric and magnetic constants ε_0 and μ_0 of the medium, being reduced to them in a state of rest, and c_0 the normal velocity of light.

From the equations (I.) we obtain immediately

$$\text{(I a)}\quad \begin{cases} \frac{d}{dx}(\varepsilon X)+\frac{d}{dy}(\varepsilon Y)+\frac{d}{dz}(\varepsilon Z)=0, \\ \frac{d}{dx}(\mu\mathfrak{X})+\frac{d}{dy}(\mu\mathfrak{N})+\frac{d}{dz}(\mu\mathfrak{B})=0, \end{cases}$$

for in a condition of rest, in which ε and μ become ε_0 and μ_0, these expressions are known to be equal to zero, and by equations I. they suffer no time change by any electrical process.

The very circumstance that Maxwell's equations assume the non-linear form (I.), *when the medium is changed by the process*, brings out the advantage of this supposition. Electric processes would always be simply superimposed if Maxwell's equations were truly linear. But most of the higher electrical processes have a decidedly non-superimposing character (*e.g.*, discharge by light, mutual repulsion of cathode rays, &c.). The method here adopted of depriving Maxwell's equations of their linearity can hardly be surpassed by any other.

Influence of Great Constant Forces.—If the charges $d\varepsilon/dt$ and $d\mu/dt$ have not to be considered, Maxwell's equations are linear, and represent the elementary optical phenomena.

But even in media in which the changes $d\varepsilon/dt$ and $d\mu/dt$ have high values, pure superimpositions of radiation phenomena are possible, namely, when the static forces X_0, Y_0, Z_0 and $\mathfrak{X}_0$, $\mathfrak{N}_0$, $\mathfrak{B}_0$ present are of such magnitude that the changes brought about by the process considered $(X-X_0)$, $(Y-Y_0)$, &c., vanish in comparison, and $(\varepsilon-\varepsilon_0)$ also vanishes in comparison with ε_0 and $(\mu-\mu_0)$ with μ_0. In this case Maxwell's equations assume the following form:—

$$\text{(I')}\quad \begin{cases} 1.\ \varepsilon_0\frac{dX}{dt}+X_0\frac{d\varepsilon}{dt}=c_0\frac{d\mathfrak{N}}{dz}-c_0\frac{d\mathfrak{B}}{dy}. \\ 2.\ \varepsilon_0\frac{dY}{dt}+Y_0\frac{d\varepsilon}{dt}=c_0\frac{d\mathfrak{B}}{dx}-c_0\frac{d\mathfrak{X}}{dz}. \\ 3.\ \varepsilon_0\frac{dZ}{dt}+Z_0\frac{d\varepsilon}{dt}=c_0\frac{d\mathfrak{X}}{dy}-c_0\frac{d\mathfrak{N}}{dx}. \\ 4.\ \mu_0\frac{d\mathfrak{X}}{dt}+\mathfrak{X}_0\frac{d\mu}{dt}=c_0\frac{dZ}{dy}-c_0\frac{dY}{dz}. \\ 5.\ \mu_0\frac{d\mathfrak{N}}{dt}+\mathfrak{N}_0\frac{d\mu}{dt}=c_0\frac{dX}{dz}-c_0\frac{dZ}{dx}. \\ 6.\ \mu_0\frac{d\mathfrak{B}}{dt}+\mathfrak{B}_0\frac{d\mu}{dt}=c_0\frac{dY}{dx}-c_0\frac{dX}{dy}. \end{cases}$$

These equations are linear, hence radiations may be superimposed.

But the constant forces and the forces of the radiation do not superimpose, since the constant forces appear as coefficients in the equations; different radiations, on the other hand, which take place in the same constant field, do superimpose.

Rarefied air also conforms to the original Maxwell theory when no great constant forces pervade it and the amplitude of the radiation is very small. But for radiations of high amplitude it obeys equations (I.) even in the absence of constant forces, and therefore admits of longitudinal rays.

Rarefied air, however, in which large constant forces are present, *has a special behaviour even for the feeblest radiations*, and obeys the equation (I').

The remarkable dependence of the cathode rays upon the constant electric and magnetic field strength here results already from the theory, and is caused, according to (I'), by the fact that in rarefied air $d\varepsilon/dt$ and $d\mu/dt$ do not vanish in comparison with the time-changes of the forces, even for the feeblest radiations.

This is the fundamental difference between my own longitudinal waves and those of Helmholtz, whose longitudinal waves behave like sound-waves as regards superposition, so that constant forces are of no importance. The difference of species which gives the cathode rays their name cannot be explained if the constant changes of the electrode defining this difference are irrelevant.

I believe I have now sufficiently proved the convenience of the fundamental supposition that ε and μ are changed by electric processes in rarefied air.

Cause of the Variability of ε and μ.—We must now establish two essentially new equations for the new variables ε and μ. These equations may be understood and formulated in such a manner that they give as the cause of the time change of these variables a certain function of the forces.

There are indeed no direct observations upon the variability of ε and μ during electric processes. But probably no such variability could be discovered at all without theoretical assistance, on account of the rapidity of all processes which may bring it about.

But theoretical considerations may lead to the establishment of the equations for $d\varepsilon/dt$ and $d\mu/dt$ without a direct foundation. Their success depends upon whether these variations occur under the direct influence of the forces. Only direct and simple connections may be guessed at by their form or by comparisons of physical processes.

Provisional Conclusion Concerning the Required Equations from the Formal Requirements.—Explicit equations for $d\varepsilon/dt$ and $d\mu/dt$ are sought, which give certain functions of the forces as the causes of these changes.

* *Wied. Ann.*, 57, 1, pp. 147—184, 1896.

† See also *The Electrician*, January 31, 1896, p. 447, and February 7th, p. 487.

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These functions must be constituted in an approximately linear manner from derivations from the force components of the first order. That is required by the possibility of approximately undamped rays.

These derivations must be *spatial*, since otherwise rays of indefinite velocities of propagation become possible.

The whole function, *i.e.*, the sum of these derivations must be invariant and scalar during changes in the system of co-ordinates, for it is equal to the invariant and scalar expressions $d\varepsilon/dt$ and $d\mu/dt$.

This refers us to Laplace's expressions, and we may suspect the following equations :—

$$\left.\begin{aligned}\frac{d\varepsilon}{dt}&=\frac{d\mathrm{X}}{dx}+\frac{d\mathrm{Y}}{dy}+\frac{\mathrm{Z}\,d}{dz}\\ \frac{d\mu}{dt}&=\frac{d\mathfrak{X}}{dx}+\frac{d\mathfrak{Y}}{dy}+\frac{d\mathfrak{Z}}{dz}\end{aligned}\right\}\text{not valid.}$$

It is at once recognised as a point of agreement that the condition for the appearance of longitudinal waves is the non-disappearance of $d\varepsilon/dt$ and $d\mu/dt$, and that purely longitudinal waves are necessitated by the disappearance of Laplace's expression.

This formal reasoning is, of course, founded in all its details upon the supposition of the greatest possible simplicity of the relation sought for. It has proved later on to be not strictly applicable, and incorrect in one principal point. But it contains the correct reference to Laplace's expression, and it at once gave a good direction to the following reasoning.

On the Material Changes accompanying Vectorial Processes.—Let us first ask the question whether a direct dependence of ε and μ from the electric and magnetic forces is not in itself unthinkable.

It would, for instance, change the sense of all mechanical equations if we were to assume that the density ρ of a body was a direct function of its velocity components Ξ, H, Z. Such a supposition is excluded, since even at the highest velocities projectiles, for instance, retain their masses.

Still the following differential equation is valid, and contains no contradiction.

$$\text{(IIa)}\qquad \frac{d\rho}{dt}=\frac{d}{dx}(\rho\Xi)+\frac{d}{dy}(\rho\mathrm{H})+\frac{d}{dz}(\rho\mathrm{Z}).$$

It is my opinion that this equation is a special case of a much more general principle governing all vectorial processes.

Equation for the Change of the State σ.—The relation between the change of density and the distribution of velocity is so characteristic of mechanics that it must be assumed that the other vectorial processes are not without a similar effect, if indeed there is any quantitative analogy between mechanical and electrical processes. But this nobody will doubt. Here we have one of the strongest foundations which can be given to any theory.

There must be an electric equation exactly corresponding to the equation (II*a*) of the form

$$\text{(II.)}\qquad a_0\frac{d\sigma}{dt}=\frac{d}{dx}(\sigma\mathrm{X})+\frac{d}{dy}(\sigma\mathrm{Y})+\frac{d}{dz}(\sigma\mathrm{Z}).$$

Here we have, instead of the velocities of equation (II*a*), the components of electric force. This is the most natural analogy. If it should yet contain a fault, this may easily be discovered and corrected afterwards.

Instead of the density ρ, we have a *new physical variable* σ, whose nature is only indicated later on. It is essentially *scalar*, and may be analogous to density, pressure, or temperature, &c. a_0 is an essentially positive reduction factor, as will be shown, whose dimensions are those of an electric force divided by a velocity. Its magnitude and sign only depends upon the usual reckoning of the forces, but not upon the nature of the medium. The equation (II.) obtains in an equal manner for all media.

Connection between ε *and* σ.—All physical conditions depend upon each other ; all properties of bodies are functions of the temperature, the pressure, &c. ; they are, indeed, functions of each other. If this were not the case, the formal conclusions above would have misled me, but not in the direction of equation (II.*a*). It might have been supposed that ε and σ are interdependent ; it follows from the form of the energy equation, σ is the analogue of the density ρ. The kinetic energy of a volume element is represented by $\frac{1}{2}\rho(\Xi^2+\mathrm{H}^2+\mathrm{Z}^2)\,dx\,dy\,dz$.

The electric energy of a volume element is therefore determined as (III.) $\mathrm{E}=\frac{1}{2}\sigma(\mathrm{X}^2+\mathrm{Y}^2+\mathrm{Z}^2)\,dx\,dy\,dz$.

It is known to be determined by ε_0 in a condition of rest

$$\mathrm{E}_0=\tfrac{1}{2}\varepsilon_0(\mathrm{X}^2+\mathrm{Y}^2+\mathrm{Z}^2)\,dx\,dy\,dz.$$

Hence it follows that ε and σ must be actually equal in a state of rest.

$$\text{(IV.}a\text{)}\qquad \varepsilon_0=\sigma_0.$$

But a simple equality cannot subsist between ε and σ except in a state of rest. For if σ were always equal to ε, the change $d\varepsilon/dt$ by equations (I.*a*) and (II.) would always have to be zero, and the theory would be reduced to that of Maxwell. After equality the following relation is the simplest :—

$$\text{(IV.)}\qquad \varepsilon-\varepsilon_0=\eta_0(\sigma-\sigma_0).$$

Here η_0 is a constant depending upon the *nature of the medium*. The correctness of equation (IV.) is immediately recognised by the following agreement. Equation (IV.) must first of all fulfil the condition that for a simple value of η_0 (say 0 or 1) the theory is reduced to that of Maxwell.

Now this takes place when $\eta_0=1$ or $\eta_0=0$, but for no other value of η_0.

For $\eta_0=1$ we have $\sigma=\varepsilon$ and equation (IV.*a*). But with a simple equality of σ and ε the theory, as already stated, reduces itself to the Maxwellian form.

For $\eta_0=0$, σ would have to be $=\infty$ in order that ε may differ from ε_0. But by equation (II.) σ can only assume infinite values by infinite forces or discontinuities. For $\eta_0=0$ we therefore have $\varepsilon=\varepsilon_0$, which also leads us to Maxwell's theory.

If we assume that for all ordinary dense bodies the Maxwellian theory, including the energy equation, is valid in every respect, η_0 for these bodies is also unity.

But when the air is rarefied the value of η_0 diminishes, and longitudinal waves become possible. In an absolute vacuum η_0 becomes equal to zero. In this extreme case longitudinal waves become impossible once more.

η_0, therefore, has an essentially positive value for rarefied gases which lies between 0 and +1, according to the density of the gas ; for dense bodies it has a value closely approaching +1.

From (II.) and (IV.) the following equation follows, if we bear in mind that the expression (I.*a*) has a constant value by (I.) :—

$$\text{(II'.)}\qquad \frac{a_0}{\eta_0-1}\frac{d\varepsilon}{dt}=\frac{d}{dx}(\varepsilon_0\mathrm{X})+\frac{d}{dy}(\varepsilon_0\mathrm{Y})+\frac{d}{dz}(\varepsilon_0\mathrm{Z}).$$

This is the required equation, which represents the charge $d\varepsilon/dt$ as a function of the force distribution.

It will be seen that it also applies to media which are non-homogeneous in a state of rest. It naturally fulfils for the state of rest, *i.e.*, for $d\varepsilon/dt=0$, the following well-known condition (which does not, however, form the basis of the present considerations):—

$$\text{(1)}\qquad 0=\frac{d}{dx}(\varepsilon_0\mathrm{X})+\frac{d}{dy}(\varepsilon_0\mathrm{Y})+\frac{d}{dz}(\varepsilon_0\mathrm{Z}).$$

The equations (I.), (II.), (III.), (IV.) and (V.) express the theory perfectly. The relation (1) is a deduction from this theory.

(To be continued.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, March 13th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read.: (1) "An Addition to the Wheatstone Bridge for the Determination of Low Resistances," by J. H. Reeves ; (2) "On Cathode Rays," by Herr Puluj.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting in the Library of the Institution. Discussion on Mr. Fennell's Paper on "Some Central Station Experience."

SATURDAY, March 14th.

INSTITUTION OF ELECTRICAL ENGINEERS.

Students' Visit to Messrs. Siemens Bros. and Co.'s works at Charlton. Train leaves Charing Cross at 10:20 a.m., Cannon-street 10:30, and London Bridge 10:33. Book to Charlton Junction.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture (IV.): "Light," by the Right Hon. Lord Rayleigh, F.R.S.

TUESDAY, March 17th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Three Papers dealing with Metallurgy will be read.

FRIDAY, March 20th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting in the Library of the Institution. Paper to be read : "Some Distinctive Features of Continental Engineering Practice," by K. Edgcumbe and E. J. Fox.

SATURDAY, March 21st.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture (V.): "Light," by the Righ Hon. Lord Rayleigh, F.R.S.

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SPECIAL NOTICE.

With this week's number of "THE ELECTRICIAN" is issued (gratis) a Supplement Sheet Table showing Total Outlay and Receipts and Expenditure for the year 1895 of Statutory Electric Supply Undertakings in London and the Provinces. Additions will be made to the Table as further accounts appear, and the Table will be issued from time to time. Complaints of non-receipt should be promptly addressed to the Publisher.

THE AUDIT OF ELECTRIC LIGHT COMPANIES' ACCOUNTS.

The audit of the accounts of electric light undertakings has been referred to in these columns on several occasions recently (see *The Electrician*, December 27, 1895, p. 299, January 10th, pp. 333 and 356), and it has once or twice been fitfully discussed at shareholders' meetings. The question has now been brought to a head, so to speak, by the action of the shareholders of the Westminster Electric Supply Corporation, who at their last general meeting unanimously passed a resolution to the effect that the Board of Trade auditor should act in the dual capacity of official auditor and shareholders' auditor. By taking this step it is sought to effect a small economy, and avoid the inconvenience of reopening the Company's books after they have been approved by the Board of Trade.

The grievance of which the shareholders of electric lighting companies have complained is, it seems to us, a very real one, though rather theoretically important than actually so. Like the generality of limited liability concerns, electric lighting companies are bound by their Articles of Association to appoint an auditor. In addition to this indispensable functionary, however, the Board of Trade, under Section 9 of the Electric Lighting Act of 1882, is also empowered to appoint an auditor. Under a sensible dispensation this irritating duplication of functionaries with functions of a similar nature would not have occurred. At any rate, the shareholders of the Westminster Electric Supply Corporation mean to try and avoid paying two men for what is practically the same job. But, unfortunately, in view of the letter of the Board of Trade dated December 18, 1895, addressed by that Department to the Secretary of the Institute of Chartered Accountants, it seems very doubtful whether in the existing state of the law the resolution passed at the recent meeting of the Company is worth the paper it is written on.

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We have always inclined to the opinion that for two distinct auditors to go through the accounts of an electric light company in quick succession is a work of supererogation, and, so far as the company itself is concerned, absolutely unnecessary. Moreover, unless considerable care and discretion is exercised by both auditors, friction is bound, sooner or later, to take place, and serious difficulties to arise. As things are now there are two auditors acting with somewhat different objects in view. The shareholders' auditor is appointed by the shareholders, and one of his principal duties consists in satisfying himself that no amounts are charged to capital which are properly chargeable to revenue. On the other hand, one of the chief duties of the auditor appointed by the Board of Trade is to make sure that no amounts are charged to revenue which are, in his opinion, in the nature of capital expenditure. During the progress and development of any large undertaking, more especially of a business such as an electric light undertaking in its early days, many items of expenditure must inevitably be of a debatable nature even when regarded from the same point of view by two different individuals, and much more so when regarded from somewhat different points of view. For whereas one auditor, in the interests of the shareholders, would look with a lenient eye upon items charged to revenue, the other would be inclined, in the interests of the Department which he represents, to be satisfied if the debatable items were chargeable to capital. Again, it is no part of the duties of the Board of Trade auditor under the Act of 1882 to concern himself with the floating assets of a company. If the Reserve Fund investments were wrongly appropriated it would be no concern of his. Again, he need not trouble himself as to the proper disposition of any cash balances either in hand or temporarily invested. With two auditors actuated by different motives what will happen when they are at issue? The shareholders' auditor will probably hold to his opinion and the official auditor to his, whilst the directors will, in all likelihood, issue the accounts in accordance with the views of the former, notwithstanding the objections of the latter. These incidents having once occurred, the official auditor cannot certify to the Board of Trade as correct any subsequent accounts, since these will have embodied in them items the treatment of which he does not endorse. The investing public will soon hear that the Board of Trade does not approve of the way in which the company's books are kept, and it is not difficult to foresee that this will indirectly have an adverse influence upon the financial status of the concern in question—an argument more cogent than that of mere economy, for endeavouring to combine the duties of the Board of Trade and shareholders' auditor in one and the same individual.

Although it is not compulsory under the Companies Act of 1862 for electric light concerns to appoint an auditor, the articles of association of all the companies contain the very necessary provision that an auditor shall be appointed by the shareholders. If, however, the official auditor does not or cannot offer himself for this post, it would seem that shareholders, to put themselves in order, must at least pass a resolution altering the articles of association so as to enable them to accept the audit of the Board of Trade as sufficient for their purpose. As matters stand the resolution recently passed by the shareholders of the Westminster Supply Corporation, although useful as a protest against the imposition of a double audit, or rather, as a protest against having to pay for the same, does not seem quite regular, and the auditor's fee of 50 guineas saved by the thrifty shareholders will be a mere nothing as a solicitor's solatium. If piling audit upon audit would appreciably add to the serenity of the investors' state of mind the extra cost would not be cavilled at. But whenever the State imposes an audit for a special State purpose upon a commercial concern, it ought in common fairness to try and make its special audit also meet the wants of the average shareholder.

REVIEWS.

Electro-Metallurgie. Die Gewinnung der Metalle unter Vermittlung des Elektrischen Stromes. By Dr. W. Borchers. (Published by Harold Bruhn, Brunswick.)

The rapid and substantial growth in many branches of electro-metallurgy which has taken place of late years has made the publication of a comprehensive and authoritative text-book an event to be welcomed. Dr. Borchers' work in its new and enlarged form may fairly lay claim to be a book of this scope and rank.

Before proceeding to detailed criticism some idea of the nature and extent of the ground covered by this treatise may be conveniently imparted. A glance at the table of contents reveals a notable fact. The author is not content with describing the methods of electrolysis available for the separation of those metals which at the present moment find commercial application. He deals also with those, such as beryllium (glucinum), cerium and uranium, which have not yet been utilised in the metallic state. The facts given concerning metals of this class accurately reflect existing knowledge, and suffice to indicate the direction in which investigation may be usefully prosecuted when the increasing abundance of the raw material or the augmenting demand for the finished product justifies the attempt to bring the winning of these rarer forms of matter within the category of industrial pursuits. Consonant with this catholicity of view is the intelligence of arrangement of the book as a whole. The work begins with a short but clear description of the principles of electrolysis and of the conditions determining the relations of thermal to electrochemical energy. In this, the theory of electrolytic dissociation is adopted *sans phrase*, and is amply expounded as far as space allows and necessity demands. Seeing that the hypothesis is as plastic as it is ingenious, it can be applied to facts long established without suffering patent fracture, but as a guide in electro-metallurgical practice it is not wholly trustworthy, and Dr. Borchers gives due warning that cases may occur where its foreshadowings must be disregarded. Not every author pinning his faith to fashionable opinions is equally temperate and candid. There is that about a clever generalisation which often blinds its believers, reducing them to the intellectual level of religious fanatics; the receptive and the critical are ever at variance.

Succeeding sections of Dr. Borchers' book treat of the metals of the alkalies and the alkaline earths, and of the metals of the earths proper, aluminium taking first rank but being suitably followed by those metals which cosmical accident has made rarer, viz., cerium, lanthanum and didymium. With these the first volume is completed. The second and larger volume deals with what may be fairly ranked as heavy metals, or metals usually extracted from recognised ores and not from such saline or earthy substances as salt, chalk and bauxite. Besides metals like copper, silver, zinc and nickel, which are generally viewed as fit subjects for electrolytic separation, others commonly ignored—*e.g.*, chromium, manganese and molybdenum—are not neglected. Space is allotted to them in proportion to what is known of their behaviour in an electrolytic cell, and what may be fairly expected of them as materials for use.

Coming to a more detailed consideration of the contents of this work, we find a sound system adopted, in that a condensed but intelligible description of the chief properties and chemical methods of preparation of each metal precedes the discussion of processes for its separation by electrolysis. Further, something is said of the uses, actual and prospective, of the less common metals. Thus, we find under the head

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of "Magnesium" not only mention of its employment as a deoxidising agent for nickel, conducing to the production of sound castings, but also the information that the reason for preferring it to aluminium is that any magnesium in excess of that necessary to bring about the reduction does not alloy with the nickel. Beryllium, as becomes a metal which, in spite of its resemblance to aluminium, is divalent, is grouped with magnesium. The alkali metals, especially sodium, are treated at length, although practically all the sodium now manufactured is prepared by purely chemical processes. The development of the best existing methods is traced from early times, and it is pointed out that in the classical experiments of Davy the important principle of causing a metallic containing vessel to function as one of the electrodes was recognised and applied. The idea subsequently adopted by inventors of distilling the sodium from the apparatus as quickly as it is separated is of dubious value, on account of the high boiling point of the metal (742° C.), and is quite impracticable for metals of the alkaline earths, which are fixed at ordinary furnace temperatures. The chapter is written in a style pleasingly caustic, and, while recording many devices which have not got beyond the patent stage, does not fail to call attention to their weak points and causes of failure; from them as much may be learned as from the positive merits—and they are not a few—of the ingenious apparatus which have been designed and forgotten. After laying down the conditions which must be fulfilled by any apparatus capable of preparing sodium by electrolysis with commercial success, the author describes one of his own planning, which appears more rational than most others, and appends an estimate, giving the cost of the sodium produced as M.2·3 per kilogramme—*i.e.*, about 1s. per lb. Under the head of sodium alloys, the Castner-Kellner method, for manufacturing caustic soda and chlorine by the use of mercury as an intermediary between the two electrodes, is spoken of, and the originality and utility of the Vautin process (in which lead is used as a cathode, and a lead-sodium alloy is obtained) are strenuously disputed. The preparation of barium, strontium and calcium is still a matter of difficulty, even in the laboratory, for the conflicting conditions that the temperature of the electrolyte should be low and that of the cathode high, have to be provided for. A high-current density—*e.g.*, 500,000 to 1,000,000 amperes per square metre—is a necessity, and is attained, as in Bunsen's original researches, by the use of a mere wire as the cathode. Unfortunately, the very success of the operation of electrolysis involves the separation of metallic globules at the cathode, which increase its surface, diminish the current density and lower the temperature. We note, by the way, that Dr. Borchers lends some countenance to the existence of hypothetical subchlorides—bodies of very doubtful character. An appendix to the section on the metals of the alkalies and alkaline earths gives an adequate account of calcium carbide and it congeners; a perfectly reasonable estimate of cost is given, and a use is suggested for CaC_2 in the refining and deoxidation of industrial metals. We may mention that calcium carbide has already been tried as a carburising material for ingot iron and has proved useless.

To the chapter on aluminium some 60 pages are devoted. Reduction of aluminium and simultaneous formation of alloys occupy the first portion, but the true electrolysis of aluminium salts for the winning of the metal unalloyed, is naturally the more interesting part. Dr. Borchers administers one more swashing blow to that evergreen myth the deposition of aluminium from aqueous solutions, but we rather expect to hear of it again; certain worthless entities die hard. In the historical description of the electrolysis of fused aluminium salts it is interesting to note that Davy tried to reduce the oxide electrolytically, but only succeeded in preparing an iron-aluminium alloy. Bunsen was the first to succeed, using the double chloride of aluminium and sodium to which sufficient common salt had been added to raise the temperature of the bath above the melting point of aluminium and thus allow the metal to collect. Pursuing the subject steadily through its many bye-ways, the author finally shows that, as it proved impracticable to obtain a material from which a vessel could be prepared capable of being heated from without and of withstanding the action upon it of the fused electrolyte, inventors were at last driven to induce and maintain fusion of the electrolyte by the use of a high current density. The author attributes the first clear statement of the principles upon which all modern methods of reducing aluminium are based, to Heroult in his French patent, No. 170,003 of 1887. He examines the patents of Hall and Minet, and concludes that they do not cover those requirements which are essential for successful work, and that those alterations which have converted them jointly into a practical manufacturing method are covered by and included in the specifications filed by Heroult. In discussing the merits and drawbacks attending the use of aluminium sulphide as an electrolyte in place of alumina, the author appears disposed to consider that the great technical difficulty of preparing the former substance will prevent its adoption on a large scale. Finally, he lays down certain conditions for the successful performance of the electrolysis of aluminium salts. These may be summarised thus:—The electrolyte should consist of a solution of alumina in the fused haloid salts of the metals of the alkalies, alkaline earths, and of aluminium itself; the content of the electrolyte in alumina should be maintained constant during electrolysis; the anode should be of carbon and the cathodes of metal, cooled by water circulation or some similar device; the vessel containing the electrolytic bath should be of iron, lined with some refractory aluminium compound; the heat necessary to fuse the electrolyte should be obtained by the use of a current density as high as 25,000 amperes per square metre at the cathode; the lining of the electrolytic bath must be kept cool enough not to dissolve in the electrolyte; the temperature of the electrolyte should be kept as low as possible, both to avoid possible re-solution of the separated metal and volatilisation of the alkali salts forming part of the bath.

The first volume, to which we have devoted much space on account of the fact that it deals with many of the most weighty problems now in process of solution by those engaged in electrolytic industry, concludes with an account of the methods that avail for the reduction of the rare metals, cerium, lanthanum and didymium.

In the second volume of this treatise one becomes conscious of being on somewhat more explored ground than that covered by the first part of the book. In dealing first with copper, Dr. Borchers, as is his wont, briefly describes the more usual metallurgical methods before proceeding to the consideration of electrolytic processes. He draws a necessary distinction between the electrolytic refining of copper of moderate crudeness and its extraction from matte and ore. The influence of impurities in copper to be refined, on the conduct of the process and the character of the product, is not overlooked; thus, copper containing cuprous oxide is apt to become covered with a film of this substance, which is a poor conductor; sulphide and selenide of copper are left with the anode sludge; the presence of tin seems to favour the separation of copper in the form of a layer more uniform and coherent than that thrown down in pure solutions, an effect long taken advantage of in the art of electrotyping. Passing to the section dealing with the extraction of copper, as distinct from its refining, we find an excellent description of the ill-starred Marchese process, the successive modifications of which, with their advantages and ultimate failures, are recorded in a lively and lucid manner. The only process which seems to have reached anything resembling a commercial footing is the Siemens-Halske, and even in this case much more is said about its modifications than of its applications. The Hoepfner process, attractive from its utilisation of the reducing power of the ore to produce an electrolyte containing the copper in the cuprous state, has seemingly also fallen short of an industrial status. Singularly enough, the fundamental reaction, according to which copper sulphide is represented as being able to reduce cupric to cuprous chloride with reasonable speed, appears to have been accepted (save in this country, where Mr. Swinburne has doubted its validity) without question. The old difficulty of obtaining a reliable anode and diaphragm seems largely responsible for the abortive outcome of the Hoepfner process.

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Few but those interested in the trade in precious metals realise the nature and extent of the changes which have occurred in their technical treatment. The displacement of parting by means of nitric acid by the cheaper process of solution of the silver in hot strong sulphuric acid was a considerable step; the present tendency to effect a separation by electrolysis is even more notable. In handling the precious metals there is the great advantage that a deposit in a finely divided state can be fused into an ingot without sensible loss. It is therefore unnecessary to attempt the attainment of a coherent coating on the cathode, and the current density may be high, a matter of importance as the interest on the value represented by the weight of metal under treatment is a serious item in the cost of the process. In treating gold, the author has but little good to say of those processes in which the aid of current is invoked to help the extraction of metal from the ore, or from that richer vein, the pockets of the public. Much space is devoted to the consideration of the advantages of the Siemens process for recovering gold from cyanide liquors in the manner now in use on the Rand. We are disposed to think, however, that the author takes rather too optimistic a view of the capabilities of the process in comparison with those of the ordinary method of precipitation by means of zinc. Decision of the relative merits of these rival recovery processes is eminently a matter to be settled by every-day working on a large scale; it is not difficult to make out a good case for either, and to condemn the other in a convincing manner.

The chapter on zinc is one of the best in the book, and is worthy of special study at the present time, when schemes for the electrolytic treatment of ores containing zinc are much in evidence. As far as can be gathered from published accounts, the winning of zinc by electrolysis has not gone beyond the stage of large-scale experiment; a works remuneratively running has yet to be found. Nevertheless, the principles upon which successful extraction must be based are well understood, and there is good reason to hope that they may soon be generally applied. As far as the refining of zinc is concerned, we learn that the zinc-silver-lead alloy obtained by the use of zinc containing 0·5 per cent. of aluminium in the Parkes process for desilverising lead, is being worked up for zinc by electrolysis in a bath of zinc chloride and magnesium chloride, the lead and silver being left undissolved at the anode. The reason for the precipitation of zinc in a spongy state is said to be want of slight acidity of the electrolyte, and too low a current density; coherent reguline zinc may be obtained, but commonly with some waste of electrical energy expended in the evolution of hydrogen at the cathode. An ingenious apparatus, somewhat resembling that used for the reduction of aluminium by the Heroult process, has been designed by the author for the production of zinc and chlorine from zinc chloride kept fused by the use of a high current-density.

There is little prospect of any electrolytic process for winning tin from its ores replacing existing metallurgical methods, but it is somewhat surprising to find that the refining of commercial tin (usually containing only 99—99·5 per cent. of Sn) is not practised. More attention has been paid to the stripping of tin plate scrap. Acid baths have many failings, and for this reason caustic soda, made conductive by the addition of common salt, is to be preferred. Thus worked, the recovery of tin from scrap is likely to be remunerative. The profitable reduction of lead and even its ordinary refining are not likely to be carried out by electrolytic methods. Commercial lead contains 99·98 per cent. or more of Pb, and room for improvement is therefore scanty. The separation of bismuth from lead containing a tangible quantity of that metal, by electrolysis in a bath of fixed chlorides, has some prospect of success. For the extraction of antimony from poor sulphide ores, a process consisting in the extraction of the ore with sodium sulphide and the electrolysis of the resulting thio-antimonate is described, but it has not passed the experimental stage. There is only a trifling demand for pure chromium and manganese, their respective iron alloys sufficing for the chief purpose to which these metals are put, but, in the event of need arising, there should be little difficulty in meeting it. Both chromium and manganese can be reduced from their aqueous solutions when a high current-density is used, but the manufacture of manganese on an industrial scale would be best performed in the way commonly used for aluminium. The electrolytic refining of ferro-chromium and ferro-manganese has been tried without much success. Iron comes within the field of electro-metallurgy chiefly in respect of the magnetic dressing of its ores and the working of finished iron by various welding processes; electrolytic refining has been proposed but remains to be achieved. The tendency of nickel to scale when the deposit on the cathode is more than a film, has proved an obstacle to the electrolytic winning or refining of a metal which in some respects appears well fitted for such treatment.

Having thus given some account of the contents of Dr. Borchers' work, a few words will suffice for a summary of our opinion concerning it. The book is not only full of valuable information, but it gives evidence of a practical acquaintance on the part of the author with many of the processes which he describes, and of a thorough insight into the technical value and possibilities of all the methods which he discusses. Considering the vast quantity of rubbish which the compiler of such a work must excavate to get at his facts, the book is singularly little burdened with descriptions of worthless patents. Many abortive schemes are described, but their insertion is justified by the illustrations they afford of the difficulties which inventors may expect to encounter and the warnings they give of attractive courses leading straight to limbo. As is not unnatural, Dr. Borchers is somewhat disposed to take a rosy view of the prospect of many electrolytic methods which, to live, must fight hand to hand with long-established and well-devised chemical and metallurgical methods, and he scarcely insists sufficiently on the high cost of power and plant inseparable from electrolytic work. No doubt he himself is fully alive thereto, but for the student and inventor this fact cannot be stated too explicitly or with too much iteration. This, however, is a small blemish on a book which, as a whole, we can commend without reservation. B. B.

Aluminium. By A. G. Brown. (London: The Aluminium Supply Company. 1896.)

The Aluminium Supply Company, who are agents for the Pittsburg Reduction Company of America, have recently issued a cloth-covered *brochure* describing the uses of aluminium and its manufacture by the Hall electrolytic process at Niagara and elsewhere. We have puzzled for some time over the first page of this book, wondering whether it is intended as a title page or as an advertisement. It does double duty. On the next page a mild shock was reserved for us where we made our first acquaintance with the slangy word "alium." It is seriously suggested that this word is a useful and rational substitute for "aluminium," a suggestion from which we dissent. The two words equally divide the attentions of the writer, and vary any monotony by occurring in the most curious sequence throughout the book. There are numerous tabulated data of aluminium, and the inevitable tables of areas of aluminium circles, &c. There are also some illustrations showing views of Niagara Falls, some pots and pans which can be made of aluminium, and of the three-phase plant used at the reduction works. Without doubt this little work contains a great deal of useful information about an engineering material the uses of which are continually extending.

STEREOSCOPIC RÖNTGEN PICTURES.

BY ELIHU THOMSON.

Whilst experimenting with the making of shadow pictures, it occurred to the author that it would be desirable to secure some indication of the position in space of various embedded solid objects, or, in other words, to obtain a pair of pictures which when placed in a stereoscope would show solidity. This would manifestly be useful in surgical examinations, as the true relations in space of the parts of a bone, or of a foreign body and the bone, would become evident. The ordinary Röntgen pictures are simple shadows on a plane surface. It is impossible to tell from such a shadow whether one object or

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part of an object is front or back of another. There is, however, no difficulty in determining the real positions when resort is had to the production of stereoscopic shadow pictures.

The first trial made by the author was completely successful, objects appearing in high relief. The process consists simply in exposing a covered plate in the ordinary way, and repeating this with the objects and Crookes tube relatively displaced somewhat from the first position. The rays thus pass through the objects in two somewhat different directions, a record of the shadows being made for each direction. Prints from the negatives so produced are mounted for use in the stereoscope. The effect is very curious. A cork or block of wood having nails or screws driven into it in various directions is clearly shown, and the screws or nails in their proper positions. When two heavily insulated wires twisted together constitute the object, the metal wires alone are seen, but standing apart in space, one around the other. The bones of two superposed figures are to be seen in their correct positions. The complete skeleton of a mouse, or other small animal, may thus be recorded so as to be seen in relief, each bone in its proper space relation to the others.

It may be possible as a development of the use of Röntgen rays stereoscopically to arrange two fluorescent screens, or even a single screen, to be viewed by the eyes and receive the image or shadow in such manner as to produce the stereoscopic effect; thus, if the Crookes tube have two cathodes a certain distance apart, which are connected to the electric source alternately, and with considerable rapidity, while small shutters are synchronously opened and closed before each eye respectively, one of the eyes would at all times receive the impression given by the rays from one of the cathodes, while the other eye would always receive the impression produced by the rays from the other cathode, and thus stereoscopic observations would be the result. This method of producing the stereoscopic effect is similar to one which has been tried and used successfully in stereopticon work; two lanterns being arranged to throw upon the same screen in nearly superimposed positions two slides which are stereoscopic in their relation to each other. A set of diaphragms were arranged, passing in front of the lantern tubes synchronously with similar diaphagms passing before the eyes of the spectators, whereby each eye always received its appropriate image on the screen, the result being to give solidity to the scene depicted.

THE DEVELOPMENT OF ELECTRIC LIGHTING ENGINES.*

BY H. LINDLEY.

In acceding to a request to write a Paper on Steam Engines, to be read before this Society, I need hardly say my feelings were to a considerable extent tempered with hesitancy and doubt, for I could not help feeling my own unworthiness for such a task. And here let me say that I do not intend, if I can avoid it, to express any preference on my own behalf for any particular type of engine, but shall, I hope, deal impartially with those that now find use for electric lighting. Having mentioned the word "type," let me therefore, first of all, make an attempt to divide the various kinds of engines now in use for electric lighting purposes into some sort of divisions or classes. I do not claim any originality when I say that a very obvious method of division would be by reference to the speeds of the engines under consideration. We will, therefore, say there are three classes—viz., slow speed, moderate speed and high speed. There is also another motor which we can hardly call a steam engine, though perhaps it might be difficult to say why, and which, therefore, and also on account of its enormously high speed, forms a class by itself, and which does not come within the scopeof this Paper.

Now, the engines to which this Paper refers are what we may call ordinary engines—viz., having cylinders, pistons, &c.; and the speed referred to is the speed of rotation of the crank shaft. Another speed very frequently referred to when speaking of steam engines is that known as piston speed—it should be strictly known as mean or average piston speed, but plain piston speed is enough for our purpose, being a term familiar to you all and well understood. Now, it is rather a singular thing that this piston speed varies but slightly in the various classes of engines we are now considering. You are just as likely to find a high piston speed in a slow-speed engine as you are in a high speed one, if anything rather more likely; there is then some connection of the inverse kind between rotation speed and piston speed, and that is, of course, the stroke: that is to say, the slow-speed engine has a long stroke, the moderate speed a shorter stroke, and the high speed a still shorter stroke. Now, I do not think I need make any attempt to discover and tell you what are the advantages or objections to slow or high speed—it does not enter into the object of this Paper to do so, and no doubt you are as well aware of them as I am, or better. I should, however, be very glad to hear, in any discussion there may be, the opinions of those who have engines under their charge, on the question of engine speed; all I wish to say is that, *per se*, slow speed has certainly obvious objections, and yet for some reason or other slow-speed engines are to-day still much used for driving high-speed electric lighting machinery. Now, I do not think it is difficult to find an adequate reason for this, and that is that it is in the nature of a legacy from past ages. In the old days, before electric lighting became a burning question, suppose a man had a few machines to drive—say a saw bench or two, or some beetling or drying machines, or a few engineers' tools—and he wanted to put down an engine for the purpose, what did he do? Well, I venture to say, as a general rule, he tried hard to remember some other shop about the same size as his own, and the size of the engine that was driving it. Well, we will suppose that an engine of the size so arrived at was put in, and if it drove the shop easily, and without undue heating or excessive repairs, it was accounted a good and well-made engine. On the other hand, if the engine heated badly, knocked, and wanted constant repairing, it was either a bad engine (which was probable) or too small (not so probable), and in either case it was replaced by a larger one. At about the same time or date as the above specimen of steam engineering was common among the generality of steam engine users, there was another section of them who proceeded on much more scientific lines, leaving out of the question marine or locomotive practice. I refer to the cotton industry of Lancashire, and to those who brought it to and maintained it at the high state of perfection in which it then was. The cotton spinner then, as befitted the most important steam engine proprietor and user, set to work on better lines. When he wanted to drive his mill he knew exactly how many spindles with the necessary preparation machinery could be driven by 1 H.P., and in buying an engine it was an easy matter of calculation to find out how much horse-power to provide. It was also an easy matter to calculate how much horse-power an engine of a given size would develop, at a given steam pressure and speed, and an engine of the size so arrived at was ordered accordingly. If then the engine did not do its work well, or without breakdowns or heating, there was no question about it—it was a bad engine, and would either have to be altered or come out. But long before this the weak points of these engines had been thrashed out and eliminated, at least by engine builders of any repute, and the cotton spinner, by dealing with firms of good repute, was practically certain of getting an engine that was up to and would give the work required of it without any undue trouble. This engine, then—the Lancashire mill engine—entered the field of electric lighting almost completely prepared for the work; the only thing was, that in the early days of electric lighting it was rather too big, and there were then not many large installations requiring to be driven.

Now, as soon as it became evident that the newly-opening-out field of electric lighting was likely to require the services of a large number of small-sized steam engines, nearly every maker of them suddenly awoke to the fact that his particular make of engine was particularly suited for electric lighting work, and advertised the fact. The wish, however, was but father to the thought, and as soon as one of these engines was set to do the work that by calculation it should be equal to doing, and which also by exact calculation it was known to have to do, the crank-pin got hot. An extra large-sized lubricator was fitted to the crank-pin, and the engine was advertised as being specially designed and equipped for electric light work. But still it did not do. Why, then, did engine builders still persevere till they did produce an engine that would do the work it should do, when all the time there was the slow-speed mill engine waiting and willing to do it? I have said it was too large; so it was, but it would not have been difficult to make small copies of it, and then the thing would have been done. Well, apart from other reasons that will occur to you, there was of course the great question of cost—the slow-speed engine was too dear.

This, then, leads us to the birth of the moderate-speed engine, that is, the modern moderate speed one, and one that would really do without flinching the work that calculation showed it capable of doing, and keep on it for considerable periods of time. The thing was not so difficult after all, but it wanted doing, and like many other things of which that may be said, it took time to do. Firstly, the stroke wanted shortening; that to a certain extent had already been done; and secondly, the bearings wanted increasing. Here

* Abstract of a Paper read before the Northern Society of Electrical Engineers.

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makers proceeded timidly, and it was some time before a correct proportion was arrived at. And no wonder, when we come to consider the great amount by which such bearings did require increasing. Take as an example an engine with an 8in. cylinder, or say 6 H.P. nominal, though this term is now obsolete in connection with electric lighting work. This engine now has a crank-pin as large as that used in a 16in. cylinder or 25 H.P. nominal of the slow-speed type not many years ago, or of to-day as made by many makers. The piston speed is about the same in both cases, but the cylinder ratios are as 1 : 4. True, the smaller cylinder has frequently to stand a rather higher pressure of steam than the older engine, but the difference is not enough to account for all that difference in the size of the crank-pins. What then was the cause? Why, as you will guess, the greater number of revolutions, that is the indirect cause, the more direct cause being the tendency to knock at the higher speeds and thus displace lubricant. The main bearings have not increased in the same ratio, and for one reason, viz., that owing to the speed being higher the flywheel can be much lighter and smaller.

Lubrication then also became a most important question, the extra large-sized lubricator on the crank-pin, spoken of before, had to be abandoned because it could not be filled while the engine was running, and in its place some continuous method of supplying oil was adopted. A whole crowd of wick or screw adjustment oilers has in most good engines now been replaced by a central oil box, with a pipe to each important bearing, and having a sight drop arrangement at the box so arranged that the supply can be cut off without altering the adjustment. By still more perfect means of lubrication a crank-pin or main bearing can be made to run absolutely noiselessly, even though the brasses are considerably worn. It will be known to many here that Messrs. Bellis, of Birmingham, have effected this by means of forced lubrication from a pump, the oil being distributed through holes, drilled in the crank shaft, to the various bearings. My own firm have a patent which secures the same result, at least in the case of crank-pins and eccentrics, the oil in this case being led to a centrifugal oiler and thence to a suitable cavity in the crank-pin. This cavity is formed by a flat rather narrower than the width of the crank-pin, and is opened or spread out into a long oil groove, the trailing corner of which is well rounded. The position of this cavity on the crank-pin is dependent on the following fact. If you examine the forces acting on a crank-pin in a double-acting engine you will find that there is one portion of the pin surface that is never acted on by the brasses. The cavity is formed on this portion of the crank-pin, and being kept supplied with oil, it passes over each half of the bearing in the big end of the connecting rod immediately before pressure comes on to it, the rounded shoulder facilitates the spreading of the oil and indeed acts as a swab, filling up any clearance or play with oil. When pressure then comes on either brass this oil has to be expelled, and acting as a dash pot prevents any sudden shock or knocking, and the bearing thus runs silently.

At the same time as affecting this displacement of lubricant by knocking, I may here mention the ingenious self-adjusting bolts of Mr. D. Abercrombie, by which wear is automatically taken up as it occurs and knocking avoided. In this arrangement the nut on the ordinary marine pattern bolt, instead of being locked hard, is under the control of a torsion spring, the torsional tension on which can be varied by means of a circular ratchet at the other end of the spring. Play or strip is allowed between the two halves of the bearing, and when the brasses wear, and the nut would otherwise tend to become slack, the spring rotates the nut slightly, thus following up wear as it occurs, just as one would with finger and thumb tighten a nut on some slow-moving piece when reciprocating action was causing knocking.

Another important detail that has led to the success of the modern moderate-speed engine is by no means a new one; it is only the almost universal adoption of it in this class of engine that is new, and that is the use of white metal in the bearings. I believe it is not too much to say that the fast-running engines of the present day, including marine and locomotive engines, in addition to those we are now considering, would be almost impossible without the use of white metal. It is impossible almost, and would at any rate be invidious, to attempt to say what particular make of white metal is the best for any one purpose. There are many makes on the market, and many good ones I believe, but to go no farther than the old Babbit metal, the advantages of its use over brass or bronze are many. Not only is it much less ready to take offence at any small particle of dirt that may get into a bearing and get hot, but it wears longer; and, moveover, by use puts a polish on the pins or journal of the shaft, that not only necessitates less oil being used, but must also reduce internal friction in the engine. In heavily loaded bearings, such as cross-head pins, &c., a quality must be used of sufficient hardness not to pound out.

Then we have another set or class of improvements that were necessary, and have been, or ought to have been, incorporated in the moderate or high-speed engine of to-day, and I refer to various fastenings about the engine. For example, some years ago, when the firm of which I am a member first began to make engines that we fondly hoped were perfect for electric lighting work, we had the lock-nuts of one of the connecting rod big end bolts, in a small engine, jar off whilst working. The lock-nuts were good enough for the old slower speeds, and when you could stop and tighten them if you heard the engine pounding badly through their coming loose, but they would not do for electric lighting. Nothing more serious than a stoppage (quite bad enough I admit) happened in this case, but from that date we abolished lock-nuts throughout the engine (except on main bearings), and used other and more secure devices in their stead.

Slides valves used to be secured on their spindles between lock-nuts in the old days, a doubly bad arrangement. No doubt many of you can recollect trying to tighten these at some now distant date with two keys (both too thick) and some pieces broken off the end of a file by way of packing, or with a hammer and chisel. And how the spindle used to spring when you tried to hammer against the nut on it. Apart, however, from the difficulty of tightening the lock-nuts in the valve chest of an engine, they were bad because of the small amount of surface they exposed for driving the valve. Knocking thus took place early at this part, and this tended still more to loosen the nuts. Some of you may say that a pin beyond the nuts would have prevented them coming off altogether if it would not have prevented the knocking. So it would, but pins are very often dropped into a crank pit, or on to a dirty floor and lost, or, sadder still, forgotten by an ordinary attendant, and as they do not grow anywhere about an engine room they are not always replaced, especially when, as very frequently happens, the engine is wanted to start off as soon as ready, if not sooner, and so split pins do not get us out of the difficulty, though they should still be used as an extra precaution should the device adopted fail from any cause. Here then, again, was a point to be remedied if the engine was to do its work properly. For the same reason lock-nuts on gland studs should be abolished, and a method adopted whereby the nuts can be prevented from jarring loose, and that whilst the engine is running. The same remark also applies to the nuts on the eccentric clip bolts, though these, of course, cannot be tightened up whilst the engine is running. The crosshead and its guide, too, was, in the early days, unsatisfactory. In the first place, unless the pin or gudgeon was too small, as it generally was, the cross-head was too heavy, the most frequent construction of forming the fork in the crosshead and fitting the brasses in an eye in the connecting rod, not allowing of a very satisfactory job being made of the crosshead if lightness were attempted, unless the pin was made rather short in the bearing. To obtain a wide pin and at the same time a light crosshead, the plan is now almost universally adopted of forging the cross head on the piston-rod, thus saving the heavy boss and avoiding the risk of the cotter giving out if water were met with in the cylinder, and forking the rod, by which means a wide pin and a light cross-head is obtained. It is also as well, in a crosshead of this type, to arrange it so that the pull does not come on to the cap bolts, as by this means the difficulty arising from the improperly-secured nuts is avoided, and at the same time a stronger construction, weight for weight is secured, the brasses being adjusted by means of a wedge and the cap bolts merely being utilised to keep the cap in position, the pull due to the steam being taken by the cap itself, which is lipped over on to shoulders formed on the crosshead for the purpose. The slipper also, though not susceptible to any radical change, should be amply proportioned, so that there is no danger of lubricant being forced out from between it and the slide. A word should also be said about pistons, not that there has been any very radical improvements made in them of late years, but rather that, of the types to hand, the most suitable should be chosen, and moreover, it should be carefully made.

Cast iron rings wear very well if made of good material, but, unfortunately they do not lend themselves, at least in the ordinary form, very well to use with a solid piston body, which is much to be preferred to one made with a junk ring, in an engine running at moderate or high speed. The ordinary pattern of piston, solid if over 16in. or so in diameter or made with a junk ring if less, with two cast iron rings expanded by an inch coil, answers very well for slow or very moderate speeds, but it is certainly advisable to avoid the screws necessary where a junk ring is used, and also to reduce as much as possible ring friction, which with the above construction is probably always more than necessary. The St. John steam expanded ring appears to give good results so far as I have tried it during the last two or three years, and it has the advantge that it can be made in cast iron and yet be sprung into a solid piston body even if of small size, and being steam expanded, it exerts a pressure on the cylinder walls in proportion only to the pressure of steam in the cylinder.

Another point that deserves attention is the valve. This may be either of the flat or piston type. The flat valve has the advantage of cheapness and steam tightness, but it takes more

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power to drive than the piston valve, and that is a consideration where automatic expansion by means of a shaft governor is used, as it always should be. It does very well, however, with low pressures of steam, and if made with a trick port, gives good openings to the cylinder and that without excessive travel. In the low-pressure cylinder of a compound engine it is advisable to carry the spindle through the valve chest so as to afford a double bearing for it and to fit a spring between the spindle and the valve, as by this means the annoying clattering present when running non-condensing on light loads is avoided. The piston form of valve has also the advantage of giving good openings in consequence of the length of lip, which is, of course, equal to the circumference of the valves, less the bars in the liner, and I suppose no one would make one without a liner. It is also balanced from steam pressure, and is therefore easy to drive, unless it is rusted up, or working with red lead squeezed out of pipe joints as a lubricant instead of oil. Provided, however, that it is clear and well-made, it works with very little friction. As regards improvements in this important detail, I am afraid it is even yet too early to speak. Undoubtedly the best construction is a well-fitting solid valve, without packing of any sort. The liners should be most carefully bored out to attain this result, ordinary boring not being good enough unless lapped out afterwards, and this is not very advisable, as it is impossible to get out all the emery used in lapping. The valve should be ground and polished to a perfect fit, and then as long as that condition of fit lasts you have the best valve. But unfortunately that condition is not an everlasting one, and there is, therefore, a great temptation to fit some form of spring packing. The objection to spring packing is that the liner gets worn as much as the rings, and when it becomes necessary to renew the valve it is like "putting new wine into old bottles"; they do not go well together.

I am hoping, however, that good results can be secured by a valve having steam expanded rings as described for main pistons. It is to be noted that a piston valve cannot leave its seat like a slide valve, and consequently it is necessary to apply spring relief valves to a cylinder fitted with this form of valve, to allow of the exit of any sudden flush of water that may come into the cylinder, and for which purpose the ordinary drain cocks are, of course, useless.

I take it for granted that by this time no engineer makes an engine in which the joint between the frame and cylinder is a steam joint, as that means dismantling the engine should such a joint blow. As regards the necessary steam chest and cylinder cover joints, the best practice is certainly to make them metal to metal, scraped and ground together, and dispense with any more jointing material than boiled oil. I have now reviewed most of the points that have required attention at the hands of engineers in adapting the moderate speed, and still most extensively used engine to the needs of electric lighting work; I have not, however, entered into the question of governing beyond suggesting that a shaft governor should be used, altering the angular lead and throw of the eccentric so as to vary the cut-off and compression. The number of forms of shaft governor is now so great that they really require a Paper of their own to adequately deal with them. I think I ought, however, to give some reason why a shaft governor is to be preferred to one operating a throttle valve, but before doing so, I might refer to one feature of the throttle valve governor wherein it is superior to the other, and that is the case with which its speed may be altered whilst the engine is running. A speeding device for a throttle valve governor usually takes the form of a supplementary spring attached to some moving portion of the governor operating the valve. When tension is put on this spring an extra resistance is added to that restraining the opening of the governor balls, and thus more speed is required to get them out, and the engine has to run faster to do so, or *vice versâ*. Speeding gear, it is true, can be fitted to a shaft governor, but it is nothing like so simple a matter; on the other hand, the advantages of a shaft governor controlling the cut-off are many and manifest. First, the great objection to a governor belt is entirely removed, this can also be secured in a throttle valve governor, and in two ways. The governor may either be driven by a pitch chain or it may be mounted on the shaft of the engine, and its motion transmitted to the valve by means of a system of levers. The first of these two methods has not made any great headway as yet, though I believe the use of chains for driving governors is extending, especially in large, or horizontal engines, fitted with Porter governors, the great improvements made in pitch chains of late years having made this system of driving governors at least feasible. The second method is more frequently used, and especially on engines for the Admiralty, the arrangement is not, however, equal to automatic expansion by a shaft governor in results, nor indeed, if speeders are not required, in first cost. Then there is the question of economy in the use of steam. It is, I may say, almost obvious, that within certain limits it is more economical to admit high pressure steam to the cylinder, cut off as early as the load will allow, and expand down. With a steam jacketed cylinder there is perhaps no limit to the point at which early cut-off is not more economical than throttling, but as an engine rarely works for long together with a very early cut-off and the consequent great variation of temperature in the cylinder, the advantages of steam jacketing become less apparent, and they are usually dispensed with. Now, with a throttle valve and fixed eccentric, the only point at which anything like full steam pressure can act on the piston is at full load, and consequently the eccentric has to be set to give a sufficiently late cut-off to deal with the maximum load that the engine is ever likely to be called upon to do. In many cases, and more especially in electric traction work, this maximum load must be considered as all that can possibly be got out of the engine with 0·6 to 0·7 cut-off, and beyond which very little extra power is obtained for later periods of cut-off. It follows, therefore, that during the greater part of its working hours an engine so fitted must be working under conditions very unfavourable to economy so far as expansion of steam is concerned. The above remarks apply with more force the greater the steam pressure used, and at very low pressures, say 30lb. or so, there may not be much in automatic expansion after all. But nowadays such pressures as 30lb. to 40lb. are rarely met with, except in old works, and they are hardly worth considering.

Then, again, on the mere question of governing—that is close regulation of speed—the shaft governor has the advantage, and for the reason that the compression of the exhaust in the cylinder is varied at the same time that the cut-off is altered. This most important feature is well seen in comparing the indicator diagrams from an engine working under varying loads, and fitted with one or the other form of governor. Take the throttled engine first; at full load the card is all right, but at light loads, it is seen that, except the pressure is reduced almost to nothing, there is still considerable area left. It becomes necessary, therefore, to insure that the steam should be throttled to reduce the pressure sufficiently to hold the engine, and this means having the throttle valve a good fit; it must not fit too well or it will stick, and it must not be too slack or the engine will run away, and those who have not seen it would be surprised to see how very little space between the valve and its seat is sufficient to allow an empty engine to run away.

Now look at the cards from an engine fitted with a single slide (or piston) valve and a shaft governor. At full load you have a full card as before, but as the load lightens the cut-off is made earlier, and at the same time the amount of compression is increased till at no load the exhaust is compressed almost up to boiler pressure, and the diagram has very little area left; just sufficient, in fact, to keep the engine running at its proper speed. The compression so produced is, at the same time, useful in bringing the reciprocating parts to rest, and thus minimising knocking if present, and at the same time is a source of economy, and for two reasons: first, that the compression raises the temperature of the exhaust steam and thus heats the cylinder walls before the advent of the new steam; and secondly, the cylinder being open to the atmosphere or condenser for a much shorter period of time, radiation and loss of heat is prevented.

I was careful just now to say "an engine fitted with a shaft governor and a single valve," and it was necessary to do so, as there is another way of using a shaft governor, and that is with two valves. A main valve is used in this case, driven by a fixed eccentric, set to give the latest cut-off and compression required. The cut-off valve works on the back of the main valve, and its eccentric is loose on the shaft and under control of the shaft-governor, but this eccentric is merely rotated round the shaft to obtain the various points of cut-off; that is, it has angular lead only altered and not its throw. This method of governing, which has for its first disadvantage the multiplication of parts necessary to operate two valves, has also the same disadvantage as the throttling method, *i.e.*, the fixed compression; but it has also another special one of its own, and that is, if any steam is admitted at all it is of high pressure, and even it be cut off at the dead centre, the clearance will be all filled, and enough steam get in to make the engine run away. It must therefore be arranged to take practically no steam at all when running empty or lightly loaded; it must not, however, cut off steam too soon before the extreme position of the governor weights is reached, or it will hunt, and the adjustment is rather a nice one. This form is, however, very seldom now, and is not worth consideration here. The above description of the main forms of governors in use is, I am aware, a very vague and incomplete one, but the limits of this Paper do not allow of my pursuing the subject further, important as it is. It will be observed that so far the bulk of this Paper has been devoted to a consideration of the form of and manner in which improvements in the moderate speed engine has come about; and I have given that portion of the subject the chief consideration, because, as I have stated, it is still the most generally used type of engine, and the one with which I myself have chiefly had to do with. I feel, however, bound to say something on my third class of engines, viz., the high speed one. Now, just as I said at the commencement of this Paper, that *per se* slow speed is a disadvantage, so I must now say that *per se* high speed is a great advantage, and for the simple reason that direct communication with the dynamo is possible, and all other means of transmission are avoided. I need hardly remind you that

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the previously-considered moderate-speed engines are also very frequently coupled direct to dynamos; and, indeed, for the matter of that, so are slow-speed engines; but whereas with a slow-speed engine the dynamo usually takes the form of a flywheel alternator, and is, therefore, very big. So the moderate-speed engine, when direct coupled either to an alternator or direct-current dynamo, requires such to be bigger and more expensive than if they were coupled to an engine running at a higher speed; and thus the important element of first cost of dynamo steps in in favour of the higher speed, but in many cases this is partially, or altogether, balanced by the less cost of the moderate-speed engine.

I will not now, any more than at the commencement, endeavour to hunt up all the advantages of high speed *versus* slow speed, but would prefer to hear what you, who have to deal with both, have to say, and why you have formed your preference. I must say this, however, that after all, the term "high speed," being a relative one, and if it is desirable to attain to speeds in the engine corresponding to those usual in the dynamos, why is it that the highest speeds to-day do not exceed 500 revolutions? It is not because dynamos cannot be made to run faster than this, because you know well that speeds from 500 revolutions in the largest to 1,000 revolutions or more in the smaller dynamos are, to say the least, quite usual.

Well, for one reason, the centrifugal strain, that is, the momentum of the moving parts, goes up as the square of the revolutions, and this imposes a limit on the speed, as bearings cannot be indefinitely increased, and then again, the high-speed engine-maker has only the same choice of materials of which to construct his engine as are to the hand of the maker of slow-speed engines. He can only be more careful in his workmanship and choice of materials, whether cast-iron, steel, or bearing metal; but if he chose, the slow-speed engine-maker could also be, and no doubt often is, equally careful. It is not very likely, therefore, that any great increase in speed, over what at present obtains, will be attained, that is in engines of the class we are considering, or where there is rubbing contact.

The high-speed engine can no doubt be made very economical, if only on account of its high speed, and the consequent higher temperature of its cylinder walls, but it is more susceptible to derangement from careless use, and if a breakdown of any part should occur, the results are more disastrous than in a slow-speed engine. Water in particular is a source of the greatest danger, and a separator is, therefore, usually fitted to this class of engine. The high-speed engine is, however, such a special piece of apparatus, and there are so few makers of them, that it is impossible to deal in any other than a general manner with them without simply describing A's or B's engine, and, therefore, also because this Paper is already sufficiently long, I cannot very well give you any historical account of the perfecting of this form of motor.

There is, however, one point to which I should like to call attention before bring this Paper to a close, and that is, that in addition to the electrical industry having created a demand for a new and improved race of engine attendants—that is, at any rate, so far as land practice is concerned—the old easy-going mill engine tenter with hardly a care to trouble him, has in central electric light stations had to give way to a man who is constantly on the watch lest anything should go wrong, and who, with others about the station, is alive to the importance of maintaining a steady and uninterrupted working of the plant under his charge. Marine engineers knew what this meant better than those in charge of stationary engines; but the advent of high speed steam and dynamo electric machinery that must be kept going, has necessitated vastly increased watchfulness and care from those in charge to what obtained only a few years ago.

On starting up a new plant, too, it is most important that the bearings should be overhauled before commencing to work, as grit and dust is nearly always present when engines are being installed, and it is almost impossible to ensure that it shall not get into the bearings. For this reason it is always advisable to keep engine and dynamos in a room quite separate from the boiler or stoke-holes, for it is quite impossible to ensure at all times that ashes and coal dust will not be blown about and get on to the engines and lead to hot bearings. The question of oil should also receive more attention than was considered necessary formerly, and filtering should be resorted to unless the makers can guarantee it free from grit. The question of oiling cylinders is in rather a curious state, some engineers of repute saying that if steam cylinders are never oiled, they do not, as it were, feel the want of it, and work very well without. For my own part, I must say, I prefer to go on using oil in them, and oil too of the best quality. Inferior cylinder oils are possibly worse than no oil at all, depositing as they do a dark sticky substance on pistons and rings, &c., and rendering the latter sometimes quite inoperative. It would be very interesting to know definitely what difference (if any) is made in the wear and internal frictional resistance of an engine working with and without oil in the cylinders. In cases where surface condensers or exhaust steam injectors are used, there is, of course, an obvious argument in favour of running without oil in the cylinder, but we have now oil separators, to prevent the feed water carrying grease over into the boilers, and something of the sort is certainly needed in cases where oil is liable to be carried into the boiler. Apart, however, from the question as to whether it is possible or not, or how far it is necessary to keep oil out of the boilers, it still remains a moot point as to whether it is better for the engine that oil should be used in the cylinders or not.

JUNGFRAU ELECTRIC RAILWAY.—INTERNATIONAL COMPETITION.

We have been requested by Herr Guyer-Zeller, of Zurich, President of the Commission of the Jungfrau Railway, to publish the conditions of an international competition for the best solution of a number of questions connected with the construction and working of an electric railway up the Jungfrau. Prizes of a total amount of £1,200 are offered. The points to which attention is called are as follows:—

I.—The Design of the Line.

(*a*) The section of the tunnel, without and with stone lining; the foundation and overhead construction, rails, rack-rail, switches and crossings.

(*b*) The system to be adopted for the electric transmission of the power; equipment of the primary stations; system of distribution of the current along the line; protection against atmospheric disturbances.

(*c*) The electric cars, with all the necessary safety devices.

(*d*) Designs for the station building and restaurant at Eigergletscher Station.

(*e*) Construction and equipment of the intermediate stations.

(*f*) Design of a *Klubhütte* shelter to take 50 persons at Mönchjoch Station.

(*g*) Elevator, about 100 metres high and 8 metres in diameter, provided with staircase, at the summit of the Jungfrau.

II.—The Construction of the Line.

(*a*) The boring of the tunnel: electric boring machines, blasting material, ventilation.

(*b*) The removal of the spoil.

(*c*) Precautionary measures for the maintenance of health and life of the workmen, patterns of movable barracks.

III.—*The Working of the Line.*

(*a*) Plans for insuring under the given conditions a continuous working of the line.

(*b*) Electric lighting of the tunnel, cars and stations.

(*c*) Electric heating of the cars and stations, precautions for the safety of passengers and working staff.

One or more of the above points may be dealt with by a competitor or several competitors collectively. Further suggestions likely to be of advantage to the Jungfrau Railway undertaking are also invited.

The scientific Commission, with the assistance of experts, will settle the award of the prizes. The results will be published. Upon the prizes being distributed the Jungfrau Railway Company will acquire the right to use the plans obtaining prizes without further compensation. The commercial copyright will, however, remain the property of the author. Rejected papers will be returned.

The following data are given:—The maximum gradient of the line is 25 per cent. The gauge is 1 metre. The sharpest curve is of 100 metres radius, and the maximum radius is 500 metres. The greatest width of car must be 2·5 metres, the greatest height 3 metres, the maximum speed 7 to 10 kilometres per hour. The water power at the disposal of the electrical plant is about 5,000 H.P., and will be taken from the river Lütschinen. The distance between the power house and the starting point of the line on the Kleine Scheidegg is about 8 kilometres, from there to the tunnel entrance it is 2½ kilometres, and the tunnel has a length of about 10 kilometres.

Competitors must illustrate their schemes by drawings or models, and must also enclose estimates of costs. The latest date for sending in schemes is August 1, 1896.

Further information may be obtained from *Bureau der Jungfraubahn, Bahnhofstrasse 10, Zurich, Switzerland*, where also general plans, the result of geological investigations and details of the water power available may be obtained.

The scientific Commission of the Jungfrau Railway will consist of Prof. Becker (Zurich), H. Brack, technical director of the North East Railway (Zurich), Prof. Golliez (Lausanne), Dr. Maurer (Zurich), Dr. L. von Salis-Guyer (Basle), Dr. Schmid (Berne), Rev. G. Strasser (Grindelwald), E. Strub, railway engineer (Interlaken), Prof. Walder-Meyer (Zurich), Prof. Weber (Zurich), Dr. Wrubel (Zurich), and President Guyer-Zeller.

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THE RAWORTH HIGH SPEED STEAM ENGINE.

The Brush Electrical Engineering Company have recently placed upon the market a high-speed enclosed steam engine, which they are manufacturing under the patents of Mr. J. S. Raworth. The name "Universal" high-speed steam engine has been given to it by the makers, who have supplied us with the following particulars of its construction. It is essentially a tandem engine, for either simple, compound, triple, or quadruple expansion, according to requirements. Fig. 1 gives longitudinal and cross-sectional elevations, and shows the chief working parts. The cylinders are arranged in pairs one above the other, and the valves are placed between the cylinders. The valves are of the Corliss type, and the high-pressure valve is distinct from the low-pressure. The high-pressure steam presses on the under surface of the small upper piston, and the expanded or receiver steam presses on the upper surface of the low-pressure piston. During the down stroke, to the point of cut-off, the receiver and the high-pressure cylinder are in communication with the low-pressure cylinder. The high-pressure piston at the top of its stroke passes ports in the cylinder, whereby the pressures in the cylinder and in the receiver are equalised; but the capacity of the receiver is so arranged that the difference in pressure between the high-pressure cylinder and the receiver shall be small. The high-pressure cylinder steam on the downward stroke of the piston expands into the low-pressure cylinder until the cut-off valve closes, when the remainder is passed into the receiver, excepting a small residue retained for compression. Any water taken into the high-pressure cylinder is discharged into the low-pressure, and when the low-pressure piston arrives at the bottom of its stroke, the water is discharged through holes in the cylinder into the lower exhaust chamber. The exhaust valve is connected with the lower exhaust chamber by an external pipe. The main exhaust pipe is carried away at the lower level, and, when working non-condensing, involving an upward turn of the pipe, a large drain pipe must be taken downwards before the exhaust pipe arrives at the first upward bend.

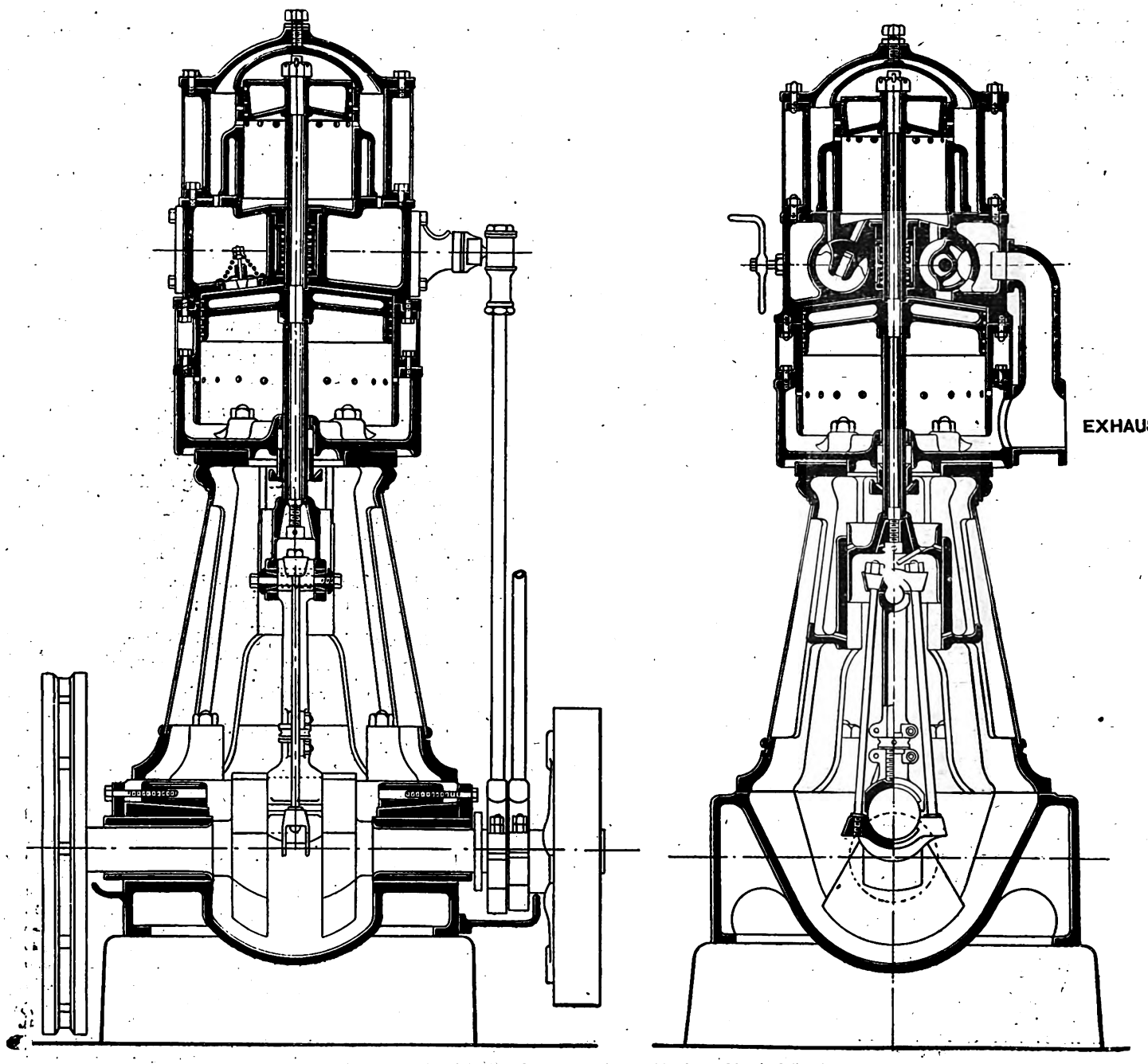

FIG. 1.—Raworth High Speed Enclosed Steam Engine. Vertical Sections.

Triple expansion engines are arranged with two pairs of cylinders and two cranks. The high-pressure and intermediate cylinders are placed in tandem over one crank, and two low-pressure cylinders are placed over the other crank. With this arrangement it is desirable to use a drain and steam trap from the intermediate receiver. Quadruple expansion engines are arranged with two pairs of cylinders and two cranks, each pair of cylinders being arranged and connected as described for the compound engine.

The cross-section of the compound form of engine on the centre line at right angles to the axis of the crank shaft (Fig. 1) shows only the port in the low-pressure valve between the high-pressure and the low-pressure cylinders. The port which communicates between the upper side of the low-pressure piston and the receiver

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is behind the parts shown in section. The valves are worked by two eccentric rods acting on levers attached to the valve spindles. The high-pressure eccentric is driven by a centrifugal shaft governor, which controls the cut-off from 0 to $\frac{3}{8}$ stroke: the low-pressure eccentric is fixed on the shaft and is set to cut off at about half stroke. Indicator diagrams in Fig. 2 show the action of the valves at full load, half load and zero load.

Lubrication is entirely automatic. The crank pin is lubricated by the oil bath in the base, while the joints and bearings of the valve levers and spindles, also the piston rod, guides and cross-head are lubricated by a small double-spur-wheel pump which takes oil from the crank pit and distributes it to the various joints and bearings. The cylinders are lubricated by means of a large displacement lubricator, which holds a month's supply of oil.

In the construction of this engine its truth, *i.e.*, the perfect alignment of the cylinders, crosshead, guide, and crankpin—is obtained throughout by machine work. The crank shaft is of

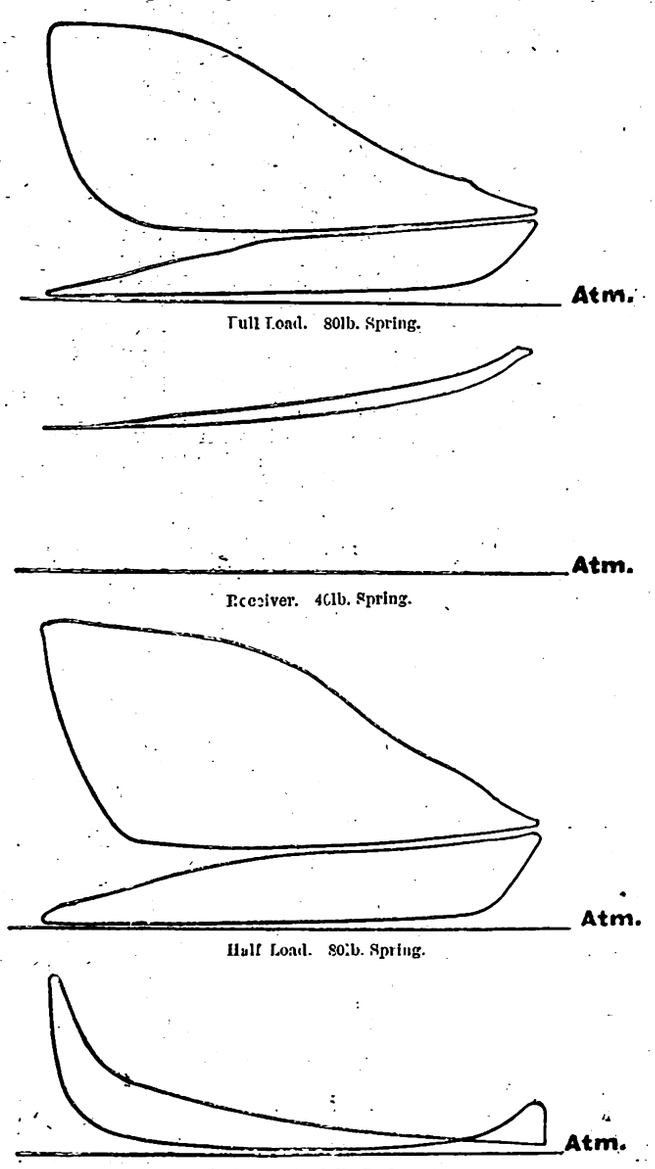

FIG. 2.—Raworth High Speed Enclosed Steam Engine. Indicator Diagrams.

Siemens-Martin steel, annealed after rough tooling, and balanced as far as practicable opposite the crank. The main bearings are fixed in solid seats in the baseplate casting, bored by a special machine which ensures absolute squareness with the centre line of the cylinders. Wedge pieces drawn up by external screws hold down the bearings. There is also an adjustment to take up end wear, should any occur.

The connecting rod is in two separate parts; an external frame transmits the pull on the up-stroke, and an internal strut takes the pressure of the down-stroke. The external frame is made of a fixed length, but the internal strut is provided with a powerful screw adjustment by which any slack can be readily taken up. This facility in taking up wear is designed to prevent knocking, and to render the running of the engine at all times quiet. When the engine is at work the adjusting screw is clamped tight, and is prevented from working loose. The cross-head pin is hollow, and is designed to be perfectly tight in work and yet quite loose for removal. This pin is a free fit in the hole in the cross-head, but the ends are bored conical and split. To fix the pin the two cone plugs are drawn up tight by the bolt, and thus expand the pin in the bearing holes. The attachment of the piston rod is such that the piston-rod can always be drawn out from above. The end of the piston-rod is screwed and fitted with a conical nut in halves. To get the rod out it is only necessary to unscrew the top nut and let the rod down a few inches, when the lower nut falls off, and the rod can then be lifted. The bottom gland is forced into position by a loose frame which will not put any cross-wind on the gland, however irregularly it may be screwed up. By being brought nearer to the outside of the engine the bolts are also made more accessible.

The high-pressure valve is of the ordinary Corliss type, and the low-pressure valve is similar, but more nearly resembles a Wheelock valve. Both patterns have been proved, by many years' experience in hundreds of other engines, to work well, with very little wear. Trip gear is not used, on account of the high speed, but the shaft governor cut-off gives even better results, as it throttles the steam at very light loads, giving thereby, according to Willans' law, the conditions of maximum efficiency. The practical results are in exact accord with the theory.

The high-pressure valve admits live steam to the high-pressure cylinder, and cuts off under the action of the automatic shaft governor. It also admits steam directly to the receiver when the

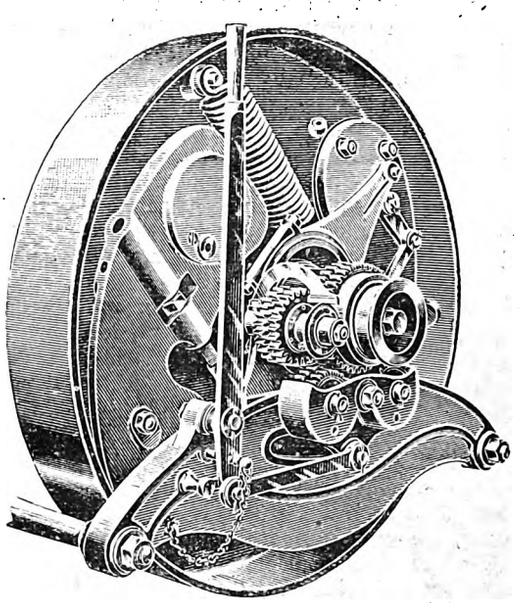

FIG. 3.—Raworth High Speed Enclosed Steam Engine. Governor and Speeder Gear.

engine is standing or running at slow speed. The receiver port is very small and narrow, and is only open in the extreme position of the valve. At full speed the governor reduces the travel of the valve, thereby shutting off the supply to the receiver.

One of the features claimed to be best in this engine is the eccentric rod joint, which is of simple construction and easy to set up. The pin is spherical, and the end of the rod is fitted with two cylindrical white-metal pads with hollow spherical faces, which grasp the pin, and are set up by the large screw cap. Excess of oil passes down hollow eccentric rods to the eccentrics, and thence to the crank chamber.

The governor (Fig. 3) is in principle an ordinary crank-shaft automatic cut-off governor; but it has many improvements in detail. It has only six parts, viz., the wheel, the banjo, two weighted arms and two springs. The springs are fitted with an adjustment which enables the user to alter the range of total variation in speed from $\frac{1}{2}$ per cent. to about 5 per cent.

Its action is at light loads to combine the effect of throttling with that of expansion. Fig. 3 shows one of Raworth's speeder gears attached to the governor, this gear enabling the speed to be varied while the engine is running.

Electric Lighting of Railway Carriages in Italy.—Accumulator-charging stations are about to be established by the authorities of the Rete Mediterranea Railways in Italy, at Milan, Rome and Turin, for the charging of the accumulators used in connection with the electric lighting of the railway carriages.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February 28, 1896.*

Röntgen Rays.—Notwithstanding the great amount of experimenting that has been done with Röntgen rays in the numerous college laboratories of this country, but few valuable contributions to the subject have resulted. Mr. O. B. Shallenberger, of the Westinghouse Company, has succeeded in taking perhaps the best radiagraphs yet made on this side of the water. He uses Teslaic apparatus, or an arrangement giving a voltage of about 250,000 volts and an enormous frequency, the latter being obtained by means of a series of disruptive discharges in circuit. But one electrode is led to the Crookes tube, the second one being connected to a disc suspended a considerable distance above the tube and vertically over the plate holder; the latter is 6in. or 8in. below the tube. With this arrangement radiagraphs taken of the hand and of small animals have the details extremely well defined. In radiagraphs of the hand, for example, the bones and sockets have the appearance of being shaded, and seem to be rather photographs by reflected light than shadows. One of the greatest advantages of this type of apparatus is that there is little if any danger to the vacuum tube, while in many of our college laboratories the stock of such tubes was quickly exhausted through breakages on account of heated electrodes. In the investigation carried on by Mr. Shallenberger it has been found that almost equally good results are obtained with either pole connected to the tube. The best results have been obtained with an exposure of 21min. Prof. Woodward, of Harvard University, has obtained some excellent radiagraphs by means of an aluminum vacuum chamber, or ray lamp. The ray lamp consists of a spun aluminum cone, with a glass base and a glass tube for exhaustion at the apex. With this ray lamp it is reported that almost instantaneous radiagraphs have been taken. Notwithstanding the attempts that have been made to properly exhaust vacuum tubes in this country, at the college laboratories and elsewhere, it is but recently that one firm, the Western Electric Company, has been able to make tubes equal to the imported Crookes or Hittorf tubes.

Electric Elevators.—The February meeting of the American Institute of Electrical Engineers, on Wednesday, was given up to the discussion of the Paper of Mr. Frank J. Sprague on "Electric Elevators," read at the January meeting (see *The Electrician*, February 14, p. 513). While some useful data was brought out, the discussion consisted of but little more than the presentation of commercial claims. The hydraulic elevator people apparently considered that the prominence which would be given to electric elevators by the Paper threatened their business, and, therefore, this interest put forth every effort to prevent its being thereby placed at a commercial disadvantage. The question of the character of the Papers to be read before the Institute is one which has given rise to much discussion among members, and it seems little likely to receive any definite answer. The December meeting was allowed to lapse on account of the rejection of a Paper thought to be too mathematical in character, and at the January meeting the other extreme was reached by the presentation of a Paper largely commercial in its bearing. The problem as to the criteria to be applied to Papers read before professional bodies is, however, probably not one confined to this country.

Massachusetts Central Stations—From an advance report of the Board of Gas and Electric Light Commissioners of the State of Massachusetts, we learn that the profits during the last fiscal year of the 83 central stations of that State amounted to $1,280,000. After paying dividends of $487,000 interest, and charging off for depreciation and sundry items, there was a net deficit of $182,000. The year before there was a surplus on this basis of $51,000. Six of the companies did not earn expenses, and 33 others did not earn sufficient to warrant the declaration of any dividend. Of the $487,000 dividends declared, $300,000 was paid by two companies in Boston, and of the companies that paid the highest dividends almost every one was in the larger cities of the State. The smaller companies either paid no dividends or very small percentages.

CORRESPONDENCE.

ALTERNATING AND CONTINUOUS-CURRENT ARCS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit me to correct a slip which the reporter of the Physical Society made in abstracting very briefly the Paper communicated to the Physical Society by me and Mr. Petavel on the 28th ult. In the last sentence of the abstract it is stated that "lowering the frequency decreases the efficiency of the alternating-current arc." A reference to our Paper will show that we made no such statement. What we did say was that lowering the frequency *increases* the efficiency of the alternating-current arc. A perusal of your editorial comments on the discussion leads me to believe that you had not the advantage of having the full Paper before you in writing them. It would otherwise have been evident to you that some of the objections raised, and which you adopt, are answered by the facts in the Paper. The second part of our investigations consisted in comparing the mean spherical candle-power of two arcs, each supplied with the *same* carbons and the same power, but one in an alternating and the other in a continuous form. The alternating current arcs were always formed with 15 amperes. *Important* variables were not left to take care of themselves. It forms no valid criticism to suggest that, having definitely limited the conditions of the problem for certain reasons, we ought to have done something entirely different. The question of the existence or non-existence of a carbon with the port-wine like character of self-improvement under disuse has no bearing whatever on the question at issue. The comparison of two incandescent lamps, irrespective of voltage and supplied with equal power in the two forms, is quite misleading, seeing that the question of "life" must enter into any useful comparison of incandescent lamps, and there is no such question in the case of the arcs. That which remains to be done is to extend our observations to the case of different currents. That is, to compare the mean spherical candle power of alternating-current arcs taking the same mean power, but formed with different currents, and ascertain whether in selecting 15 amperes we have in any cases taken a current which is not that which for the selected wattage gives the greatest mean spherical candle-power. Whatever may be the result, it is perfectly clear that the alternating-current arc has a long leeway to make up before it can rival its continuous-current brother, even if aided by a carbon which secretly and specially prepares itself for alternating-current work.—Yours, &c.,

J. A. FLEMING.

X-RAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Dr. McKay, of the Packer Institute, Brooklyn, Me. tested my idea, termed a scheme in the *Electrical Engineer* of New York, as to the possibility of exposing upon a fluorescent screen the shadows of invisible objects in motion. We saw, in what is conveniently termed a kinetoskotoscope, the motion of the bones of the fingers when bent backward and forward, the shadow of the rest of the finger being faint. The result was so successful that I noticed a curious feature which was not known to me before, and that is that the bones appear in a side view to be at the back of the finger, and very thin measured from the back to the front. There is a reason for this, I suppose, in that the inner side of the finger should be more like a cushion, so as to be better able to handle objects. An experiment was also performed, consisting in opening and closing a pair of pincers which were absolutely invisible to the eye; but the shadow of the moving parts was clearly visible upon the screen. A chain was shaken back and forth, and the separate links moving relatively to each other were clearly visible. These experiments would prove that with the present condition of the X-rays the skeleton of a fish could be seen to move backward and forward in the act of swimming, as well as the skeletons of all small objects while in motion and performing the functions of life. I think that some of the best objects to be looked at while in motion would be, for

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instance, a bird, through which the rays would so easily pass except as to the skeleton. All youthful forms of life could be examined, very probably, by this means, and the motions exhibited.

I have for two or three weeks been trying different kinds of experiments, &c., and I find that certain precautions are necessary in order to obtain the best results. In the first place, it is necessary, very probably, to show just how I made my fluorescent screen, because I find that others have tried to make it by crystallising the chemical barium-platino-cyanide from a solution upon a sheet of paper. Others merely pressed the crystals upon a surface like filter paper. Such screens are of little value, especially as the substance then fluoreses blue, which is nearly invisible, and only so in spots. By the following means, the results are so excellent and the screen is so luminous that the shadows are clearer than in the X-ray photographs. The cyanide should be powdered to the finest dust possible. Then some of the clearest colourless varnish should be put upon a piece of tracing cloth, because the same is so strong, and so transparent to the fluorescent light which is produced. The powder may now be mixed very thoroughly and intimately with the varnish, so as to make a homogeneous mass, in quantity sufficient to spread over the cloth to a thickness of about one-eighth of an inch. This is mentioned because experimenters are likely to make the layer too thin. The reason for powdering the material is to produce a maximum amount of reflecting surface. The object of the varnish is to hold it together and yet permit the reflected rays of fluorescent light to become visible. The varnish should then be dried, but not necessarily perfectly dried. These directions should be followed very closely for good results. The end of the tube which is directed towards the Crookes' tube, and which contains the screen, should be covered with photographer's black paper used for wrapping up sensitive plates. Either side of the screen may be directed towards the Crookes' tube. A very important precaution is to perform the experiments in a rather dark room. It may be light enough to be able to see objects, but if the room is very light the eyes are not used to darkness, and therefore the experiments are not satisfactory, but if the room is quite dark the screen in the closed tube appears, immediately upon putting the eye to the hole in the tube, to be perfectly luminous. It will be more luminous under these precautions than luminous paint which has been held in the sunlight and brought into a dark room, and yet if performed where the eyes are exposed to the daylight the experiments are not so satisfactory. Another precaution is to have the electrical apparatus so arranged that the phosphorescent light from the Crookes' tube is steady, which may be done, of course, by means of Leyden jars or other condensers.

My idea of this new use for the X-rays was conceived and attested on February 1, 1896.—Yours, &c.,

EDWARD P. THOMPSON. M.E.

5, Beckman-street, New York, February 26th.

WATER POWER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Murray's report to the Worcester Corporation is certainly instructive, but I think your remarks thereon are calculated to unnecessarily alarm those who may be thinking of applying water-power to electric lighting. That great care must be taken to calculate the amount of power available at the minimum flow is quite certain, and it must also be considered how far the coal saving will warrant the double capital expenditure, and the more so as hydraulic works are usually very costly, though the maintenance should be small. At the same time it is hardly fair to consider only one year. Although water has proved insufficient last season, there may be much more than enough for the day load in the coming season. Last year was exceptionally bad; a dry summer following an exceptionally dry winter. Some system of storage is no doubt desirable, and it can be carried out at a reasonable cost in hilly country by the system of hydraulic storage of power to the study of which I have devoted a considerable amount of time, and have concluded generally that where the nature of the ground admits of a reservoir being constructed not more than one mile from the generating station, and where the reservoir site is not less than 200ft. above the site of the generating station, then this system will pay, if coal costs not less than 18s. per ton and is of fair quality. I am, of course, assuming that the pipe line is in duplicate, and all materials and construction of the best. I think that this system has not been sufficiently considered in this country.—Yours, &c.,

GEO. T. PARDOE.

81, Harrow-road, W., March 9, 1896.

LEGAL INTELLIGENCE.

Fowler v. The Chelsea Electricity Supply Company and Sandon v. same.

In the Chancery Division on Friday Mr. Justice North again heard these actions. The plaintiffs are the landlord and some tenants of residential flats in Cadogan-gardens. They complained that the works of the defendant Company have caused annoyance and nuisance to them, and his Lordship granted a restraining injunction suspending its operation for a certain period. The defendants now asked for suspension for a further period.

Mr. WARMINGTON, Q.C., for the plaintiff Sandon, said his client was unable to get an inspection by electrical experts.

His LORDSHIP: Did I not give the plaintiffs some option to have some inspection.

Mr. WARMINGTON: Yes; and we are entitled under the order to inspect with an expert, but defendants claim the right to object, and that the matter should come before your Lordship to say whether the person whom we desire should inspect is a proper person or whether their objection is a good one. No definite objection is taken, but defendants think he is not a fit and proper person.

Mr. SMITH, for the defendant Company: We say that he is connected with a rival company, and that it is undesirable that he should be appointed.

His LORDSHIP said he thought he had given the plaintiffs the option to have some inspection by experts, and that if there was any difficulty he should appoint some person himself.

Mr. SMITH said the terms of the order were that the plaintiffs were at liberty to inspect by persons agreed upon by the plaintiffs and defendants, and in case of difference by some person appointed by the Judge. The defendants had suggested six persons—all persons of eminence—to all of whom the plaintiffs objected. The defendants were now perfectly willing that any independent person whom his Lordship should name should go and inspect the premises.

His LORDSHIP said he really did not appreciate the difficulty, as there must be plenty of persons competent in London to whom no objection could be made.

Mr. SMITH said that Mr. Birstall had already been on behalf of the plaintiffs, and he might go again.

Mr. WARMINGTON: Mr. Birstall is a surveyor; we want an electrical expert to go there. If the matter was before your Lordship for a quarter-of-an-hour, if a particular name was objected to, we could name another, and then we could get an order.

It was finally agreed that the plaintiffs should furnish a list of three or four persons, and the defendants would state their objections, if any, to one or other of the persons. The case to be heard on Monday.

Clarke v. Julius Sax & Co., Ltd.

In the Chancery Division on Friday Mr. SWINFEN EADY, Q.C., stated before Mr. Justice North that he had a motion to restrain the infringement of a registered design for an electric lamp of a particular shape. It was in respect of the same design as was before the Court the other day (see *The Electrician*, Feb. 14, p. 525). On that occasion he moved for an injunction to restrain the infringement of the registered design, and there was a cross motion to take the design off the register. His Lordship then refused both motions, and the result was that the registration of plaintiff's design was upheld, and it was held that the defendant had not infringed plaintiff's registered design. Now what the defendant had done was to exactly copy plaintiff's design.

Mr. VERNON SMITH, on behalf of the defendant, interposing, said he disputed that. His case was that there were substantial differences between the defendant's lamp and the plaintiff's.

Motion ordered to stand over for a week.

Charging for Electric Current.

Mr. Justice Romer, in the Chancery Division, on Monday last, had before him a summons (for leave to commence an action) in the matter of the House and Land Investment Trust (Limited).

Mr. BUCKLEY, Q.C., said that the Trust were the owners of property in Whitehall-court, on the Thames Embankment, and the applicants were an electric lighting company which supplied the owners of the property with electric current. The question in dispute was as to how the Trust had to pay the company for the electric light, and the question arose under a contract of April 19, 1888. In April, 1888, the Whitehall Electric Supply Company, who were the predecessors in title of the Metropolitan Electric Supply Company (Limited), the present applicants, entered into an agreement with the Trust to supply them with electricity at a fixed

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charge per lamp, not exceeding the lowest price at which the Company should at any time, or during the lease—which was for 90½ years—charge for supplying electricity to any other person or company. The present claim was for £3,630. 5s. 8d. As a general rule the Company supplied current by meter, but they also had certain lamp contracts. He submitted that these lamp contracts had nothing to do with the matter, and that the question was which was the lowest charge per unit at which the applicant Company had supplied electricity to other consumers.

Mr. BRAMWELL DAVIS, Q.C., on behalf of the liquidators of the trust, submitted that they were entitled to take into account these lamp contracts, which would have the effect of very much reducing the sum due to the applicants.

His LORDSHIP said that it was agreed between the parties that the contract could not be carried out according to its strict letter; that as between the parties the arrangement was to supply electricity at per unit, and that the basis of the account should be the lowest rate per unit which the Company were supplying other consumers at, and he so decided. With regard to the rendering of accounts he thought that three months was a reasonable time, and that the charge should be per three months at the lowest rate which the Company charged per unit, and that should apply to the past as well as the future.

The exact figures due to the applicants were left to be worked out.

Jackson v. Coventry Electrical Engineering Company (Ltd.).

This case came before Mr, Justice North in the Chancery Division on Tuesday last, on a motion in a debenture-holder's action for the appointment of a receiver and manager of the assets of the Company. The Company consented to the motion. The reason for the application was that there were actions against the Company in which there were summonses for judgment which would be heard the following day. The Company had no defence, and judgment would then be signed and execution put in at once on the assets of the Company. The Company asked for the appointment of Mr. Pearson. The Court appointed Mr. Pearson as receiver and manager to act at once, his security to be completed forthwith.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d., abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations issued February 6th.

NEW BOOKS AND EDITIONS.

The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices:—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

'THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.), Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue Dr. Gore's book is now ready, price 10s. 6d. post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables. 30s., post free.

TENDERS INVITED.—The Corporation of Bradford invite tenders for batteries, surface condensing plant, cables, travelling crane and steam and exhaust pipes. Forms of tender and specifications may be obtained from the Electricity Office, and tenders, addressed to the Chairman of the Gas and Electricity Committee, must be delivered at the office of the Town Clerk (Mr. W. T. McGowen), Town Hall, Bradford, by the 26th inst. Further particulars appear in our advertisement columns.

——— The Edinburgh Corporation require tenders for the wiring of the City Chambers. Specifications, &c., can be obtained at the office of the resident electrical engineer, 5, Dewar-place, Edinburgh, and tenders must be sent in to the Town Clerk, Mr. Thomas Hunter, W.S, not later than 10 a.m., on the 28th inst. Further particulars will be found in our advertisement columns.

——— The Edinburgh Municipal and Police Departments require tenders for a large variety of articles, including cast-iron lamp-posts and lamp-bases, lamp globes and electric lighting materials for the Powderhall destructor.

——— The Electric Light Committee of the Bedford Corporation invite tenders for the supply and erection of one 240 B.H.P. double-acting compound enclosed engine, and one 150-unit alternator with stationary armature. Tenders must be sent in to the Clerk to the Urban Sanitary Authority (Mr. T. S. Porter) by April 4th. Further particulars are given in our advertisement columns.

——— Estimates are required by the Guardians of the Kingston Union for providing electrical communication between the workhouse premises and the headquarters of the Kingston and Surbiton Fire Brigade; also for telephonic communication between the workhouse, police station, fire station, union offices, medical officer, &c. Tenders have to be in not later than March 21st, to Mr. James Edgell, Union Offices, Portsmouth-road, Kingston-on-Thames. Some additional information is given in our advertisement columns.

——— The Municipal Authorities of Prague invite tenders for the erection and equipment of a municipal electricity generating station, for electric lighting, power and tramway traction purposes. Tenders to the Stadtrath, Prague, Austria, by June 1st.

——— The Altona Direction of the Prussian State Railways require tenders for the supply of 93,000 arc lamp carbons and 1,600 incandescent lamps. Tenders to the Königliche Eisenbahn Direction, Central Bureau (Verwaltungs-Gebäude), Altona, by the 20th inst.

——— The Wallasey District Council invite tenders for the supply of electric light machinery and apparatus. Tenders in to the Clerk, Public Offices, Egremont, Cheshire, by Monday, April 6th.

——— The French Telegraphs Department require tenders for a multiple switchboard for the Exchange in the Rue Chaudron, Paris. Tenders have to be in by the 17th, to the Direction Générale des Postes et des Telegraphes, 183, Rue de Grenelle, Paris.

——— The Visitors' Committee of the Lancaster County Lunatic Asylum invite tenders for the supply of electrical sundries, steam fittings, belting, india-rubber goods, &c., for the twelve months ending April 5, 1897. Tenders to the Chairman of the Committee by 20th inst.

TENDERS ACCEPTED.—The Electric Lighting Committee of the Belfast Corporation have accepted the tender of Messrs. Kerr, Stuart and Co. for the supply and erection of a compressed air engine starter for their electricity works.

——— The tender of the Keighly Electrical Engineering Company has been accepted by the Keighley Town Council for fitting up telephones at the Hospital buildings.

——— The tender of Messrs. John Brown and Co., of Sheffield, has been accepted by the Bradford Town Council for supplying and fixing two steam boilers at the Valley-road electricity works for the sum of £3,000.

——— The Baths and Washhouses Committee of the Portsmouth Corporation has decided to accept the tender of Mr. Grossmith for wiring the Public Baths for the electric light.

——— The Corporation of Durban has accepted the tenders of Messrs. Macfarlane and Co. for the supply of 60 arc lamp columns and of Messrs. D. Y. Stewart and Co. for six miles of 3in. and 4in. cast-iron electric mains for their electric light works.

——— The Buckingham Town Council have renewed the contract for the electric lighting of a portion of the town by Messrs. Gillies and Hornidge. The terms are similar to those of last year.

——— The tender of Mr. J. Jarvis has been accepted by the Tunbridge Wells Town Council for the extension of the electricity supply station buildings for £1,356.

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TENDERS RECEIVED.—The following tenders have been received for wiring and fitting up for the electric light the new St. Marylebone Public Baths and Washhouse :—

F. A. Donnison and Co.	£2,050	0	0
Frank Suter and Co.	1,950	5	4
Harry South	1,950	0	0
Roger Dawson (Limited)	1,681	3	7
A. Emanuel and Sons (Limited)	1,666	0	0
Strode and Co.	1,633	10	5
L. Alwyn	1,422	0	0

APPOINTMENT.—The Plymouth Town Council have appointed Mr. J. H. Rider borough electrical engineer, at a salary of £300 per annum. There were 40 applicants for the position, but this number was reduced to five by the Electric Lighting Committee. Mr. Rider, who was born at Bristol in 1864, was apprenticed to Messrs. Paterson and Cooper in 1883. In 1887 he was engaged as an electrical engineer by Messrs. Blakey, Emmott and Co., and was appointed borough electrical engineer of Bolton in 1893, which position he has held to the present time.

——— It has been unanimously decided by the Electric Lighting Committee of the Edinburgh Town Council to recommend the appointment of Prof. A. B. W. Kennedy to the post of permanent consulting electrical engineer to the Corporation at a remuneration of £200 per annum. Prof. Kennedy will advise the Corporation on all points in connection with its electric supply system. Seventy applications have been received for the post of resident electrical engineer in succession to Mr. E. W. Monkhouse, which have been reduced to six, and these are under consideration by Prof. Kennedy, who will finally recommend the most suitable applicant.

TRUST DEED.—A trust deed has been executed by Mr. P. B. Steele, trading as an electrical engineer under the style of P. B. Steele and Co., 43, Commercial-street, Dundee. Mr. J. Mess, C.A., and Messrs. Johnstone and Kilgour are acting as agents.

LIQUIDATION.—Creditors of Froggatt's Electric Lighting Company (Limited) are requested to send in particulars of their claims to the liquidator (Mr. W. P. Eldrid), 11, Old Jewry Chambers, E.C., on or before the 23rd inst.

——— A meeting is to be held at 7, North-street, Sheffield, on April 7th, at 2 p.m., for the purpose of receiving an account of the winding-up of F. Marten Hale and Co. (Limited), telegraph apparatus manufacturers.

BANKRUPTCY. — A receiving order has been made against W. Northcote and Co., described as now or late of New Cross-road, London, S.E., inventors and electricians.

——— The public examination of Charles Frederick Fox, described as an "electrical engineer," Halifax, took place at the County Court on Monday last. The liabilities amounted to £544; assets, £349. The debtor stated that up to November last he was a tobacconist. He had commenced business in 1893 with a capital of £30, and he did fairly well out of it; but as he did not like close confinement in a shop he started as an electrical engineer! He had lost over £100 by a contract for electrical work at Rishworth. Examination closed.

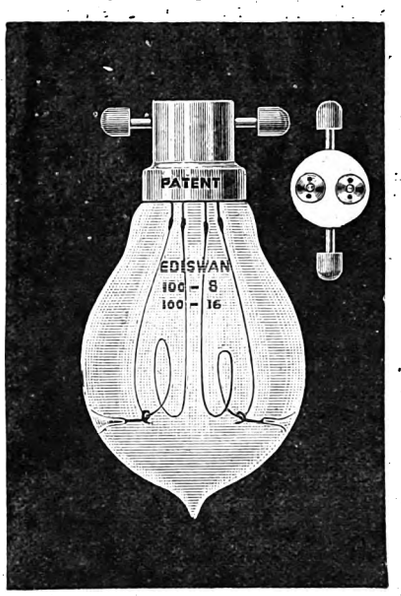
PRESSURE REGULATORS.—We are informed that Messrs. W. H Bailey and Co. (Limited), of Salford, Manchester, have been appointed by the Foster Engineering Company, of Newark, N.J., U.S.A., licensed manufacturers for Great Britain of the well-known Foster pressure regulators.

MACHINERY AND APPARATUS FOR DISPOSAL.—A quantity of first-class engines, boilers, machines, and telegraph and telephone stores are advertised for disposal in this issue, for which offers are invited by "Kent."

LESSING CARBONS.—Dr. Lessing has recently invented special machinery for manufacturing carbons for electrolysis, and at extensive works, lately erected, plates are manufactured up to 60in. in length and tubes of 55in. of 6in. diameter. The plates are described as of exceptional hardness and conductivity, and have been adopted by many manufacturers engaged in electric furnace and heavy electrolytic work. The agents in this country are Messrs. Krupka and Jacoby, 15, Queen-street, Cheapside, E.C., whose catalogue (Section 1), giving prices and particulars of arc lamp carbons, battery blocks, agglomerate blocks, &c., is now ready.

LAMPHOLDER SWITCH.—Munro's Electrical Manufacturing Company (Limited) send us particulars of a new lampholder switch called the "Empress." Make and break contact is effected by means of one of the plungers used in the ordinary lampholder, which by a simple arrangement is made to turn each time it makes or breaks, thus ensuring a good rubbing action. The working parts of the switch are entirely enclosed in the porcelain cover, and are not liable to damage when being wired, the wires passing through two separate holes entirely apart from the movement. Half the contact part of the switch is renewed each time the lamp is renewed. This form of lampholder switch can be used on a light ornamental fitting where the ordinary lampholder switch would look out of place.

ELECTRIC LAMPS AND ELECTRIC LAMP SWITCHES.—The illustration herewith shows a new design of lamp switch recently introduced by the Edison and Swan Company for regulating incandescent lamps. As will be seen, the movement consists of a sliding bar which puts the switch into action. The switch is used with a lamp (also comparatively new) supplied with two filament, one of 8 c.p. and one of 16 c.p. By means of the switch this lamp can be used as an 8 c.p., 16 c.p., or 24 c.p. lamp, or can be switched off entirely. The switch in the illustration is fixed in the cap of the lamp, but it is adaptable to any incandescent installation without alteration to either fitting or holder. The lamp and switch have obvious advan-



tages, and in working the switching arrangement is extremely simple. It will be seen that all necessary care has been taken to prevent the filaments approaching each other.

CATALOGUE.—A pamphlet of handy size has been brought out by Messrs. Mosses and Mitchell, setting forth the merits and prices of vulcanised fibre. The two qualities of this material, "hard" and "flexible," are used for a great number of purposes in machine construction and the engineering arts. Messrs. Mosses and Mitchell not only supply the vulcanised fibre in sheets, rods, &c., for working up, but they also undertake the manufacture of it in any practicable finished shape. This material has now been upon the market for 20 years.

EXPORTS OF TELEGRAPH WIRE AND APPARATUS.—The value of the exports of telegraphic wire and apparatus during the past month amounted to £109,840. The figures for the preceding month and the corresponding month of last year were £57,224 and £9,411 respectively. The value of the exports for the months of January and February amounted to £167,064, against £44,604 in the corresponding period of 1895.

THE "JOURNAL."—Part 120 of the *Journal* of the Institution of Electrical Engineers is now ready, price 2s. 6d., and can be obtained of the publishers, Messrs. E. and F. N. Spon, 125, Strand, W.C. This issue contains the inaugural address of Dr. John Hopkinson, and the first part of the discussion on the wiring papers recently read before the Institution, a Paper by Mr. G. W. D. Ricks on "Electricity Supply Meters," a communication by Mr. Desmond G. FitzGerald, and a classified list of articles on electricity and magnetism appearing in the principal technical journals during the month.

THE "ENGINEERING MAGAZINE."—The March issue of this excellent magazine contains a number of interesting articles. The subjects dealt with cover a wide range, and the illustrations and plates are of the usual high character. The subjects dealt with include—"The Money Question and Constructive Enterprise," by John R. Dunlap (Editor); "The Scotch System of Branch Banks," by J. Selwin Tait; "Prof. Röntgen's Discovery of a New Radiance," by Dr. M. I. Pupin; "The Railroad Facilities of Suburban New York," by Foster Crowell; "Standpipes for Fire Protection and Street Flushing," by L. L. Tribus; "Artistic Engine-room Interiors," by E. T. Adams; "Lighting Residences by Electricity," by A. Noll; "The Architecture of Modern Bank Buildings," by R. W. Gibson; "Prospecting with the Diamond Drill," by J. Parke Channing, and "Practical Assaying at Mines and Works," by H. Van F. Furman. The usual exhaustive review of the World's Technical Press is also given. This number, as well as all the back numbers, may be obtained at the offices of the European edition, 1, 2 and 3, Salisbury-court, Fleet-street, London, E.C.

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THE FAR EAST.—Under the title of "Future Trade in the Far East," Messrs. Whittaker and Co. have in the press a work by C. C. Wakefield, F.R.G.S., who has had special opportunities for obtaining information from personal observation. The book will deal solely with commercial matters, is fully illustrated, and will contain a new and important map showing the latest developments in the trade routes, particular attention being given to the Trans-Siberian railway now in progress.

PRICE LISTS.—Messrs. Johnson and Phillips forward an additional page, forming part of their cable list No. 6, giving particulars and prices of vulcanised rubber-covered cables and wires (up to 19/18), taped only; also a new sheet of prices and particulars of Prof. Perry's patent electricity supply meters for continuous current, of which Messrs. Johnson and Phillips are the sole manufacturers.

"CASSIER'S MAGAZINE."—The contents of the March number of this magazine include "The Development of Electric Power Stations," "Protection of Electrical Apparatus against Lightning," "Some Recent Departures in Steam Engine Piston Construction," "Modern Shipbuilding Tools," "The Evolution of the Fittest Education," "New Power Developments at Niagara Falls," and "The Expert Engineer." The frontispiece is a portrait of Lord Armstrong, C.B.

ASHTON-UNDER-LYNE.—The Town Council have decided to consent to the application of the promoters of the Oldham, Ashton-under-Lyne, Hyde and District Electric Tramways, for a Provisional Order authorising the incorporation of a company, and the construction and maintenance of tramways, as set out in the Order.

BRADFORD.—At the meeting of the Town Council on Tuesday the minutes of the Gas and Electricity Committee contained reports upon negotiations with the Bradford Guardians as to lighting the whole of the workhouse buildings by electricity. The Committee also recommended that the electrical engineer be empowered to proceed with the necessary alterations at the Bolton-road electricity station for the purpose of adapting the works to the increased pressure caused by the change from the two to the three-wire system, and that the Committee be authorised to invite tenders for plant for the new electricity works and to extend the area of the Corporation's electrical supply. Mr. W. C. Dixon, the chairman of the Committee, moved the confirmation of the minutes, and said that the Electricity Department was making more satisfactory progress than was at first anticipated. The establishment of the three-wire system was rapidly approaching completion, and the greater part of the Borough, if not all of it, would shortly be put upon the 230-volt basis. In 1895 the Committee had sold 373,372 units of current, against 307,977 in 1894, an increase of 65,395 units, and the demand was still increasing. The Committee had at the present station a total H.P. of 2,210, and this power was often taxed to its utmost capacity. After paying interest and sinking fund charges and allowing for depreciation, there was a profit on the past year's working of £1,792. 19s. 1d,, against £918. 10s. 5d, in 1894, an increase of £874. 8s. 8d. After a brief discussion the minutes were adopted.

BRIDGEND.—Mr. J. C. Howell has offered to take over the Council's Provisional Electric Lighting Order, and to put down an installation for public and private lighting. The matter is to be considered at a special meeting of the Council on Monday next.

BRIGHTON.—At the last meeting of the Town Council the Lighting Committee reported that they had decided to erect 15 arc lamps in Upper St. James's-street,, St. George's-road and Chesham-road, and 15 in Lewes-road and Richmond-terrace. The Committee have also decided to extend the electric light mains to Edburton-road at a cost of £165. The Town Clerk has been instructed to appeal against the assessment of the electricity works. The accounts of the department for the year ended December 31, 1895, were submitted. The total expenditure amounted to £9,561. 0s. 8d., and the revenue (including £1. 10s. 3d. from last year) to £18,575. 3s. 8d., a gross profit of £9,014. 3s. The net revenue account showed that £1,404. 1s. 9d. had been applied to local rates and £3,000 paid to reserve fund, and, after payment of interest and sinking fund appropriations, a balance of £1,150 was carried forward. The Committee also resolved that the sum of £2,000 be transferred to the district fund account. In moving the adoption of the Committee's report, Councillor Stafford stated that the net profit for the year amounted to £1,150, but he wished it to be understood that the Council must add to that sum £4,148 paid over to the sinking fund. That left, after paying interest on money borrowed, a net profit of £5,298. He had anticipated that the profit for 1895 would not be anything like it was in 1894, owing to the lowering of the price of current. The policy of the Committee had been to make the light available for the masses, and their efforts had been successful. The receipts from private customers for 1895 were £16,177, and for street lighting only £860. They were not depending on trade lighting alone, although that would become a great acquisition during the present year. The total amount paid over to the sinking fund since the commencement of the supply was £9,330. They were aware that this was a purchasing fund, and at the end of a certain time the whole business would be purchased. The Committee were determined to pursue this policy so long as the Council would support them. He was able to state that up to that day the increase in the applications for lighting since the beginning of the present year was nearly 50 per cent., an increase nearly double that of any previous year. That showed that the policy of the Committee was a right one. The average number of units sold was 7½ per inhabitant, which was largely in excess of any other town. They had 53,000 lamps connected to their mains, but this did not include 600 lamps applied for at their last meeting, so that they were progressing by leaps and bounds. After a short debate, the report was adopted unanimously.

BURNLEY.—From the annual statement of the Finance Committee, which has just been presented to the Town Council, it would appear that the Council's electric lighting works are making excellent progress. The Committee estimate that the receipts from the department will realise £1,415 more than last year.

BURSLEM.—The Town Council have decided, on the recommendation of the Tramways Committee, not to oppose the Bill of the Potteries Extension Tramways Company. At the last meeting of the Council the Corporate seal was affixed to the amended agreement with the Company, and to an agreement with the North Staffordshire Tramways Company extending the power of the Council to purchase the Company's undertaking to 21 years from August 1st next.

CARDIFF.—All the requisite material was at hand at the last meeting of the Corporation for another petty squabble on the condition of the machinery at the electrical works, but matters were smoothed down by mutual concessions, and the minutes of the Committee finally agreed to. In the course of the discussion Mr. Carey, the Chairman of the Committee, stated that the Committee had made a great mistake in engaging four fitters at two guineas a week each, instead of three engine drivers and one practical fitter. The result of the Committee's appointment had been that each man had considered himself the equal of the other, and had made an independent report as to the condition of the machinery. Mr. Hallett, one of the most experienced engineers in the town, had now made a report which had been embodied in the minutes of the Committee.

CHELSEA (LONDON).—At the last meeting of the Vestry, the surveyor presented a report on the application of the Chelsea Electricity Supply Company for sanction to erect a generating station in Alpha-place. The report recommended that exception be taken to a portion of the scheme, as the Company proposed to erect a shaft lower than 20ft. from the centre of the roadway. It was decided to ask the County Council to withdraw its consent to this part of the application.

CHESTER.—At the meeting of the Town Council on Tuesday, the Mayor (Chairman of the Electric Lighting Committee) said that they were somewhat startled at the figure of the lowest tender for the erection of the buildings for the electric lighting machinery; but their consulting engineer, Prof. A. B. W. Kennedy, had advised them that it would be false economy to spend only £3,000 on the buildings. The building they now proposed to put up would be sufficient to triplicate the supply of electric current throughout the town, and would be sufficient for many years to come. They were advised that with an expenditure of about £5,000 more on plant also, they would be enabled to utilise the full output of the new building. The estimate for the machinery and the dynamos had also been increased, on the recommendation of Prof. Kennedy, by about £1,400, making the total amount for the machinery and plant about £15,600, against £14,200, the sum originally suggested. This increase was caused by the addition to the estimate of the arc lights for the streets, which would be a decided benefit. The total amount for the electric lighting scheme would now be within £22,000.

CHESTERTON.—The District Council recently invited the Cambridge Electric Light Company to tender for the public lighting of the district, but the Council have now received a letter the from Company stating that their powers do not extend beyond the borough of Cambridge, and consequently they could not send in a tender as requested.

COLLIERY LIGHTING.—The electric light is at present being installed at the Langwith Colliery. About 100 incandescents, varying from 16 to 50 c.p., will be employed. The contract is being executed by the Sheffield Electric Light and Power Company.

CORK.—Mr. W. W. Barrington held a Board of Trade inquiry last week at Cork in connection with the proposed construction of electric tramways in the city. Mr. Wm. Murphy, who is one of the promoters, gave particulars of the scheme, and said it was proposed to construct a tramway of 3ft. gauge and to equip the same electrically on the overhead trolley system.

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GARSTON.—The Town Council have written to the Liverpool District Lighting Company, who are promoting a Provisional Electric Lighting Order for the district, asking whether they would be prepared to reduce the maximum price of current to 8d., as in the case of Liverpool, and whether they would undertake to supply any part of the district when required by the Council. In the event of an affirmative reply being given, it is probable that the Council will consent to the Company's application for an Order.

GLASGOW.—At the meeting of the City Council on Friday last, the report of the Tramways Committee recommended that a sub-committee be appointed to visit various places on the Continent where electric traction is employed, for the purpose of collecting information for the guidance of the Committee in their efforts to find a suitable system of mechanical traction for the tramways under their control. The recommendation was adopted.

GOOLE.—It has been decided to light the docks electrically.

GREAT YARMOUTH.—The Town Council are considering the question of the extension of the electric light mains to the North Quay. The electricity accounts for February show that the receipts exceeded the working expenses by £80. 2s. 9d.; but after allowing for interest, sinking fund charges, &c., there was a deficit of over £19. At present there are 6,987 lamps connected.

GRIMSBY.—The Public Lighting Committee have presented a report on the electric lighting question. The Town Council obtained a Provisional Order in 1894, but nothing has been done to comply with its provisions, and the Committee now recommend that the matter be proceeded with. A Sub-Committee has been appointed to obtain further information and report to the Council.

HARROGATE.—The Local Government Board have conditionally sanctioned the borrowing of £27,000 by the Town Council for electric lighting purposes.

HASLINGDEN.—The Town Council have decided to apply for a Provisional Order.

HELENSBURGH.—At a recent meeting of the Police Commissioners the Lighting Committee recommended the erection of 17 additional gas lamps. Mr. Bryden said that instead of extending their present antiquated system, the Committee should rather be empowered to consider the question of the introduction of the electric light. The town was very favourably situated, as there was an abundance of water power available. Provost Whyte endorsed this view, and stated that he was making some inquiries into the matter, and as soon as he had received complete details he would bring the subject before the ratepayers. Mr. Bryden's suggestion was in the meantime agreed to.

KIDDERMINSTER AND STOURPORT ELECTRIC TRAMWAY.—The Great Western Railway Company have lodged a petition praying to be heard by counsel against this Bill when the committee stage is reached.

LECTURE.—A lecture on "Electricity in Connexion with Building" was delivered by Mr. W. H. Preece, C.B., on the 4th inst., at Carpenters' Hall, London. The lecturer stated that at the present time there was practically no difference between the cost of electric light and gas. The cost of the production of electricity was being reduced, and he thought the time was not very far distant when, comparing the ordinary burner with the electric lamp, it would be cheaper than gas.

LIVERPOOL.—The City Engineer has been authorised to conduct experiments with a view to enabling the electric light to be used in the sewers during repairs and other operations.

MARYLEBONE (LONDON).—At the meeting of the Vestry, on Friday last, the Chairman of the Electric Light Committee (Mr. Brooke Hitching) succeeded in inducing the members to try an experiment in electric lighting. It is proposed to light Upper Regent-street, from Oxford-circus to the Langham Hotel, by means of arc lamps, at an annual cost of £180. The present gas lamps, which cost £150 per annum, yield 850 c.p., but the Vestry will obtain 6,000 c.p. from the arc lamps.

MONIFIETH (DUNDEE).—A public meeting will shortly be held to discuss the lighting question. There is a feeling in favour of the introduction of the electric light.

MONMOUTH.—At the special meeting of the Town Council on Tuesday, a letter was read from the Board of Trade approving the scheme for the introduction of the electric light into the town.

MOTOR-CARRIAGE EXHIBITION.—An influential gathering was held at the Mansion House, London, on Friday last, in connection with the Exhibition of Horse and Horseless Carriages to be held at the Crystal Palace in May next. Amongst the speakers were Sir David Salomons, who pointed out the advantages to be expected from mechanically-propelled vehicles, and the advisability of keeping the matter out of the hands of company promoters. Amongst those taking part in the meeting were Dr. John Hopkinson, Prof. D. E. Hughes and Major Floodpage.

OBITUARY.—The death is announced of Mr. Wm. Henry Lefevre, C.E., President of the Balloon Society, who expired at his residence at Kensington on Friday last. Mr. Lefevre was born at Jersey, where his remains were conveyed on Monday last. He was president of the Balloon Society from 1880.

PAISLEY.—In anticipation of the establishment of municipal electric lighting works in Paisley, the Town Council have decided to wire the Town Hall for the electric light.

PORTSMOUTH.—The balance sheet of the Electric Lighting Committee for the year 1895 shows that the receipts exceeded the expenditure by £2,463. 14s. 6d., a sum sufficient to pay a dividend of 3¾ per cent. on the Council's capital outlay. It is stated that the demand for current is increasing in a most gratifying manner.

THE USE OF ELECTRICITY FOR THE AGEING OF WINES.—It is stated that Italian wine merchants have reason to congratulate themselves on the introduction of the electrical process for the ageing of wines which has been lately introduced in the wine-producing provinces of Italy. The process is said to render possible the most extraordinary modifications in the bouquet and body of the vintage, and it is probable that within a short period the process will be adopted in connection with Californian, and even with Australian, wines. Owing to the richness of the soil in which the grapes are grown, some such process of dealing with the product would, it is believed, prove advantageous.

WANDSWORTH (LONDON).—The County of London and Brush Provincial Company have notified the District Board of Works that they are advised that the Board has exceeded its powers in granting to a local tradesman the right to open the streets for the purpose of laying down electric light mains for supplying current. This is undoubtedly the stand that should have been taken at the outset. Having obtained a Provisional Order for lighting the district, the Company are surely entitled to the protection of the Local Authority.

WINDSOR.—The Corporation have decided to transfer their Provisional Electric Lighting Order to a local company, which has been formed for the purpose of lighting Windsor and Eton electrically.

WIMBLEDON.—The Local Government Board have intimated to the District Council that they could not entertain the proposal of the Board to borrow money for electric lighting purposes until they had obtained a renewal of their licence from the Board of Trade, and only then for the period for which the renewal would extend. The matter was discussed at the last meeting of the Council; some of the members favoured an immediate application for an extension of the licence, while others suggested waiting till November, when an application for a Provisional Order could be made. The Council have decided to adopt the latter proposal.

WORCESTER.—At the last meeting of the City Council the Electricity Committee presented an elaborate statement of the working and cost of the Council's electric lighting station during 1895. The total capital expenditure to the end of the year amounted to £52,225. 15s. 9d., the revenue to £3,254. 7s. 4d., while the year's working came to £3,057. 10s. 7d., leaving a profit of £196. 16s. 8d. A sum of £893. 6s. 9d. had to be set aside for interest and £952. 13s. 4d. for sinking fund purposes, in all £1,846. 0s. 1d., leaving a deficiency of £1,549. 3s. 5d. Accompanying the Committee's statement was the report of the city electrical engineer (Mr. E. T. Ruthven Murray), which was given in our last issue. Alderman Williamson moved that the accounts be passed. A long discussion followed, but eventually the motion was passed. The Council also decided to erect 20 arc lamps in various parts of the city as recommended in Mr. Murray's report.

BOOKS RECEIVED.

"Professional Papers of the Corps of Royal Engineers." 1895. Vol. XXI. Edited by Major C. B. Mayne, R.E., Chatham. (Messrs. W. and J. Mackay and Co. Price 10s. 6d.)

"James Clerk Maxwell and Modern Physics." By R. T. Glazebrook, F.R.S. (London: Cassell and Co.)

"Physical Units." By M. Maclean. (London: Messrs. Biggs and Co. Price 2s. 6d.)

"Alternating and Interrupted Electric Currents." By Prof. G. Forbes. (London: Messrs. Biggs and Co. Price 2s. 6d.)

"Griffin's Electrical Engineers' Price-Book." Second Edition. Edited by H. J. Dowsing. (London: Messrs. Charles Griffin and Co. Price 8s. 6d.)

"Electric Wiring." By Russell Robb. (London: Macmillan and Co. Price 10s.)

"*Journal* of the Institution of Electrical Engineers," No. 120, Vol. XXV. Edited by F. H. Webb. (London: E. and F. N. Spon.)

"Index to Vol. XXIV. of the *Journal* of the Institution of Electrical Engineers."

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COMPANIES' MEETINGS AND REPORTS.

City of Bath Electric Lighting and Engineering Company (Limited).

The fifth annual general meeting of this Company was held at Bath on Saturday. The Chairman (Mr. T. O. Callender) moved the adoption of the following report:—

During the year the gross profit amounted to £1,570. 8s. 3d., and a much more efficient service has been given to consumers. After payment of bank charges and mortgage and debenture interest, there remains a net profit of £1,131. 0s. 3d., to which must be added £388. 0s. 9d. brought forward from 1894. This sum would enable the Directors to pay 4 per cent. on the Ordinary share capital of the Company and to carry forward about £150, but it has been considered expedient to place the amount to reserve account, after the payment of the Directors' fees. During the year the Company's business has increased in a very satisfactory manner. The revenue from the sale of current and from installations, &c., has risen from £5,067 in 1894 to £6,152. A continuous supply of current has been kept up throughout the year, and the increase in the profit over 1894 has taken place notwithstanding that this additional supply involves a serious loss throughout the summer months. The number of lamps conected is 11,231, an increase of 2,904 compared with 1894. The existing station plant is now well loaded, and as soon as the question of the Provisional Order is settled the advisability of putting down plant for an additional 15,000 lamps will be considered. All the expenses of keeping the plant in good condition have been charged against revenue. The running of the plant has been most satisfactory, and it is now in the highest state of efficiency. In consequence of the opposition of the Local Authority to the Company's application for a Provisional Order, a Board of Trade inquiry was held in March last, with the result that the Board could not see its way to dispense with the consent of the Authority. Last November the Company again gave notice of its intention to apply for a Provisional Order, and the Local Authority also made application for an Order. At the invitation of the Board of Trade a conference has been held between the Company and the Authority, at which the appointment of an independent valuer by the Board of Trade to report on the value of the Company's property was proposed. This proposal has been agreed to by the Directors and the Bath authorities. The Directors hope this independent valuation may prove useful in bringing the two parties to an agreement.

The CHAIRMAN said that during the year they had supplied a good deal more electrical energy than in previous years, and their customers had increased in number. They had also made more profit, and there was a substantial amount to their credit on the year's operations, and under ordinary circumstances they would have declared a dividend, but in view of the special circumstances in which they stood it was deemed safer to carry the amount forward than divide it at present. During the last few months they had done better than ever before, and there was every prospect of a satisfactory future if they could only come to terms with the authorities. The Chairman then referred to the Company's application for a Provisional Order, and stated that Prof. Kennedy had been appointed to act as valuer, in accordance with the suggestion of the Board of Trade. It would be noticed that the first of the instructions which had been given to the valuer by the Board recognised what the Company had done, and pointed out that they were entitled to some consideration in respect of their work. He therefore believed they would be able to present a very good case when Prof. Kennedy came down.

Mr. VAN TROMP seconded the motion.

Mr. RUDDOCK then moved that a dividend of 3 per cent. be declared, but after a short discussion the amendment was rejected, and the retiring Director (Mr. Van Tromp) and the auditors were then re-elected.

Dover Electricity Supply Company (Limited).

The second annual meeting of the shareholders of this Company was held on Wednesday last at the offices, Park-street, Dover. Sir William Crundall, who presided, moved the adoption of the following report:—

The expenditure on capital account for the period under review amounted to £23,037. 19s. 8d., making, with the expenditure of the previous year, a total of £48,259. 1s. 6d. The revenue account shows a loss upon the first nine months' working. This was largely due to the fact that the six months of lightest consumption, viz., from April till September, when the load was also abnormally light owing to the limited number of lamps connected, are included; but in December the revenue about balanced expenditure, and the Directors believe that by the end of the current year the Company will be earning revenue in excess of working expenses. During the year the generating station has been completed, the plant and machinery installed in complete working order, and a continuous supply of current is now available throughout the whole of the main business streets and in a considerable portion of the residential districts.

In October last exhaustive tests were made by Profs. A. B. W. Kennedy and Silvanus P. Thompson of the whole of the machinery in the station, with gratifying results, the efficiency of the plant being found to be very satisfactory. The Directors, with a view to promote the extended adoption of the light, have reduced the price of current, as from January 1st last, to 7d. per unit up to 12 units per annum per 8 c.p. lamp for lighting, and to 5d. per unit for current used for lighting in excess of such consumption, as well as for heating and power purposes. At the end of the year there was an equivalent of 4,125 8 c.p. lamps connected. It is stated that the prospects of obtaining further connections in the present year are very encouraging; the Lord Warden Hotel is to be fitted up for the electric light, and current is to be taken from the Company's mains. The arc lamps on the sea front and in some of the main streets have given satisfaction, and the Corporation has ordered 10 more lamps for Snargate-street, which have been in use since the beginning of the present year. The Chairman said that the Directors had reason to be satisfied with the position of the Company, bearing in mind the fact that they had not yet been working for a year. At the present time they had the equivalent of about 5,000 8 c.p. lamps connected, with promises of support in various directions, including the Lord Warden Hotel. They hoped that the reduction in price which had been made would induce many of the townspeople to adopt the light. It brought the price of the current down to nearly the price of gas, and he thought that in view of the luxurious light given by electricity, and the freedom from damage to health and to decorations, it would be recognised as true economy to instal it. He next referred to the prospect of the construction of electric tramways in Dover. The Provisional Order would be obtained in the summer, and he thought the Council would be compelled to carry out their scheme at an early date. He believed that the Company would be able to offer inducements for the supply of the current, which it would be in the interests of the Council and the ratepayers to accept rather than to go to the expense of laying down costly plant of their own.

The report and accounts were then adopted, the retiring Directors and the auditors re-elected, and the proceedings terminated with a vote of thanks to the Chairman, Directors, and staff.

Oxford Electric Company (Limited).

The ordinary general meeting of the shareholders of this Company was held at the offices, 45, Broad-street, Oxford, on the 6th inst., under the presidency of Sir Henry C. Mance.

The CHAIRMAN, in moving the adoption of the report and accounts, said that the progress of the Company had been very satisfactory, and its prospects were most promising. The commercial efficiency of their system had steadily improved, being now about 70 per cent. The number of customers had increased during the year from 154 to 225, the more important additions to their list of customers being Balliol College, Somerville Hall, additional lights in Exeter College, and the important installations of Messrs. Elliston and Cavell, the new Municipal Buildings and the Corn Exchange. The system of supply to the public lamps has been almost entirely altered. All the half-night lamps are now connected in series. The additions to the circuit, and the change from one system to the other, were effected by the Managing Engineer, Mr. McLean, without the slightest interference to the service. The all-night arc lamps still remain connected with the low-tension mains. When the half-night lamps are suppressed, that is to say, about midnight, each arc is replaced by two incandescent lamps. He had every confidence that the new public lighting contract would give even greater satisfaction to the public than the old one. On January 1st they had an equivalent of about 15,000 8-c.p. lamps connected, and he had every reason to anticipate that the increase during 1896 would be quite as encouraging as during the past year. It was obvious, therefore, that the increased demand required that they should supplement their means of production with additional plant. Their engineer had now under careful consideration plans and estimates which were intended to provide for possible requirements during the next three years. For these extensions it would be necessary to provide additional capital. He asked the shareholders to approve of the distribution of 3½ per cent. on the Ordinary shares.

The motion was seconded and duly carried.

The retiring Directors, Mr. Alderman Buckell and Mr. L. A. Selby Bigge, were then re-elected, and a vote of thanks to the Chairman terminated the proceedings.

Barcelona Tramways Company (Limited).

At the ordinary general meeting of this Company, on Wednesday last, the CHAIRMAN (Mr. E. M. Underdown, Q.C.), in referring to the question of electric traction, said that he had received some letters from shareholders who took exception to the proposed increase in the capital of the Company for introducing electric traction on their lines, but he thought that they had not mastered the position thoroughly. The Directors had, after long study, extending over two or three years, and having made a close examination of tramways in other places, and having made studies of all the different systems and been in communication with all persons who are working, or desirous of working, this system, come to the conclusion that electric traction is absolutely necessary in a town like Barcelona. They had to provide for the enormous increase in the traffic which had to be carried in that city. People were more disposed to use their conveyances, as they were now more and more going to live in the suburbs, and had, therefore, to come every day to the city for business purposes. If they had to provide sufficient horses to meet the large amount of traffic either at particular hours of the day or on particular days, the benefit obtained from meeting those requirements would be frittered away, because the horses would be idle during the time the large traffic does not take place. In horse traction there was no elasticity which would enable them to meet the extra demands of a temporary character, and that is precisely what electric traction could do, and without any large extra expense it was possible to run the number of cars to accommodate the traffic which might come to the line. Under these circumstances, and having studied the question thoroughly, the directors had come to the conclusion that the introduction of electric traction would not only give an income amply sufficient to pay whatever interest they might decide to pay upon the capital which they proposed to raise for the purpose of introducing the system, but it would largely increase the income payable upon the Ordinary shares. Not only were they going to keep up their dividend, but to largely increase it. They had made every pre-

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paration to put themselves in a favourable position for introducing electric traction into Barcelona. They had acquired some additional land, and had made arrangements for acquiring other lands, with the object of being ready to carry out this work, and to consolidate their stables and depositories for their rolling stock and other matters in a more convenient way than at present. The Directors had, with some of the chief inhabitants and officials of Barcelona, visited Milan and Marseilles, in order to show to those gentlemen the working of electric tramways. That had given great satisfaction to the authorities, and the Directors were now asking for permission to introduce this system, and he believed that they would before long obtain the necessary authorisation.

Eastbourne Electric Light Company (Limited).

The report of the Directors of this Company, to be presented at the ordinary general meeting to be held on Monday next, states that there are 37 arcs and an equivalent of 14,206 8 c.p. incandescents in circuit, an increase of 2 arcs and 2,150 incandescents for the year. The gross profit amounted to £3,182. 2s., and after adding £400 to the depreciation fund, and paying Debenture and other interest, there remains a sum of £1,656 available for dividend. The Directors propose to add £300 to the reserve fund and to pay a dividend of £7. 10s. per cent. per annum, carrying forward £557. 5s.

A new boiler has been put in during the year, and the plant, mains and machinery of the Company are in excellent working order. The reserve for depreciation now amounts to £2,225.

The retiring Director is Mr. Harry Sutton, who offers himself for re-election, as do the auditors, Messrs. Hart Brothers, Tibbetts and Co.

Brush Electrical Engineering Company (Limited).

The Directors of this Company have issued an interim report for the half-year ended December 31st last, which states :—

The works have been fully employed on central station and other orders. No large contracts have been entered into, but the volume of smaller orders has been well maintained, and additional large contracts are in course of negotiation. The new type of direct-driven alternating plant has proved satisfactory, recent tests made by Profs. Kennedy and S. P. Thompson for the Dover Electricity Company having yielded very good results, both as regards the economy and efficiency of the machinery supplied by the Company. A specially favourable feature, to which attention is drawn, is that the machines remain practically cold after a prolonged run at full load.

Negotiations are proceeding for an amicable settlement of the Company's claim against the City of London Electric Lighting Company for plant supplied.

The Company's Austrian and Australasian branches are showing improved results. The development of electric traction is being actively pushed forward, and the Directors anticipate important orders from this source. The new high-speed engine designed by the Company's chief engineer has been fully developed and tested, and has given satisfactory results. Steps are now being taken to place it upon the market, and the Directors anticipate a large sale of these engines for general application, as well as for electrical purposes.

The Board are making efforts to institute and maintain economies in every department, and with this object the policy of concentration at the works at Loughborough is being consistently followed as opportunity arises, by expiration of leases or otherwise, for the disposal of the London premises. During the half-year the issue of £105,000 Four and a-Half per Cent. Redeemable Second Mortgage Debenture Stock, mentioned in the last report, has been offered to the shareholders, and £76,770 has been allotted. The balance is held in reserve for issue at a premium when necessary, but the Company's funds are ample for all present requirements.

The Directors state that they do not propose to declare an interim dividend, as they prefer to await the result of the complete financial year, which closes on June 30th.

NEW COMPANIES, STATUTORY RETURNS, &c.

BULLERS (LIMITED).—This Company was registered on March 4th, with a nominal capital of £100,000, divided into 10,000 Preference and a like number of Ordinary shares of £5 each, to acquire and take over as a going concern the business carried on by a company of the same name, with a view to such acquisition, to enter into and carry into effect an agreement to be made with the said old company, and to carry on the business of engineers and contractors, whether manufacturing, mechanical, electrical, telegraphic or otherwise, and iron and brass founders and workers, and to manufacture, produce, sell, let on hire and generally deal in electrical plant, electricity, electric power and other forms of energy. The subscribers are :—Messrs. Howard C. Jobson, Summer Hill, Kidderminster, engineer ; John T. Harris, Radford, Stone, engineer ; Edward J. Chambers, Castle Cottage, Dudley, engineer ; E. Percy Jobson, W. Greenhill, T. R. Griffiths, and H. C. Pinsent. The first Directors are Messrs. Howard C. Jobson, John T. Harris, Arthur K. Tharp and Edward J. Chambers.

CANUTE SYNDICATE (LIMITED).—This Company was registered on March 3rd, with a nominal capital of £1,500, in £1 shares, to acquire any patents, patent rights, concessions, or other rights, to use any invention relating to the utilisation of substances suitable for the manufacture of electrical fittings and appliances, and to use, develop and otherwise turn to account the same, and to manufacture, sell and deal in goods and articles made in accordance with such inventions.

HOLOPHANE (LIMITED).—During the week this Company, which has been formed for the purpose of acquiring the patent rights for all countries (except France and the United States) of Messrs. Blondel and Psaroudaki, inventors and patentees of the "Holophane" Globe, invited subscriptions for 65,000 £1 shares.

WILLIAMSON AND JOSEPH (LIMITED).—This Company was registered on March 9th, with a nominal capital of £10,000, divided into 5,000 £5 per Cent. Cumulative Preference shares and 5,000 Ordinary shares of £1 each, to acquire and take over the business referred to in an agreement with Edward L. Joseph, and to carry on the business of electrical and mechanical engineers, suppliers of electricity for light, heat and motive power purposes, and manufacturers of and dealers in all kinds of apparatus and things used for or capable of being used in connection with the generation, distribution, supply, accumulation and employment of electricity. The first subscribers, with one share each, are :—H. Glenister, C. E. Wellaby, F. C. Moore, T. M. Middleton, E. H. Minton, G. H. Congleton, and A. A. Jones. Mr. E. L. Joseph is to be one of the first Directors.

CAMBRIDGE ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return to February 7th has been filed. 4,077 shares have been subscribed out of a capital of £50,000, in £10 shares. £8 per share has been called.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The annual return to February 26th has been filed. The whole nominal capital of £220,000 in 16,000 Ordinary and 6,000 Preference shares, of £10 each, has been taken up, and the full amount has been called and paid.

HOUSE TO HOUSE ELECTRIC LIGHT SUPPLY COMPANY (LIMITED).—The annual return to March 5th has been filed. The capital is £350,000 in 57,900 Ordinary, 100 Founders' and 12,000 Preference shares of £5 each. 8,322 Ordinary, 100 Founders' and 5,000 Preference have been taken up, and all the Founders' and 1,000 Ordinary have been issued as fully paid. The full amount has been called on the remainder.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31 7/16d. per oz. (March 12th). Consols (2¾ per cent.) 109¾—110 for money, 109⅞—110 for account ; 2½ per cent. 106—106½ (March 12th). Stock Exchange Settling Days : Consols, March 30th ; Stocks and Shares Continuation Day, March 25th ; Ticket Day, March 26th ; Pay Day, March 27th ; Mining Share Carry-over Day, March 24th.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended March 8th, were £977, against £971 in the corresponding week of 1895, an increase of £6. The total receipts for the half-year amount to £9,837, against £9,911 for the corresponding period of 1895, a decrease of £74.

COMMERCIAL CABLE COMPANY.—The report of the Directors of this Company for the year 1895 states that the gross earnings amounted to $2,009,737, and the working and other expenses to $794,340, leaving a balance of $1,215,397. There was an increase in the earnings of $236,304, and in the expenses of $31,344, as compared with the previous year, resulting in an increase in net earnings of $204,959. Dividends of 1¾ per cent. for the quarters ended March 31st, June 30th, September 30th and December 31st have been paid—a total of 7 per cent. for the year on the capital stock—amounting to $700,000. The reserve fund has been augmented by the purchase of $200,000 United States Government Bonds. The balance of the year's profit, amounting to $315,397, remains to the credit of profit and loss. Six sections of the Company's cables were interrupted at different periods during the year, chiefly caused by contact with anchors of fishing vessels. The repairs were, however, promptly effected. The whole of the Company's system is in excellent condition.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The Directors of this Company have decided, subject to audit, to recommend the payment of dividends at the rate of 10 per cent. per annum on the Preference shares, and of 4 per cent. per annum, free of income tax, on the Ordinary shares, both for the half-year ended December 31, 1895.

IMPERIAL TRAMWAYS COMPANY (LIMITED).—The report of the Directors of this Company, to be submitted at the general meeting to be held at Bristol to-morrow (Saturday), states that as the Dublin Southern Tramways Company's lines were in course of reconstruction, the tramways have been closed to traffic for practically the whole of the period under review. The Directors, however, state that there is every prospect of the lines being ready for opening within the next few weeks. The Company are promoting a Bill in Parliament in the present Session with a view to obtaining powers for considerable extensions of their electric tramways in the city of Dublin and suburbs. The assents of all the suburban townships have been given to the Bill. The whole of the projected lines can be operated from the location of the Company's central power station. The Bill also provides for changing the name of this Company to the "Dublin Electric Tramways Company."

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 8th inst. amounted to £1,040. The amount for the corresponding week last year was £937. Increase £103.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended March 6th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,777.

WESTERN UNION TELEGRAPH COMPANY.—The Directors of this Company have decided to recommend the payment of the usual quarterly dividend of 1¼ per cent. The quarterly statement of the Directors shows a deficit, after dividends, of $185,000, compared with $271,000. For the nine months to date the surplus is $389,000, against $298,000.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Mar. 4.	Price Wednesday, Mar. 11.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending Mar. 7. Highest	Lowest
			TELEGRAPHS.						
£1,012,820	Stock	18/0	Anglo-American ..... xd	46 48	46 48	5 4 2	Jan., Apr., July, Oct.	..	..
£2,993,560	Stock	36/0	Do. Preferred ..... xd	87 88	87⅛ 88½	5 12 0	" "	88	87⅛
£2,993,560	Stock	5/0	Do. Deferred	7⅛ 7⅜	7 7⅛	.. ..	..	7⅛	..
£173,460	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)....	100 104	100 104	3 17 6	January and July ..	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	10½ 10⅝	10⅝ 11	.. ..	..	10½	..
180,000	£10	3/0	Brazilian Submarine	14⅛ 14½	14⅛ 14⅜	4 14 11	Mar., June, Oct., Dec.	14⅜	14⅛
£75,060	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1905)	111 115	111 115	4 7 9	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	160 170	160 170	4 3 2	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine ..... xd	12½ 13½	13½ 13½	5 14 4	February and August	13½	..
6,000	10	10%	Do. Preference 10 per Cent. ..... xd	20½ 21½	20½ 21½	4 13 0	.. ..	..	..
12,931	5	2/0	Direct Spanish (fully paid)	4 5	4 5	4 0 0	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	105⅞ 108⅞	105⅞ 108⅞	4 4 4	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	9 9½	9½ 9⅝	4 2 1	Jan., Apr., July, Oct.	9½	..
400,000	10	2/6	Eastern	17 17½	17 17½	3 14 4	" "	17⅞	17⅝
79,000	10	6%	Do. 6 per Cent. Preference	18 18½	18 18½	3 4 10	" "	18⅛	18
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	129 132	129 132	3 1 2	May and November	131½	129½
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899.....	105 108	105 108	4 13 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17⅞ 18½	17⅞ 18½	3 16 9	Jan., Apr., July, Oct.	18½	18
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128 131	128 131	3 1 4	February & August	129	..
£54,100	100	5%	* Do. 5 p. c. (Anstln. Gov. Sub.)Debs. 1900	101 105	101 105	4 15 11	January and July ..	101	101½
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb.,1900	101 105	101 105	4 15 11	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) ..	105 108	105 108	3 14 1	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112⅞ 115⅞	112⅞ 115⅞	3 10 2	May and November	112	..
180,227	10	1/6	Globe Telegraph and Trust	10 10⅛	10⅛ 10⅜	3 16 9	Jan., Apr., July, Oct.	10⅛	10⅛
180,042	10	6%	Do 6 per Cent. Preference	16⅞ 17⅛	16⅞ 17⅛	3 9 7	" "	17	16⅞
150,000	10	5/0	Great Northern.....	22½ 22⅝	22½ 22⅝	3 14 9	Jan., April, and July	..	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue....xd	102 105	102 105	4 15 3	March & September	..	..
17,000	25	12/6	Indo-European	46 49	47 50	5 0 0	May and November	48½	48
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	.. ..	" "	..	..
£160,000	100	6%	* Do. 6 per Cent. Debentures ..... xd	105 108	105 108	5 11 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942..	108 111	108 111	3 12 7	.. ..	109½	..
11,839	8	4/0	Reuter's	5 6	5 6	.. ..	April and October ..	5½	..
3,331	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	132 137	132 137	4 7 7	" "	135	132½
15,609	10	2/0	West African Telegraph	5⅜ 6⅜	5⅜ 6⅜	.. ..	January and July ..	..	..
£238,300	100	5%	* Do. 5 per Cent. Debentures (red.) ..... xd	101 104	101 104	4 13 2	March & September	..	..
30,000	10	2/0	West Coast of America	1 2	1 2	.. ..	January and July ..	..	..
£156,000	100	8%	Do. 8 per Cent. Debentures, 1902	94 99	94 99	8 4 1	June and December	..	..
88,321	10	1/3	West India and Panama	1 1½	1 1½	.. ..	" "	1⅛	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	10⅜ 11⅛	10⅜ 11⅛	5 6 8	May and November	11	10⅜
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108 111	108 111	4 10 8	June and December	..	..
64,248	15	3/0	Western and Brazilian	8⅜ 9⅛	8⅜ 9⅛	5 5 8	May and November	9⅛	8⅜
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6⅜ 7	6⅜ 7	.. —	..	..	..
33,129	7½	1/6	Do. Deferred Ordinary.....	2⅞ 3⅛	2⅞ 3	.. —	..	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	102 106	102 106	5 13 2	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	102 106	102 106	5 13 2	" "	..	..
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds....	113 118	113 118	6 0 11	May and November	..	..
£164,200	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.) ....xd	102 105	102 105	5 14 8	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3 3⅛	3 3⅛	.. ..	..	3⅛	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance ..	⅛ ¼	⅛ ¼	.. ..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid).....	⅛ ¼	⅛ ¼	.. ..	Yearly	..	..
484,597	5	3/0	National ..... xd	6⅜ 6⅝	6⅜ 7	3 18 7	June and December	6⅝	6⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref. ....xd	16 18	16 18	3 6 8	" "	17⅜	17
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)..xd	16 17	16⅛ 17⅛	3 8 7	" "	17	14⅜
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref. .....xd	6⅜ 6⅞	6⅜ 6⅞	3 12 9	—	6⅞	..
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	104 107	104 107	3 5 10	January and July .	106⅛	105⅛
58,000	5	3/0	United River Plate	3⅛ 4	3⅛ 4	.. ..	" "	3⅛	3⅝
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	95 100	95 100	5 1 0	" "	97½	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	10/0	City of London Electric Lighting (fully paid) ..xd	14 15	14 15	3 6 8	—	14½	14½
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid) .....xd	16 17	16 17	3 10 7	—	16⅞	..
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	134 138	134 138	3 13 0	June and December	137½	136
19,900	£5	..	Electricity Supply Co. for Spain.....	.. ..	.. ..	.. ..	—	..	..
£80,000	£5	3 0	Charing Cross & Strand Electricity Supply Corp. xd	6⅞ 7⅛	6⅞ 7⅛	.. ..	—	7⅛	7
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	.. ..	—	..	..
22,475	£8	..	County of London & Brush Prov. Ord. (fully paid).	8 9	8 9	.. ..	..	..	..
10,000	£10	9½d.	Do. Pref. (£8 paid)	10 11	10 11	.. ..	..	10½	..
8,322	£5	..	House-to-House Electric	.. ..	.. ..	.. ..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	.. ..	.. ..	.. ..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	.. ..	January and July ..	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 8⅛	7⅞ 8	3 15 0	—	..	..
111,000	5	..	London Electric Supply.....	.. ..	.. ..	.. ..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	12½ 12⅝	12⅜ 18½	2 5 3	—	13	12⅞
£150,000	Stock	4½%	* Do. 4½% Debs.	116 119	116 119	3 16 5	June and December	..	..
6,462	£10	4/0	Notting Hill Electric ..... xd	8½ 9	8½ 9½	.. ..	—	8½	8½
..	..	..	Rand Electric	⅞ 1⅛ prem	⅞ 1⅛ prem.	.. ..	—	..	..
19,980	£5	5/3	St. James and Pall Mall	9⅜ 10½	9⅜ 10½	.. ..	—	9⅜	9⅜
20,000	£5	7%	Do. 7 per Cent. Preference.....	9 9½	9½ 9⅝	3 11 10	—	9½	9⅜
59,900	5	4/6	Westminster Electric Supply (fully paid) .....xd	9½ 9⅝	9½ 10	3 10 0	—	9½	9⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1⅜ 1⅝	1⅜ 1⅝	5 3 8	—	1⅝	1⅜
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝ 1⅞	1⅝ 1¾	3 4 0	—	1⅞	1⅝
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures..... xd	110 113	110 113	3 19 8	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref..	2½ 2⅝	2½ 2⅝	.. ..	January and July ..	..	..
89,261	5	1/6	Edison and Swan United..... xd	1½ 2	1½ 1⅝	.. ..	..	1⅝	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	103 106	103 105	4 6 7	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	.. ..	.. ..	.. ..	..	..	..
110,000	2	..	Electric Construction.....	1⅛ 1⅜	1⅛ 1⅜	.. ..	..	1⅜	1⅛
12,845	2	1/0⅝	Do. 7 per Cent. Cumulative Pref.	2⅛ 2⅜	2⅛ 2⅜	5 1 10	..	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅛ ⅜	⅛ ⅜	.. ..	..	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	⅛ ⅜	⅛ ⅜	.. ..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works .....xd	19½ 20½	19 20	5 0 0	February & August	20	..
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 7 5	March & September	..	..
15,995	£10	..	International Okonite Ordinary.....	.. ..	.. ..	.. ..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference.....	.. ..	.. ..	.. ..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid).....	⅜ ½	⅜ ½	.. ..	..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	38 41	39 41	4 5 9	March and July.....	41	37½
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	103 105	4 16 2	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)..	.. ..	.. ..	.. ..	—	..	..
41,098	£5	..	Do. Preference (fully paid).....	.. ..	.. ..	.. ..	—	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary.....	15 16	15⅛ 16⅛	3 12 9	—	16	..
£30,000	10	7/0	Do. 7 per Cent. Preference	16⅛ 17⅛	16⅛ 17⅛	3 19 9	—	..	..
£50,000	Stock	4½%	Do. 4½% Mort ge Debenture Stock.....xd	107 112	107 112	4 0 4	—	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway Con. Ordy.	40 42	40 42	2 19 6	May and November	41½	40⅛
7,650	10	5%	Do. 5% Perpetual Preference	14½ 15	14½ 15	3 6 8	..	14½	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	130 132	132 134	3 0 3	May and November	132½	..
£7,500	£10	3½%	Liverpool Overhead Railway	13⅜ 13⅞	13⅜ 14	2 1 8	—	—	—
10,000	10	5%	Do. 5% Preference	15⅜ 16	15⅛ 16	3 2 6	—	—	—
148,000	Stock	4%	Do. 4% Debenture	111½ 116	114½ 116½	3 10 2	January and July ..	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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THE ELECTRICIAN:

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NOTES.

THE discussion on Mr. ADDENBROOKE's Paper on "High Voltage Lamps and their Influence on Central Station Practice," was, for these days, unusually short and to the point. The lamp-makers had a fine field-day, and their remarks were noteworthy for their candour and explicitness. But the lamp-makers were not alone, far from it; they had the cordial support of the central-station engineer and the no less cordial opposition of the consultant and the alternate-current engineer.

IN regard to the question of high-efficiency *versus* high-voltage lamps, Mr. SWAN pointed out that it would be courting failure to place 2½ watt lamps on supply circuits subjected, as these are, to such undesirable variations of pressure; an 8-c.p. 2½-watt lamp was already sufficiently strained by 100 volts, and it had but a small factor of safety. From the consumer's point of view, therefore, as well as from that of the lamp maker and central-station engineer, the high-voltage lamp was to his mind to be preferred; it would be subjected in all probability to smaller variations of pressure than the 100-volt lamp, and neither he nor Mr. STEARN could see any *a priori* manufacturing reason for anticipating for it a short life or an appreciably lower efficiency than 3½ watts per candle. Mr. J. F. C. SNELL, of the St. Pancras staff, was able to assert from personal experience that a life of 1,300 hours was obtainable with 220-volt lamps, and his chief, Mr. SYDNEY BAYNES, naturally gave the Paper his benediction and passed on to the consideration of the arrangement of feeders and the working current density advisable for distributors.

BUT the progressists did not have it all their own way. Mr. GEIPEL said he knew a leading lampmaker who candidly admitted that a good 200-volt 3-watt 8-c.p. lamp could not be made at present, and without this desideratum Mr. GEIPEL would have nothing to do with the latest new thing; indeed, "he thought the 200-volt lamp policy a mere subterfuge, which should be strongly opposed." Mr. H. W. HANDCOCK was also a disbeliever in the efficiency, durability and suitability of the high-voltage lamp, and, like Mr. SWAN himself and other speakers, he was doubtful as to the reliability of existing wiring and fittings under the extra strain.

THE many advantages of a 200-volt lamp to the low-pressure central station engineer are in no need of exposition, but none the less Mr. ADDENBROOKE did good service in putting them all into black and white, and in thus affording lamp-makers an opportunity of taking us more or less into their confidence and of showing us their wares. The consumer's convenience must, however, be consulted, unless, indeed, in our "ardour for progress" we are to progress backwards. If the advent of the 200-volt lamp means to him no greater outlay on wiring, lamps and current, and, above all, no greater bother, he will, after his suspicions have been allayed, readily adopt it. On the other hand if it is to deprive him of a reliable 8-c.p. lamp, increase his outlay on wiring and lamps, and run up his quarterly bill for current, central station engineers will do incalculable harm by forcing the pace. Our advice is: Hold your hand. St. Pancras has 4,000 high-voltage lamps connected, Edinburgh will shortly have a still larger number; after a twelvemonth's experience in these two localities, we shall know exactly where we are. A false step in this matter will give the electric lighting industry a grievous set back The lamp-makers undoubtedly made out a very good case for themselves at the Institution last week, but even they would probably prefer a gradually increasing demand to a sudden rush. We cannot afford to increase either the trouble or the general expense of electric lighting, if it is ever to become the universal illuminant. When the lamp and the wiring questions are settled by actual experience, the economies resultant upon the higher pressure of distribution will enable the price of the Board of Trade unit to come down handsomely. But even a 2d. unit would scarcely be a complete compensation for unreliable lamps and expensive fittings.

WE publish this week in full the new wiring rules just issued by the St. Pancras Vestry. These are interesting as being the first of the kind drawn up since the 220-volt lamp came down from the high regions of pioneering experiment to the commercial level. Like all rules and regulations, these issued by Mr. BAYNES appear formidable when "taken in the loomp," but in the main they are such as would probably be voluntarily observed by a firm of good repute when carrying out a 220-volt wiring job which had not been let to the lowest tenderer. There are several stipulations which, we imagine, a wiring contractor may have well-grounded objections to, but there is a general air of determination and practical acquaintance with the work in hand about the St. Pancras rules; a distinct relief after the somewhat flaccid and academic tone of many rules it has been our painful duty to digest.

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That some attempt is being made to effect the removal of tin from tin-plate scrap according to the principles laid down in Dr. Borchers' book, which was last week reviewed in these columns, is evident from the fact that in a recent German patent Herr Kotzur proposes to use caustic alkali as the electrolyte in a bath of which the anode is the scrap to be stripped, and provides for the inevitable deterioration of the electrolyte in the following way :—When the voltage required rises to an unremunerative height, a fraction of the electrolyte is removed and replaced by fresh caustic soda. The saturated material is freed from tin by treatment with carbon dioxide, which decomposes sodium stannate, leaving sodium carbonate in solution. The stannic oxide precipitated is free from impurity, and can be readily reduced to metallic tin, while the sodium carbonate may be causticised and used again. An alternative plan consists in precipitating the tin as calcium stannate by boiling the spent electrolyte with lime, and thus freeing the caustic solution from its acquired disability. The calcium stannate is then reduced to metallic tin by ordinary metallurgical methods.

Some researches have recently been undertaken by Mr. E. Taylor Jones with a view to ascertain whether the agreement between Maxwell's equation for, and the observed values of, magnetic tractive force at moderately large inductions also exists when much higher inductions occur. The analytical investigation is to be found in Vol. II., Chap. XI., of Clerk Maxwell's "Electricity and Magnetism," which treats of "Energy and Stress in the Electromagnetic Field," and the equation in question, $B^2/8\pi$, can be directly deduced from Maxwell's generalised equations on pp. 278-9 of that volume. Whether this equation for tractive force in terms of B is correct, or whether some alternative expression—such as the $2\pi I^2$, which has been given by Stefan and others—should be taken, Mr. E. T. Jones had already in a previous investigation sought to determine; but the relatively low values of magnetic induction—6,000 to 20,000 C.G.S. lines per square centimetre—and the relative insignificance of H, rendered it still doubtful whether or no H played the part implied by Maxwell's equation. To settle this latter point, it was necessary to carry on the investigations under conditions such that the first term in the expression $H + 4\pi I = B$ should become but an inconsiderable fraction of the whole; in other words, to measure the tractive force when the permeability was reduced to a small value.

The results appear to give a complete justification to Maxwell's $B^2/8\pi$ equation, to the discomfiture of the advocates of $2\pi I^2$, though it must be admitted that we have yet to receive the answer of these latter. Soft iron and glass, hard steel have been experimented upon by Mr. Jones, and the curve giving the relation between the square root of the observed tractive forces and the corresponding values of B, from 0 to 40,000 C.G.S. lines per square centimetre, is a straight line from which the departure of none of the observed values exceeds 3 per cent.; while the majority of the readings are very close indeed to their theoretical value, as given by Maxwell's equation. The soft iron was subjected to a maximum magnetising force $H = 17{,}690$, and a corresponding induction, $B = 39{,}260$, under which conditions a tractive force of 63,000 grm. per square centimetre was developed. The glass-hard wolfram steel sample was subjected to $H = 17{,}830$ and $B = 36{,}110$, and exhibited a tractive force of 52,900 grm. per square centimetre.

Maxwell's equation thus verified for all values of magnetic induction, it was an obvious corollary to employ it conversely in the determination of extremely high inductions. The permeameter of Prof. S. P. Thompson had already been devised for the measurement of inductions of common magnitude; but now the applicability of such an instrument where the induction was too high to be measured in other ways was proved. Accordingly inductions due to enormous magnetising forces were estimated from the tractive forces developed in a sample of iron or steel. And, if this method be correct under such conditions, inductions as high as 100,000 C.G.S. lines per square centimetre can exist in iron. It is interesting to notice that at this induction a force of no less than 3,185lb. per square inch was developed in the test piece, at the moment of its parting from the opposite pole-surface. A full account of these researches is contributed by their author to the current number of the *Phil. Mag.*

The forthcoming Berlin Industrial Exhibition, whatever it may or may not effect, is at any rate to be the scene of an interesting attempt to solve that hitherto insoluble problem of selecting a Jury of Awards which shall satisfy the exhibitors. The exhibitors in each department are to select their own judges. The mutual jealousies of the electors may certainly be expected to result in the election of an admirably open-minded jury; whether its members will be equally competent may be doubted. The idea, however, possesses the merit of originality and contains many of the elements of success.

Sir John Pender.—The statements that have appeared as to Sir John Pender's health are misleading. Though there is less immediate cause for anxiety than there was some weeks ago his condition is still very serious. There has been no substantial improvement, and he is quite incapable of attending to any business.

Cable Interruptions :—

	Date of Interruption.
Puerto Plata—Martinique	December 19, 1895
Aden—Zanzibar	March 16, 1896

The P.-Q. Cable.—We understand that the French cable ship François-Arago has lifted and buoyed the St. Pierre end of the P.-Q. cable in deep water.

New Books.—Messrs. Macmillan and Co. will publish the Miscellaneous Papers of Prof. Hertz, with an introduction by Prof. Lenard, the translation being done by Messrs. D. E. Jones and G. A. Scholt.

Municipal Purchase at Southampton.—At Wednesday's meeting of the Town Council, the proposal to purchase the undertaking of the Southampton Electric Light and Power Company, and to borrow £50,000 for that purpose and for extensions, was carried.

Prof. Schuster.—*Nature* states that the Committee of the Athenæum Club, acting under the provisions of the rule of the Club which empowers the annual election by the Committee of nine persons "of distinguished eminence in science, literature, the arts, or for public service," have admitted to membership Prof. Arthur Schuster, F.R.S.

The Royal Society.—The following papers were down for reading yesterday :—Capt. Abney, F.R.S., "The Photographic Value of Moonlight and Starlight compared with the Light of

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a Standard Candle." Lord Blythswood on "The Reflection of Röntgen Light from Polished Speculum Metal Mirrors." J. R. Erskine Murray on "The Effect of the Röntgen X-rays on the Contact Electricity of Metals." C. T. R. Wilson, "The Effect of Röntgen Rays on Cloudy Condensation."

Royal Institution.—The following are some of the lecture arrangements after Easter:—Mr. C. Vernon Boys, three lectures on "Ripples in Air and on Water"; Prof. Dewar, three lectures on "Recent Chemical Progress." The Friday evening meetings will be resumed on April 17th, when a discourse will be given by M. G. Lippmann on "Colour Photography"; succeeding discourses will probably be given by Prof. Silvanus P. Thompson, Prof. J. A. Ewing, Prof. J. A. Fleming.

The Bilbao Telegraph Office and the Electric Tramway.—On the evening of the 16th inst. a telephone linesman at Bilbao, who was working on the roof of a house, accidentally dropped a roll of copper wire, which fell on the overhead wires of the Government telegraphs and the electric tramway. The telegraph wires were melted and the commutator and instruments in the Government telegraph office, which was only a few yards distant, were destroyed, and the instrument room set on fire, thus stopping for a time all Bilbao's inland telegraphic communications.

Serious Telephone Breakdown in Vienna.—On Monday, March 9th, a heavy snowstorm caused the destruction of a large part of the overhead network of the Vienna Telephone Exchange. Of the 8,980 subscribers, more than 4,000 were unable to make use of their instruments. The snow was of a sticky character and covered the wires to a thickness of 1¼in. This enormous weight broke down most of the wires, and also a great number of the cast-iron poles. Several interurban lines have suffered in the same way, and telephone communication has almost entirely been suspended.

The Goldsmiths' Company's Technical and Recreative Institute.—The New Cross Technical and Recreative Institute of the Goldsmiths' Company appears by its recent report to have met with greater success in the past year than heretofore. More than 1,000 entries in excess of the number for the previous year were registered, and the technical classes are very much patronised by the young people for whom they are held. Space does not permit us to mention all the excellent provisions which this Institute affords for recreation and study, but we may note that the classes in electrical subjects appear to be duly appreciated.

The Electrical Standardizing, Testing and Training Institution and X-Rays.—It may interest our readers to know that the authorities of Faraday House, Charing Cross Road, have placed in one of the private rooms the necessary apparatus for photographing by means of X-rays. This has been done at the suggestion of certain prominent members of the medical profession, and already a large number of negatives have been produced. The apparatus is of course manipulated by the staff of the Institution, but it is desirable that patients should be accompanied by a medical gentleman who is attending them.

"L'Industrie Électrique."—Our esteemed contemporary has found it necessary to make the following delightful apology for its issue of March 10th:—

"La composition de ce numéro, par suite d'un singulier concours de circonstances, diffère, par le manque de variété, de tous ceux qui l'ont précédé, bien qu'il renferme 52 pages au lieu de 24. D'une part, la quatrième édition de notre *Statistique des chemins de fer et tramways électriques*, en exploitation, en construction ou en projet, statistique dont l'importance n'échappera pas à nos lecteurs, occupe à elle seule 16 pages: d'autre part, les communications faites à l'Académie des sciences sur les rayons X, communications qu'il nous faut au moins résumer, se succèdent avec une abondance désespérante. Nos lecteurs voudront donc bien excuser le caractère un peu monotone de ce numéro. Il nous a paru utile de *liquider* toute l'Académie en une seule fois. Le prochain numéro reprendra son allure normale et présentera sa variété habituelle."

"Legal Fees for Technical Experts in Germany."—Under this heading the *Zeitschrift des Vereins Deutscher Ingenieure* for March 7th gives some interesting information with regard to the inadequate remuneration offered by the German Law Courts to technical experts. According to law the fee is fixed in proportion to the expert's income, namely 1s. 6d. per hour for an income under £300 per annum, and 2s. per hour for over that sum. In June last year a mechanical engineer of some standing was asked to act as technical expert in an important case. He furnished a long report and attended the trial. Sending in a £20 bill it was returned by the judge with the remark that according to paragraph so-and-so no round sum could be charged, but the number of hours was to be put down at 2s. each. A protest was entered into, but nothing was heard of it for some time, until one day the gentleman in question received the magnificent sum of £5, which the judge had fixed as sufficient remuneration for his time and trouble. On appealing to a higher court the committee of a leading engineers' society was asked to give an opinion as to what were the "usual" fees for expert work, and on receiving the answer the Court at once granted the full claim.

The Hermite Electrical Sanitation Process.—The installation of this system at the Military Hospital, Netley, has now been working since the beginning of the year, and a visit of inspection was, Messrs. Paterson and Cooper inform us, made a few days ago by the War Office authorities, who expressed themselves thoroughly satisfied both with the effect on the main sewer and the effluent, and also with the remarkable improvement in the atmosphere of the various wards. The ward-masters are also unanimous in their approval. The French War and Naval Departments have officially approved the system, and are considering to which of their stations it shall be first applied. The Brazilian Government have given instructions for the Marine State Hospital at Rio to be fitted with Hermite plant on the same lines as the Victoria Hospital, Netley. As to the success of the demonstrations of the Hermite process at Rio last year, it may be of interest to state that in that part of the city where the working of the plant has been continued, not a single case of yellow fever has occurred, though it is a most unsanitary spot, and in previous years has suffered severely. Other parts of the city have suffered as usual from the periodical visitations of this scourge.

Expiring Patents.—On Saturday will expire Prof. A. E. Dolbear's Patent No. 1358 of 1882, for "Improvements in Electric Cables," the improvements being a hollow insulating tube containing a bare conductor twisted with a wide helix of cotton. On Monday next, the 23rd inst., will expire Patent No. 1,412 of 1882, granted to Messrs. Woodhouse and Rawson for "Improvements in Electric Lighting and Apparatus Connected Therewith." The invention chiefly relates to the silvering of one half of an incandescent lamp bulb. On Wednesday next, the 25th inst., will expire Patent No. 1,444 of 1882, granted to Richard Werdermann, for "Improvements in Electric Incandescent Lighting Apparatus." The specification describes a semi-incandescent type of lamp, and the claims are for (1) "The fixed electrode enclosed within an air-tight globe, cylinder or chamber (which may or may not have a vacuum therein) and the moving electrode arranged to be kept in contact with the fixed electrode," and (2) "The combination, with the moving electrode, of the collar or ring of steatite, magnesia or other suitable refractory material." On Friday next, the 27th inst., will expire Patent No. 1,464 of 1882, granted to MM. Laland et Chaperon for the primary battery which bears their name.

The Coehn Carbon Consuming Cell.—A new proposal for making a galvanic cell consuming carbon was made by Dr. A. Coehn, in a communication to the Elektrotechnischer Verein of Berlin, on February 25th. The *Elektrotechnische Zeitschrift* for March 12th makes the following remarks on the subject:—"The investigation is based upon a fact which has been already observed by several other electro-chemists, but which has so far been found very inconvenient in electrolytical processes in which insoluble anodes are required. The carbons mostly employed have not, under the influence of the current in different liquids, shown sufficient resistance to disintegration. On the contrary, the carbons fell to pieces. In proceeding step by step and with experiments well arranged, Dr. Coehn has been able to find out the exact conditions required to enable the carbon to produce on oxidation only carbon dioxide (CO_2) and carbon monoxide (CO) on the anode. It was found that a certain temperature and a certain current density were necessary conditions, as electrolytic diluted sulphuric acid of a certain gravity was used. Dr. Coehn was further successful in depositing on

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the cathode the carbon given off by the anode. This proves that the carbon or a compound of it plays an important part in the transport of the electricity through this liquid. To construct a cell which is based on the combination of carbon the necessary oxygen must be supplied to the cathode. This is done by employing peroxide of lead cathode. In such a carbon cell, with dilute sulphuric acid and a peroxide of lead cathode, an E.M.F. of 1·03 volts is obtained, and it works in such way that at the anode the carbon burns to carbon monoxide and carbon dioxide, while on the cathode peroxide of lead is reduced to metallic lead." Dr. Coehn's communication is shortly to be published in full.

Electric Propulsion of Canal Boats.—Mr. Charles R. Barnes, City Electrician, of Rochester, U.S.A., has made an official report on experiments in electric propulsion on the Erie Canal, a description of which was published in *The Electrician* of November 15, 1895, p. 88. For the purpose of the tests the State scow "Tonawanda" was used, and was towed up and down the experimental section a number of times, under varying conditions of wind and current. The "Tonawanda" weighed 60 tons, carried a load of 157½ tons, making a total displacement of 217½ tons, and drew 5½ft. of water. Each run was made over a distance of 0·4 mile, and an average speed of about 2½ miles per hour was attained at the expenditure of only about 8½ electrical horse-power for the 217½ tons towed. Taking these figures as a basis, together with the price at which the Erie Canal Traction Company is bound by virtue of its franchise to furnish electric power to boatmen—namely, not to exceed $20 per horse-power per season of navigation, which ordinarily covers 210 days—and assuming that the tow-motor worked constantly during the whole season, thus making 35 single trips between Buffalo and Troy with such vessels and at such speed as referred to, the cost per trip would be, assuming continuous work, about $5, or less than 1·4 cents per boat-mile. Now, assuming that during one-third of the entire time the motor remained idle at locks and elsewhere, although power was charged for just the same, then the cost per boat-mile covered would average 2·1 cents, or $7.66 per trip. If in addition to this a rental were charged for the motor, at the same rate per horse-power and season as for the electric power itself, for the entire time, including the periods of idleness, the total cost per boat-mile run would amount to 4·2 cents, or $15.32 per trip. At this rate not only would power be cheap to the consumer, but the renting out of motors, Mr. Barnes believes, would prove a profitable enterprise. If the boat speed were to be, say 3½ instead of 2½ miles per hour, the power would be increased from 8½ to about $23\frac{4}{10}$ electrical horse-power, the cost of the electric current from 2·1 cents to 4·1 cents per mile, and the item of motor depreciation or rental also from 2·1 cents to 4·1 cents; this would make, together, 8·2 cents per mile, or $29.93 per trip for the higher speed. A tow-motor running continuously would make 48 trips at the higher speed, against 35 trips at the lower speed per season; but if one-third the entire time were lost by delays, in either case there would still be made 32 trips at the higher or 23 trips at the lower speed per season. Of course the time allowance for delays, which is here assumed at one-third of the entire season, is an arbitrary one, and it seems rather unlikely that anywhere near as much time would necessarily be lost, especially not with the proposed improvements in the locks. Of the various systems that have been proposed or suggested for canal traction the towage system seems to appeal most favourably to boatmen, as only the towing facilities require to be changed from the mule or horse to the tow-motor. Another feature of some value is the absence of the wash unavoidable with propellers. The towage system, further, appears to afford greater flexibility of manipulation, as extra tow-motors could more readily and at less expense be kept in reserve at suitable points along the canal to meet odd demands than would be the case with propeller boats, and boats could be towed even singly or in couples with a fair degree of economy, not necessitating the making up of long trains as with propellers.

Röntgen Rays.—The *Comptes Rendus* of the Académie des Sciences continue to be well filled with Röntgeniana. In the issue of March 2nd (No. 9, 1896) M. D'Arsonval describes experiments, which he sums up as follows: "All bodies giving rise to greeny-yellow fluorescent radiation can *impress photographic plates through opaque bodies*. . . . It follows that the *rôle* of cathode rays in Röntgen's experiments would appear to be limited to fluorescing the special kind of glass of which the Crookes tubes is composed." M. Henri Becquerel in the same number refers to his previous brief announcement of experiments, showing the existence of *invisible* radiation emitted by certain phosphorescent substances and passing through bodies opaque to light. Such radiation is emitted by strips of the double sulphate of uranyl and potassium $[SO_4(UO)K + H_2O]$. MM. A. Imbert and H. Bertin-Sans made a communication on "The Diffusion of Röntgen Rays." They find that within the limits of their experiments Röntgen rays are regularly reflected to only a very slight extent; on the other hand, they may be much diffused, and the "intensity of the diffusion appears to depend much more on the nature than on the degree of polish of the diffusing body. A fact which tends to show that the new rays have a very small wave length such that it is impossible for us to attain the degree of polish necessary to cause regular reflection. The *clichés* obtained by us reveal, moreover, in quartz and cork different degrees of transparency in regard to the rays diffused by the different bodies used." MM. Bleunard and Labesse have a note on "The Passage of Röntgen Rays through Liquids." They state that water is very transparent, and, as has been previously observed, they find that colour has no perceptible influence. Solutions of bromide of potassium, chloride of antimony, bichromate of potash, offer "a somewhat considerable resistance to the passage of Röntgen rays." Solutions of borate of soda, permanganate of potash, are less resistant. In the *Comptes Rendus* for March 9th, M. Henri Becquerel describes further experiments with the invisible rays emitted by phosphorescent bodies, which do not emit *light* for more than about $\frac{1}{100}$th of a second after cessation of excitation. Electrified bodies are discharged. Using an Hurmuzescu electroscope, which, protected against electrical influence by a metal case and against ultra-violet light by yellow glass, can retain its charge for months, M. Becquerel found that on replacing some of the yellow glass by a strip of aluminium 0·12mm. thick, and applying a strip of the phosphorescent body to the outside, a charge was dissipated in 2h. 56min.; placing the phosphorescent body inside the case under the divergent gold leaves naturally resulted in their more rapid collapse. Experimenting with a view to discover how long after exposure to light these invisible rays continue to be emitted, M. Becquerel finds that with sesquioxide of uranium, double sulphate of uranyl and potassium, sulphate of sodium, and sulphate of ammonium, the power of the rays emitted is not sensibly diminished after 160 hours in the dark. In another series of experiments some sulphides of calcium giving blue, blue-green, and orange luminosity, some sulphide of strontium (green luminosity), and some hexagonal blende, all powdered, were placed in tubes closed at one end, and inverted on strips of glass 0·2mm. thick and sealed thereto with paraffin, the whole being placed on a sheet of aluminium 2mm. thick and put into a dark box with a photographic plate. After 13 hours the plate was developed, the blende, (orange) sulphide of calcium, and sulphide of strontium gave nothing, but the other two sulphides of calcium exhibited great activity. "The two images obtained with the two sulphides of calcium through the aluminium merit special notice as exhibiting important peculiarities," says M. Becquerel. "The quantity of phosphorescent powder contained in the tubes formed a column several millimetres high, and in the case of the blue sulphide, almost a centimetre high. The radiation from the lateral surface gave large very black spots, in the middle of which could be distinguished the light image of the section of the glass tube, and especially clearly the outline of the glass strips. These outlines, black inside and surrounded by an absolutely white line, show that the oblique radiation penetrated the glass strip, and was refracted and totally reflected at the surface of separation of the glass and the air." M. Becquerel also finds that air has no very marked absorbing effect on these rays.

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THE AMAZON CABLE SYSTEM.

The great advantages of direct telegraphic communication with the many important towns on the banks of the Amazon are self-evident, and have long been recognised. In 1893 an attempt was made by the Brazilian Federal Government to establish a land line, but after a large outlay had been incurred the line had to be abandoned, owing to the difficulties experienced in the forests and swamps bordering on the river. Application was then made to Congress, with the result that by a contract made in April, 1895, the Federal Government granted a concession which includes important privileges—viz., the exclusive right for a term of 30 years to lay subfluvial cables in the zone comprised between Pará and Manaos; an annual subsidy of £17,125 during the first 20 years of the concession; all favours granted to similar enterprises in Brazil; permission to treat with the Governments of the States of Pará and Amazonas for the establishment of other branch cables, any subventions granted by these Governments to take effect without prejudice to the subsidy or other favour conferred by the Federal Government in the concession. At the expiration of the 30 years the system of cables will become the property of the Federal Government, which has also the power to purchase the undertaking after 10 years, at a price based on the value of the works and the average profit for the preceding five years, but not less than the capital sum expended by the Amazon Telegraph Company in laying down and working the cables. The cable is to connect the city of Manaos, more than 800 miles up the Amazon, the capital of the State of Amazonas and the chief market of the indiarubber trade in Brazil, with the important city of Pará at the mouth of the river, with intermediate stations or branch lines at Pinheiro, Mosqueiro, Souré, Cametá, Breves, Gurupá, Chaves, Macapá, Monte Alegre, Santarem, Alemquer and Obidos, all in the State of Pará, and Parintins and Itacoatiara in the State of Amazonas. At Pará the cable joins the land lines of the Brazilian Government, and is in touch with the cables of the Western and Brazilian Company, connecting with the rest of Brazil and the Argentine Republic, whilst through the cables of the Brazilian Submarine Company Manaos is in communication with Europe and the rest of the world.

The contract for the construction and laying of the cables, as well as for the supply of all the station material and repairing machinery, was placed with Messrs. Siemens Bros. and Co. in July last. The engineers for the Amazon Telegraph Company are Messrs. Clark, Forde and Taylor, under whose supervision the cables have been made and laid.

The total length of the cables is 1,365 nautical miles, and almost the whole of this is main cable, there being no intermediate cable, and but little shore end and beach cable. The core consists of a single 7-strand conductor, insulated with gutta-percha. For the main type of cable, this core is served with jute, sheathed with 12 galvanised steel wires, and finished off with two layers of jute and compound. For the short lengths of beach cable, or perhaps it would be more appropriate in this instance to call it "bank cable," the core is taped, covered with a continuous cold-drawn lead tube, served with jute, sheathed with 24 steel wires, and finished as usual. The shore ends are made by applying to the beach-cable a further sheathing of 12 steel wires again protected by jute and compound. The main cable measures nearly 1in. in diameter, and weighs 56cwt. per nautical mile; the beach cable $\frac{7}{8}$in., and 53cwt.; and the shore end 1$\frac{1}{2}$in., and 193cwt. The distances from station to station being comparatively short, the working is carried on with Siemens' double-current Morse instruments, with polarised relays.

Early in September last Mr. Alexander Siemens proceeded to Brazil, and directed a careful survey of the Amazon from Pará to Manaos, settling the route for the cable, and selecting the most suitable landing places. The cable has been laid quite up to Manaos by the "Faraday," to which the "Malvern" has acted as tender. The "Faraday," with Mr. Siemens in charge, sailed from the Thames in the middle of December last, and the first through message from Manaos was received in London on February 10th this year.

EXPERIENCE WITH THE ELECTRIC LOCOMOTIVE IN THE BALTIMORE TUNNEL.*

After a short period of experimental work, electric locomotive No. 1 on August 4, 1895, took up the regular freight service through the Belt Line Tunnel of the Baltimore and Ohio Railroad in the City of Baltimore. The tunnel, which is the largest "soft dirt" tunnel ever built, extends from the present Camden passenger station of the Baltimore and Ohio Railroad, a distance of 7,350 feet north under the heart of the city,

Shortly after locomotive No. 1 had been put into service, and had given an exhibition of its ability to haul the heaviest freight trains, it became a matter of general interest as to how much it could pull and how fast it could go. The locomotive was therefore given a trial at hauling several of the passenger trains at high speeds, which it did satisfactorily to all concerned. As the conditions for operating the passenger trains entirely by the electric locomotive could not, on account of track facilities, be perfected until the new Mount Royal station, at the northern portal of the tunnel, was completed, it was decided to operate them in the meanwhile by coke burning steam locomotives. The new Mount Royal station will be ready in April or before, and preparations are now being made to then operate all trains, both freight and passenger, by the electric locomotives.

It was shown, from the few trials made with passenger trains, that not only could the guaranteed speed of 30 miles an hour be attained, but speeds of 35 and 40 miles, with 500 ton trains, were possible. An exhibition of high speed was made with the locomotive running light up the 0·8 per cent. grade, and a speed of 61 miles per hour was attained for a short time, without the slightest trouble from trolley or motors. Several of the many exhibitions made by the locomotives in pulling heavy loads have been described in the newspapers. Probably the most striking was when two trains were coupled together and hauled through the tunnel. For some reason the freight trains had become "bunched" on the Washington division, and when they did get through they came so fast that it was decided to have the electric locomotive haul them two at a time. The first composite train, therefore, consisted of 44 cars, loaded with coal and lumber, two regular steam freight engines and a steam "pusher" engine. The whole weight was approximately 1,900 tons, and was equivalent to about 52 loaded cars. The steam locomotives did no work to assist the electric locomotive. The start was made easily and gradually, but when the train was in the tunnel and entirely on the grade the steady, heavy pull was too severe on a defective coupling near the head of the train, and it parted. After coupling together again, the electric locomotive started the heavy train, with all drawbars stretched—no slack in the train—and accelerated it to a speed of 12 miles an hour, without slipping a wheel, and in every way with the greatest ease. It reminded one of the start of an ocean steamship, so noiseless was it and free from any manifestations other than those of mighty power. The current recorded on the ammeter was about 2,200 amperes during the acceleration period, and after the train was up to speed it settled down to about 1,800 amperes. The voltage on the line was 625. By reading the amperes we were able to readily compute the drawbar pull, and found it to be about 63,000lb. All four motors were in series, and we were, therefore, getting the maximum pull for that current.

It may be of interest to steam railway engineers to know how we determined the drawbar pull exerted for each ampere of current put into the locomotive. The Pennsylvania Railroad Company's dynamometer car was secured and coupled in between the electric locomotive and a train of known weight. The weight of each car in pounds had been accurately determined beforehand. The regular two-mile haul up grade was then made. When the train was in the tunnel on the grade the pull was uniform, as was shown in the diagrams taken on the dynamometer car.

When no drawbar pull was recorded the pen rested on base line No. 1. The height or ordinate of the irregular curve at any point represented the drawbar pull at that instant. Measuring the same in inches and subtracting a constant and then multiplying by 4,000, gave the drawbar pull in pounds—*i.e*, every inch in height represented 4,000lb. The paper travelled under the pen at a rate proportional to that of the train. An irregular line marked No. 2, above the base line, was the planimeter record, from which was determined the mean pull for any time. Having, then, the velocity, or the feet per minute, and the mean pounds pull exerted during any period, we readily obtained the horse-power developed.

Another line on the diagram showed the chronograph record, each of the small offsets in the line occuring every five seconds. For every 100ft. the train moved the paper moved 1in. The distances in inches between any two of these offsets gave us readily the velocity of the train. Another line represented the time readings of current and voltage which were taken in the locomotive, a

* From the *Electrical Engineer* of New York.

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push-button in the locomotive being electrically connected with this recording apparatus. These readings were numbered, so it was easy to tell the current at any time and location. Still another line showed a record of the different stations in the tunnel. From this we determined the location of the train at any time.

The first test showed (*a*) how the start was made on the down grade leading to the tunnel; (*b*) how, after the train was fully started, the drawbar pull dropped off; then (*c*) how it gradually increased as the train came on to the 0·8 per cent. grade in the tunnel; and (*d*) after the train was wholly on the grade, how even the pull was, until near the stop, when the grade increased 1·2 per cent. Mr. Dunbar, the official of the Pennsylvania Railroad Company in charge of the car, showed some diagrams of steam locomotive work under similar conditions, and it was seen that their amplitude of vibrations was considerably greater than those of the electric locomotive. This was undoubtedly due to the absence of the angle crank on the electric locomotive, and because its pull is uniform throughout the entire revolution of the armature. Most of the vibrations of the pen shown on these curves were due to vibrations of the dynamometer car which was mounted on a single truck.

From test No. 1 we obtained the total drawbar pull in pounds, and knowing the weight of the train we found the drawbar pull to be 22. + lbs per ton of weight. Subtracting the grade pull, which, in the case of an 0·8 per cent. grade, is 16lb., we obtained 6. + lbs. per ton as the train resistance. This confirms the usual allowances made for freight train resistance. These observations were taken in September, 1895, on a very hot day. During the past winter months the train resistance has increased, due, no doubt, to greater journal friction caused by thickened lubricants, and we find it to be from our records about 20 per cent. to 30 per cent. greater than in September.

Test No. 2 was made after we had switched off six cars. The run was made under similar conditions and the same character of observations was made. The difference in drawbar pull of the two trains would naturally be the drawbar pull necessary for the six cars switched off. We had their exact weight, and were thus again able to find what the drawbar pull per ton was. It was a check on our first figure, and was very close to it, the slight difference we found being due to one brake on the six cars being partially set during the first run and unknown to anyone.

We had the readings of current during the first run, also during the second. The difference of these should show the current required to haul six cars switched off. Dividing the difference in the drawbar pulls recorded in the two tests by the difference in current recorded, gives us directly the net drawbar pull in pounds per ampere of current. This was 28·6lb.

It will, of course, be noted that by this method we eliminated the current required to drive the locomotive. To determine how much this was, and to check our conclusions, we divided the drawbar pull in pounds recorded in the first by 28·6, and thus obtained the current that should exert that net drawbar pull. Subtracting this current from the current actually recorded on the locomotive would give the current required to drive the locomotive. We found it took 144 amperes. As a further check we figured similarly for the second test and obtained precisely the same, *i.e.*, 144 amperes. So at any time now when hauling a train with the four motors in series, if we take the current indicated on the amperemeter and substract the 144 amperes needed for the locomotive, and multiply the remainder by 28·6, we have the total net drawbar pull in pounds, and if we divide this by the drawbar pull per ton we get the tons of load we are pulling.

From the results obtained above we were able to show the current and drawbar pull at any moment while accelerating a train. The curves (Figs. 1 and 2) explain themselves very fully. The acceleration curve (Fig. 2), was obtained by dropping doughballs every two seconds, and they were the markers used in determining the distances travelled in each interval, as shown on the curves in Fig. 2.

When it comes to comparison of the economy of electric and steam locomotives it is readily seen that it is a difficult undertaking, knowing as we do the figures of only a single isolated electric plant operating under special conditions and for a comparatively short time. One great incidental advantage of electric locomotives in tunnel service is that they are smokeless. This is an important hygienic consideration, but one which can hardly be computed in dollars and cents. But it may be of general interest to know how the actual operating expenses per engine mile of the electric locomotives during October, 1895, compare with those of a prominent and large eastern railway for the same month.

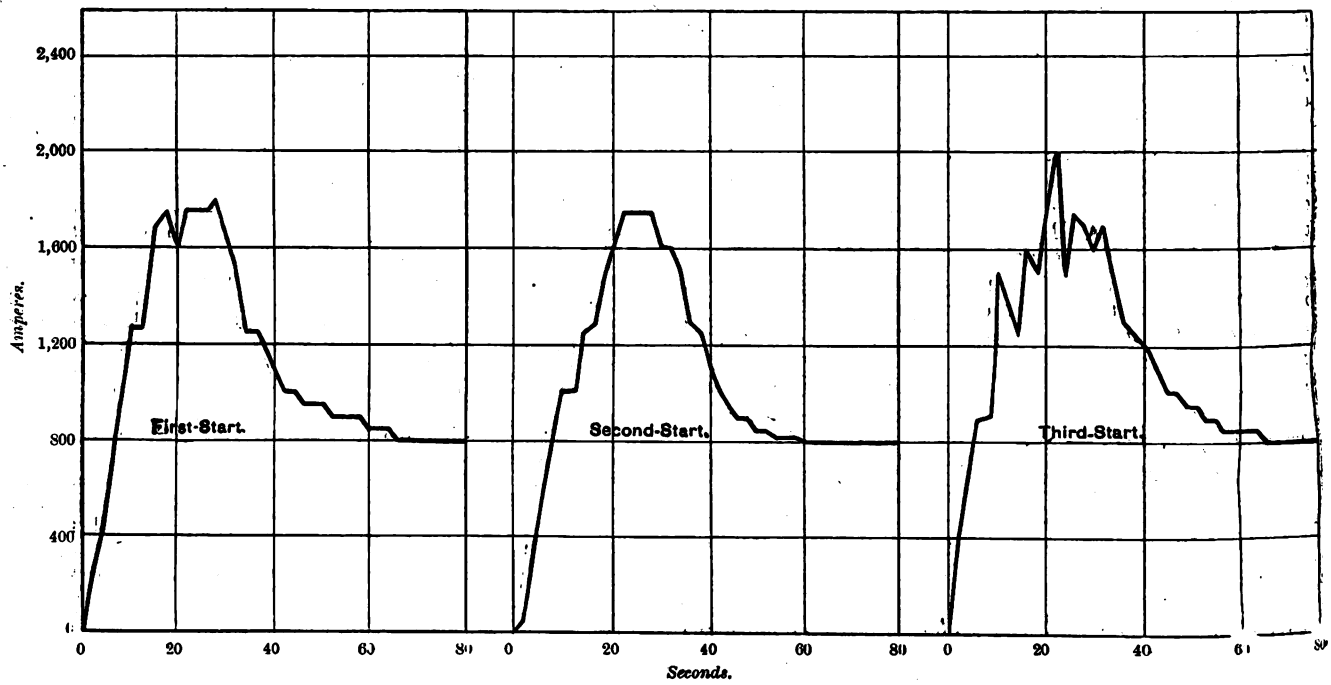

FIG. 1.—Current Record, two second readings. Three successive starts of a freight train on a grade of 0·8 per cent. Approximate weight of train, 875 tons.

For the operation of the Baltimore and Ohio tunnel power house for the month of October, 1895, the itemised expenses were as follows :—

Labour	$1,345.70
Coal ($1.35 per ton)	400.96
Oil and waste	151.26
Water	50.56
Maintenance	25.42
Total	$1,974.00

The expense of electric locomotives was :—

Motor engineers	$200.00
Oil and waste	12.16
Total	$212.16
Total expense	$2,186.16

There were hauled through the tunnel 353 trains.

Average weight of train	tons	1,095
Average time of trip	minutes	20
Average current	amperes	966
Distance of trip	miles	4
Total engine travel	miles	1,412
Total engine travel "idle"	miles	3,756
Actual time consumed for above service	hours	118
Idle time for month	hours	626

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It is customary to consider an engine with steam up as equivalent to six engine miles for each hour it is idle, so that, for comparison, the actual mileage made by the engines must be increased $6 \times 626 = 3,756$ miles.

The large charge of labour at power house will be the same for one, two or three locomotives in service. The items, coal, water and maintenance, and the expense on locomotives, increase with the number of locomotives in service. If we assume this increase to be proportional, the total expense and cost per engine mile are as follows :—

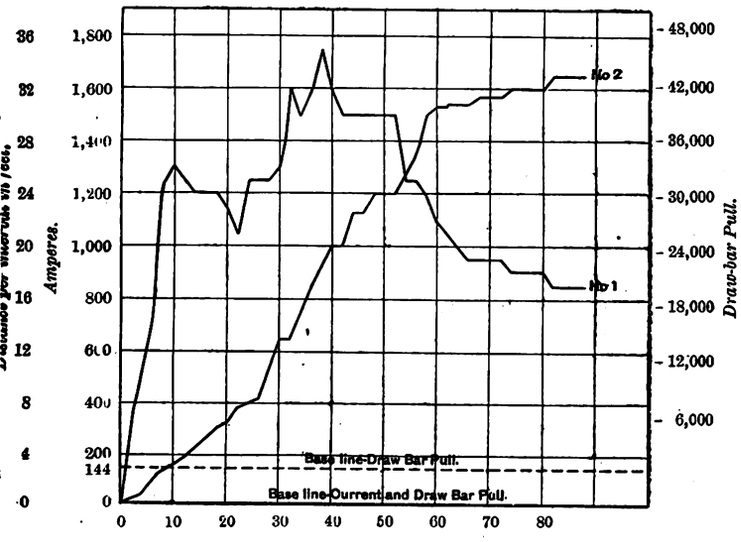
—	Total Cost.	En. miles.	Cost per en. mile.
For one locomotive	$2,186.16	5,168	$0·423
For two locomotives.....	2,875.36	10,336	0·278
For three locomotives	3,564.56	15,504	0·23

The steam railway records referred to above are for October, 1895, and may be briefly abstracted as follows :—

Steam Locomotive Performance.

—	East div.	West div.	Cen. div.	N.&W. div.	Entire Line.
Locomotives in service	74	57	33	28	192
Av. engine mileage in service	2,834	2,966	2,293	2,305	2,703
Average cost per engine mile—					
Passenger engines	0·1926	0·1666	0·1629	0·1552	0·1765
Freight engines	0·2472	0·2656	0·3428	0·2303	0·2615
Switching engines	0·1489	0·1659	0·1828	0·1425	0·1577
Work engines	0·2391	0·2258	0·2617	0·2169	0·2354
Total Engines	0·2080	0·2183	0·2121	0·1797	0·2095

From the figures given above it is seen that the actual operating expenses of the electric locomotives for that particular month are about the same as for the freight locomotives on the steam railroad, *i.e.*, 23 cents per engine mile. The service of the electric locomotives at that time was only about one-third that which it is expected they will have to do when the passenger service is taken up and the line extended the full distance.



No. 1.—Current and Draw-bar Pull.
No 2.—Acceleration, feet per interval of two seconds.

FIG. 2.—Electric Locomotive, B. and O., No. 1. Current and Torque and Speed Record of the start of a freight train of 28 loads and two dead engines on a grade of 8 per cent. Weight of train, 910 tons.

As originally intended, a method of using to advantage the power of the station while the electric locomotives are idle is soon to be incorporated in the plant. Under the new conditions, the cost per engine mile for the electric locomotives will be far under that of steam.

A comparison of the efficiencies of steam and electric locomotives shows slightly in favour of the electric. Observations made on French railways and on the Pennsylvania Railroad show that about 45 per cent. to 55 per cent. only of the indicated horse-power of steam locomotives is applied to hauling trains. The efficiency of the Baltimore and Ohio plant is in the vicinity of 60 to 65 per cent. under normal conditions.

A word may be added as to our experience with the overhead conductor system. The conductor in the tunnel has now been in position for nine months. During all of this time coke-burning locomotives have been used for passenger service, with the consequent presence of a good deal of gas and vapour. For the first six months about half of the conductor was constantly wet from the drip due to leaks in the masonry. This occasioned a muddy, slimy deposit over the insulators, and a considerable portion of the conductor. The porcelain insulators are almost entirely obscured in some places by this deposit, and that of small particles of carbon given by the locomotives.

Current was first turned on the line about three months after the tunnel structure was erected. The leak to earth was at first 21 amperes, but in a day or two this dropped to about 4 amperes—the present leakage. The inside of the conductor was coated with a combined deposit of rust and muddy sediment. Heavy currents were taken from it by the contact shoe only with difficulty and the presence of much arcing, heating and showers of sparks. It was found impracticable to run on this surface. By applications of kerosene and frequent scraping with special shoes, a direct contact of the trolley shoe with the conductor was made possible. Although a single contact shoe then worked with little or no sparking, two shoes in tandem were adopted. Their operation through the conductor is smoother, and the contact over muddy portions of it is more nearly positive. At intervals of about three weeks the conductor is treated with kerosene, and brushing shoes are run through it, about one or two trips with these brushing shoes being all that is necessary. This serves to prevent the further accumulation of rust, and to remove the sediment from the contact surfaces. An inspection shows a smooth surface over which the shoes run. Contact with the metal is seen to be in high spots and thin lines which are slowly increasing in extent. No considerable sparking now occurs, except at the wet places, where it is occasioned by the presence of water and sediment. With the exception of three places, about 200ft. long each, the conductor is at present dry.

The bolts to the arch of the tunnel are both galvanised and painted. They show no signs of rusting. The painting has, in general, protected the surface of the conductor and channels. The sides and top of the inside of the conductor are coated with rust. Most of this is hard and close gained, some of it, however, flaky. In no case is there apparent a reduction of thickness of any of the ironwork due to rusting. Outside the tunnels the conductor is in uniformly good condition. It adapts itself to changes of temperature without trouble. The inside of the conductor is coated with rust, but in no case has there been any trouble from it. The deposit appears to be very light. There was at no time any sparking between contact shoes and conductor outside of the tunnel.

FLYWHEEL ACCIDENTS IN POWER STATIONS.*

The recent flywheel accidents, although of the utmost importance to street railway and electric light companies, seem to have attracted very little attention. The Hoboken accident has been referred to, as a rule, in a most misleading manner, and the result of the investigation held by the Company some time after the accident seems to have been overlooked. The Albany accident appears to have attracted still less attention, though coming, as it did, shortly after the other, and being the cause of several deaths, it should have been of deep interest to all liable to the same casualty.

The Hoboken accident is laid by the owners to the carelessness of the engineer, and is consequently of little interest, since it shows no fault in the design or operation of the plant and machinery.

An inquiry made of the employés in the Albany power house the day succeeding the accident brought out as answers to some natural questions the statement that there was no apparent electrical trouble, and that while the plant was in normal operation under light load an engine was seen to gain speed. The engineer noticed it and immediately closed the throttle, which action of his did not interfere with its increasing speed. Running to the switchboards he cut the dynamo belted to that engine out and turned around just in time to see the wheel flying to pieces. No fuse had melted, and the generator remained in circuit until cut out by the engineer. Accepting as true that the throttle was closed in time, we can only surmise that the generator belted to the wrecked engine had been driven as a motor by the other generators feeding the same lines. This cause of the accident seems perfectly clear, and it is remarkable that there have been no such accidents before.

The plant consisted of two 500-kilowatt generators compounded for a line loss of about 10 per cent., and driven separately by Corliss engines of like capacity. In addition there were several smaller generators, driven in pairs by high-speed engines. Under the severe requirements of railway work, engines are liable to vary considerably in speed. The two 500-kilowatt generators and two of the smaller ones were connected in parallel to the lines, and if one of the engines lost speed from any cause, there was a possibility of the current from the stronger machines sending current backward through the lagging one. This is particularly liable to

* From the *Electrical World* of New York.

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happen when the load is light, and is a common occurrence, understood by every electrician who has spent much time in a railway power station.

What is liable to happen in such a case is as follows: The shunt field-winding would still keep the field magnetism in the same direction, but, the direction of the current through the armature being reversed, the generator would be driven forward as a motor. The series winding would then contain a current flowing in an opposite direction to that in the shunt winding, and would consequently tend to weaken the fields of the machine and increase the current flowing through it. Indeed, the influence of the series winding is usually strong enough to so weaken the fields as to cause enough current to flow through the machine to operate the automatic brake commonly used. This would not necessarily follow, as the immense force exerted would quickly speed the generator and engine attached to it until it would develop a counter E.M.F., with its weakened fields equal to the E.M.F. of the generators driving it. The E.M.F. of the driven machine once lowered, it is a matter of some time to get it back, notwithstanding the increased speed; and the heavy current that would flow until a balance was effected would leave the fields in the same condition as at starting, when it required a very considerable period of time to build up the fields to their normal strength. Sometimes an engine will give way under such an unusual speed as would thus be attained before a balance was reached.

The danger is not so great from small generators as from large ones, and the time taken for a machine to attain its normal voltage when running at full speed is a fair comparison as to its liability to run away. The greater the proportion of series winding, the greater also the danger. From the instant the current starts to move the reverse way through the armature, it increases in quantity of flow, slowly sometimes on account of the time taken to reduce the magnetism of the fields by reason of their mass and construction, and the higher speed of the engine as its load is entirely removed; this follows because the action of the current in the field windings is more rapid than the gain in speed of the weighty engine, until the engine after a time gets a start and brings up its speed with a rush, increasing its E.M.F., and at the same time decreasing the current flowing through it.

The element of time in the strengthening or weakening of a large field magnet is so considerable that the writer has frequently seen one 500-kilowatt generator being reversed by its mate driven by the same pulley, and by quickly strengthening its field by a turn of the field rheostat has brought it back to its work as a generator. Were it not for the element of time in changing the strength of the magnets, no physical movement would be quick enough to check an action that is theoretically as instantaneous as the flow of electricity where there is so little self-inductance. It is this element of time in changing the strength of the fields that will cause an engine to run away.

The cure is as simple as the disease. A spring switch, the spring held in place by a compound magnet balanced by a weight, the magnet wound with both the main wire and the field shunt, and also so balanced as to hold the weight while both currents were in the same direction, and to release it when they opposed each other; this could easily be made and would prove effectual. A prop to hold up the weight could be arranged similar to that commonly used to hold up the governor weights on Corliss engines for convenience in starting.

ELECTRIC SUPPLY IN GERMANY.

The *Elektrotechnische Zeitschrift* for March 5th contains some tables showing the state of the electric supply business in Germany. There were on October 1st, 1895, 180 central stations in operation and 82 in progress or definitely decided on; of these latter, however, several have meanwhile commenced supply. Continuous-current is still the leading system, and is represented by 80 per cent. of the total output and by 74 per cent. of the total number of stations. Table I gives an analysis of the different systems. Of the continuous-current stations, 73 per cent. possess accumulators, the total capacity of which is about 30 per cent. of the total dynamo output of those stations. Table II. shows the different motive powers employed, steam leading with 55 per cent. of total capacity and 82 per cent. of the total number of stations. The largest central station is the Mauerstrasse station in Berlin, which has a dynamo capacity of 3,146 kilowatts. Then follow others at Hamburg, Berlin, Frankfort-on-Main, Leipzig, Munich, &c. In all there are 23 large stations, 58 of medium size, and the remainder which represent half the total are stations with dynamo capacities under 100 kilowatts. The 180 stations are distributed over 168 towns. Connected to the supply mains there are 602,986 50-watt glow lamps (England, 2¼ million 35-watt lamps), 15,396 10-ampere arc lamps, and motors to the extent of 10,254 H.P. These figures compared with last year show an increase of 22 per cent. in glow lamps, 24½ per cent. in arc lamps, and 82 per cent. in motors.

TABLE I.

System.	Number of stations.	Capacity of dynamos (kilowatts).	Capacity of batteries (kilowatts).	Total capacity of stations (kilowatts).
Continuous current with accumulators	102	18,165	5,420	23,585
Continuous current without accumulators	37	11,581	...	11,581
Alternating	16	4,396	...	4,396
Three-phase	12	4,468	...	4,468
Combination systems:—				
Three-phase & continuous current	4	1,746	566	2,312
Alternating current (generated), continuous current (distributed)	1	99	116	215
Continuous and alternating current	1	16	...	16
Not stated	7	...	...	...
Total	180	40,471	6,102	46,573

TABLE II.

Motive power.	Number of stations.	Total capacity of dynamos (kilowatts).
Steam	99	33,222
Water	41	4,224
Gas	5	265
Compressed air	1	14
Electric motors	3	126
Combination systems:—		
Water and steam	19	2,280
Water and gas	1	30
Steam and gas	3	310
Not stated	7	...
Total	179	40,471

THE PROPOSED ELECTRIC TRAMWAY CONDUIT IN PARIS.

In a Paper recently read before the Société des Ingénieurs Civils, of Paris, on the subject of "Electric Railways with Underground Conductors," M. A. Lavezzari describes an interesting conduit-railway which is projected in Paris. The line will begin at the Place Cadet, near the Porte de Montmartre, and will extend through Rues Cadet, Rochechouart and others, to the end of Rue du Poteau. The road will be 1⅝ miles long, 1⅛ miles of which will be double-tracked, and the remainder single-tracked.

The heaviest grade is only 6 per cent., and occurs in Rue Rochechouart; the other grades average less than 3 per cent. The smallest curve radius is 105ft. The localities traversed are of the most thickly populated in Paris, and those where travel is most active throughout the day, and it is expected that the line will transport 20,000 passengers a day.

The gauge of the track is one metre (39⅜in.), and on the double-track portion of the line the conduits are arranged as shown. One rail of each track is of the usual girder type, but the other is a modified T-rail, and a similar rail is laid alongside it, with sufficient space between for the passage of the plough. The conductor conduit is located, of course, immediately beneath these rails, and contains both the positive and negative conductors, the rails not being included in the circuit.

The beams rest by means of cast feet on the two side walls of masonry of the main conduit, which is really a large sewer of the usual Parisian type, 5ft. 7in. high under the arch, and provides ready access for the inspection and repair of the conducting system. To facilitate inspection and the transportation of material small trucks may be run along the lower part of the conduit; the track will be formed by two angle-irons set in the masonry.

The transmission of energy between the station and the cars is provided for by two feeders, positive and negative, which are supported in the upper part of the large conduit. These feeders, for perfect separation, are held apart every 13ft. by supporting insulators. Every 328ft. connection is made by branch conductors between the feeders and the working conductors, which latter are of steel and shaped thus:] The branch connections are single conductor flexible cables, provided at one end with pins or shanks which fit in sockets attached to the feeders, permitting ready disconnection when it is desirable to cut out a section of the line.

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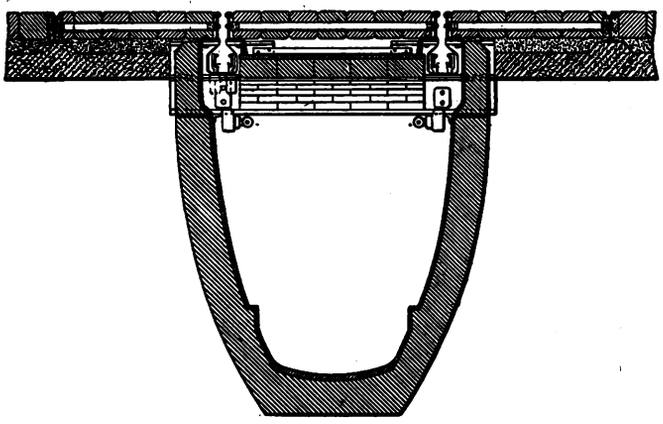
The steel working conductors are supported every 6½ft. by cast arms bolted to the short beams forming the yokes. Double-petticoat porcelain insulators are provided for the conductors. Every 1,000ft. bells or telephone instruments will be installed in the large conduit to place each section of the line in communication with the power station. The collector has the form of a shuttle and rubs against the faces of the steel conductors, contact being maintained by means of springs. The shuttle is flexibly attached to a plough suspended from the car; both are so arranged that in case the car leaves the track they will detach themselves and become disconnected mechanically and electrically from the car without causing damage.



Cross-Section showing Double Track Construction.

The station will contain three engines of 150 H.P. each, coupled by belts or ropes to three 500-volt dynamos, each of 100 kilowatts capacity. The cars will have a capacity, including the platform, of 36 passengers; there will be no top seats. All the cars will be equipped with two motors of 10 H.P. each, but will run in pairs, and the front car will contain all the controlling apparatus, the rear car being provided with motors only.

LONGITUDINAL LIGHT.*

BY G. JAUMANN.

(Concluded from page 657.)

The State τ. Connection between μ and τ.—The magnetic phenomena are connected in the same way with mechanical as are electric phenomena. We may, therefore, repeat the reasoning of the last paragraphs *verbatim*, if instead of electric we deal with magnetic forces, and put μ for ε, and instead of σ we speak of a new physical condition, τ, influenced by the distribution of the magnetic forces.

This gives an equation analogous to (II.'), and this might be taken for the equation required to represent $d\mu/dt$ as a function of the distribution of the magnetic forces. It is correct, indeed, but is *not the equation sought.* From this parallel reasoning we only accept the final equation for the condition of rest of any medium,

$$0=\frac{d}{dz}(\mu_0\mathfrak{X})+\frac{d}{dy}(\mu_0\mathfrak{Y})+\frac{d}{dx}(\mu_0\mathfrak{Z}).$$

As long as we lack proofs—as I know of none—that Maxwell's theory is also insufficient in the magnetic direction, it is not advisable to assume this. However correct it may be to translate the considerations above into magnetic terms, still the choice of the constant corresponding to η_0 is free. This must have the value 1 for all media, and also for rarefied air. *Then μ is independent of the distribution of magnetic forces.*

The assumption of different values for η_0, and the sole value of units for the corresponding magnetic constant amounts to a purely numerical inequality, and corresponds to the notable asymmetry of the known electric and magnetic phenomena.

The electric phenomena are much more varied; there are electric, but not magnetic cathode rays, discharges and chemical phenomena.

The difference of this chapter from the preceding one will show that the present theory is not a merely formal structure, or it would have certainly now lapsed into considerations of symmetry.

Connection between μ and σ.—It does not follow from the remarks contained in the last paragraphs that μ retains a constant value during electromagnetic processes. This cannot be. In that case the constant magnetic forces $\mathfrak{X}_0$, $\mathfrak{Y}_0$, $\mathfrak{Z}_0$ would vanish from equation (I') although we know that constant magnetic forces have a great influence upon the course of the cathode rays.

Wied. Ann., 57, 1, pp. 147—184, 1896.

In reality μ must vary with σ; σ is a physical condition like temperature, pressure, &c. With the temperature all properties of a body change, and also ε and μ. In the same way ε and μ will vary with σ; ε stands, of course, in a different relation to σ from μ, since σ depends upon the electric, but not upon the magnetic forces. But this different relation is expressed in (I.) and (II.), not in (IV.).

The connection between μ and σ is represented by

$$\mu-\mu_0=\nu_0(\sigma-\sigma_0).$$

Here ν_0 is a constant depending upon the nature of the medium, which for dense bodies has the value 1, for rarefied air, according to its decreasing pressure, smaller values, and becomes zero for an absolute vacuum.

Finally we have from (V), (IV), and (II.'):

$$\text{(II.'')}\qquad \frac{a_0}{\eta_0-1}\cdot\frac{\eta_0}{\nu_0}\cdot\frac{du}{dt}=\frac{d}{dx}(\varepsilon_0 X)+\frac{d}{dy}(\varepsilon_0 Y)+\frac{d}{dz}(\varepsilon_0 Z).$$

This is the required equation representing du/dt as a function of the distribution of forces, but not, as expected, of the magnetic, but of the electric distribution of forces.

The reason why the magnetic constant corresponding to η_0 was said to be unity for all bodies, lies in the absence of magnetic cathode rays.

The reason why ν_0 for rarefied air is taken as smaller than 1 is that constant magnetic forces are not without influence upon cathode rays.

IV.—Deductions (Provisionally Communicated).

From the foregoing theory follows the necessity of the appearance of longitudinal electric rays (especially in rarefied air in the presence of large static electric forces), which completely bear the character of cathode rays.

In electro-optics also the theory shows a remarkable agreement.

From the latter field we may gather a large number of new experimental motives, but these will not be discussed until the experiments have been made, for which the means are not at present at my disposal.

Longitudinal Plane Wave. Difference of Species of the Cathode Rays.—Let there be present in a rarefied air space a static electric force Z_0 and no magnetic force. Then an electric longitudinal wave is possible in the z direction. The equations (I.') and (II.') are reduced to

$$\text{(I'3.)}\qquad \varepsilon_0\frac{dZ}{dt}+Z_0\frac{d\varepsilon}{dt}=0,$$

$$\text{(II.')}\qquad \frac{a_0}{\eta_0-1}\frac{d\varepsilon}{dt}=\varepsilon_0\frac{dZ}{dz}.$$

One of the solutions is

$$\text{(a)}\qquad Z=Z_0+C\sin\frac{2\pi}{\tau}\left(t-\frac{z}{c}\right).$$

$$\varepsilon=\varepsilon_0+E\sin\frac{2\pi}{\tau}\left(t-\frac{z}{c}\right).$$

The period τ of these rays is arbitrary, and they superimpose.

The ratio of the amplitudes E and C is

$$\frac{E}{C}=-\frac{\varepsilon_0}{Z_0}.$$

The velocity of propagation c is found to be

$$\text{(3)}\qquad c=\frac{\eta_0-1}{a_0}\cdot Z_0.$$

It follows, from the position of the sines in (a), that propagation takes place in the positive z direction if c is positive. Whether any propagation in that direction takes place depends, therefore, upon whether c in equation (3) has a positive value.

Since η_0-1/a_0 has a definite value, it depends upon the sign of the static electric force Z_0 whether propagation is possible in the positive or negative z direction. Only one of the alternatives is possible, not both, as in the case of transverse waves, when c is determined by a quadratic equation. The longitudinal wave can only, if a_0 is positive, be propagated in the direction of the negative electric force, for η_0-1 has by the foregoing an essentially negative value.

This explains the difference of species of the cathode rays. The necessary limiting conditions* for the excitation of cathode rays, viz., the oscillations of electric forces in the normal to the surface perpendicular to the z direction, are provided by the wire waves

* In 1892 (see above) I specified rapid variations of force normal to the electrode as the condition of excitation of cathode rays. E. Wiedemann has simultaneously arrived at the same conviction on experimental grounds. He says (*Zschr. f. Electro-Chem.*, 8, 1895): "If at the border separating *any* medium from a rarefied gas, rapid variations of potential occur, they give rise to the phenomena usually observed at the cathode in discharge tubes, especially cathode rays, &c.; similar structures appear at the boundary surfaces of differently constituted portions of the same gas, at the boundary of the dark space, at narrow parts of the tube, &c." See also Wiedemann and Ebert, Phys. Med. Soc. in Erlangen, February, 1892.

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approaching the two electrodes in the same manner. But the cathode rays can only issue from the cathode, for there they have in the outward direction (metal to air) a positive velocity of propagation. At the anode they have a negative velocity outwards, and cannot therefore occur.

η_0 has been shown to have a value very near 1 for dense bodies. Hence the velocity of propagation is very small in dense bodies, and longitudinal rays are difficult to obtain. But as rarefaction proceeds η_0 steadily decreases, so that the velocity of propagation of the cathode rays increases until it attains the limiting value Z_0/a_0 in a vacuum.*

The Blue Cathode Light.—It may be supposed that the blue positive brush light in ordinary air corresponds to the blue cathode light in rarefied air. The latter is known to be an effect of the cathode rays. Then the blue positive glow is an effect of anode rays, which, to judge from their slight thickness and greater luminosity, must have very small velocities of propagation.

From this it may be supposed that η_0 in dense air has a value slightly larger than 1. Accordingly, by (3), only anode rays of small velocity are possible. During rarefaction η_0 falls to 1, then by (3) $c=0$, and no longitudinal waves are possible. As rarefaction proceeds further, η_0 falls belows 1 to 0. These anode rays are excluded, but cathode rays appear, and their velocities of propagation increase with the vacuum. The blue layer appears at the cathode and increases in thickness, while losing in luminosity.

The production of the blue light must be connected with an enfeeblement of the cathode rays. But according to the approximate equations here used (I.′) which obtain for larger static forces, the cathode rays are undamped. Near the cathode, *where the static force preponderates*, the blue light cannot occur. This is in reality a dark space,† which *gradually* passes into the blue light.

At greater distances from the cathode, where the amplitude of the ray does not vanish in comparison with the static form of the field, the equations (I.) apply, which no longer admit sine rays. On entering this region the cathode rays experience an easily-calculable modification and enfeeblement.

Propagation of Longitudinal Rays at an Angle to the Static Force. Transverse Waves.—In rarefied air, also, longitudinal rays are possible, whose wave front is inclined to the direction of the static electric force, and whose direction, as will be shown later on, is perpendicular to the wave front. These rays are, however, not purely longitudinal, but are provided with transverse components. The following equations apply :—

$$\text{(I.′1)} \qquad \varepsilon_0 \frac{d\mathrm{X}}{dt} + \mathrm{X}_0 \frac{d\varepsilon}{dt} - c_0 \frac{d\mathfrak{Y}}{dz} = 0.$$

$$\text{(I.′3)} \qquad \varepsilon_0 \frac{d\mathrm{Z}}{dt} + \mathrm{Z}_0 \frac{d\varepsilon}{dt} + c_0 \frac{d\mathfrak{Y}}{dx} = 0.$$

$$\text{(I.′5)} \qquad \mu_0 \frac{d\mathfrak{Y}}{dt} - c_0 \frac{d\mathrm{X}}{dz} + c_0 \frac{d\mathrm{Z}}{dx} = 0.$$

$$\text{(II.′)} \qquad \frac{a_0}{\eta_0 - 1} \cdot \frac{d\varepsilon}{dt} - \varepsilon_0 \frac{d\mathrm{Z}}{dx} - \varepsilon_0 \frac{d\mathrm{X}}{dx} = 0.$$

One of their solutions is

$$\mathrm{Z} = \mathrm{Z}_0 + \mathrm{C} \sin \frac{2\pi}{\tau}\left(t - \frac{mx+nz}{c}\right).$$

The other three variables X, $\mathfrak{Y}$, and ε are "coherent" and equal-phased, and their amplitudes are proportional to the amplitude c. By putting in this solution we obtain four homogeneous equations for the determination of these amplitudes. The determinant of their coefficients must vanish. This gives the condition

$$(c_0 - \mu_0 \varepsilon_0 c^2) \cdot \left[\frac{a_0}{\eta_0 - 1} \cdot c - (m\,\mathrm{X}_0 + n\,\mathrm{Z}_0)\right] = 0.$$

In wave planes with the direction cosines m and n of the normal we may therefore have three different waves. Two of these correspond to the velocities of propagation

$$c = \pm c_0 \sqrt{\frac{1}{\varepsilon_0 \mu_0}} \left(\frac{d\varepsilon}{dt} = 0\right).$$

In rarefied air also, and in the presence of large static forces, ordinary transverse waves may be propagated in all directions.

The third wave is partly *longitudinal*. It has the velocity

$$\text{(5)} \qquad c = \frac{\eta_0 - 1}{a_0}(m\,\mathrm{X}_0 + n\,\mathrm{Z}_0).$$

This, therefore, is proportional to the cosine of the angle between the total static electric force and the wave normal.‡

Longitudinal rays may therefore not only be propagated in the direction of the negative force, but also at an angle to it, when the velocity decreases. Perpendicularly to the direction of the electric force they have zero velocity. On turning them still further in the direction of the positive force, they are no longer propagated, since their velocity becomes negative.

The insertion of (5) into the amplitude equations shows that these rays have the stronger transverse components, the greater their inclination to the static force. These transverse components lie in the wave surface, the electric transverse component X being in the plane of incidence of the static force, and the magnetic transverse component $\mathfrak{Y}$ at right angles to it.

The condition imposed upon the ray by a normally acting magnetic force, $\mathfrak{Y}_0$, is not without interest. This occurs in equation (I′.5) in the term $+\mathfrak{Y}_0\, d\mu/dt$. It also enters into the determinant, but just in the place where it contributes nothing to its value. Hence the velocity of propagation is not affected by a magnetic force. The transverse components also remain equal-phased, but they alter the ratio of their amplitude to that of the longitudinal component. The total electric vibration is thereby given a different direction with respect to the wave normal. It would not be correct to interpret this in the sense that the magnetic force rotates the direction of electric vibration of the rays, but it means that a ray of such a wave surface, *i.e.* a ray which is not deviated by the magnetic force, is only possible when provided with transverse components under the limiting conditions, such components differing according to the magnitude of the normally acting magnetic force.

Reflection: Inapplicability of Huyghens' Principle.—These rays may be regularly reflected at the bounding plane of another medium, supposing that the static electric force is parallel to the reflecting plane.*

In every other case, especially where the angle of incidence of the rays is smaller than the complement of the angle of incidence of the static electric force, a regular reflection is not possible, for the reason that by equation (5) the velocity of these rays depends upon their direction. This causes the curious phenomenon observed by E. Wiedemann and H. Ebert†, that cathode rays are usually *diffused* by a smooth bounding surface.

The possibility of regular reflection shows that Huyghens' principle does not apply to cathode rays. Equation (5) determines the surface of normals. In this case it is a sphere whose surface, however, passes through the centre of excitation and whose centre lies in the direction of the negative electric force. All the wave surfaces touch the pole to this sphere. Hence, this pole represents the whole Huyghens surface. This would imply that the direction of the rays can only coincide with the direction of the negative force. This is not so, since regular reflection is possible.

In this case, and in the following, the conclusions from Huyghens' principle are in contradiction with the direct calculation from the same fundamental differential equations. Huyghens' principle gives for transverse waves and sound waves, representing a case of the second degree, two solutions—a forward and a backward wave. One of these is right, the other wrong. In this case of the first degree the principle gives only one solution, and that a wrong one.

Sharply defined Cathode Rays.—Limited Transverse Rays.—The cathode rays have, as shown already, a period of about 10^{-9}sec., or much longer than light. In addition, they are longitudinal. It is therefore remarkable that they are not propagated like sound, but in sharply-defined rays like light. Now I can show that just the longitudinal rays of my theory have, with any period, the capacity of yielding sharp rays, while transverse light only yields sharp rays with small wave lengths.

For simplicity the propagation of sharp rays in the direction of the electric force Z_0 only is to be dealt wth. We may then put $X_0 = 0$ in the differential equations. A characteristic solution of these equations, after eliminating $d\varepsilon/dt$, is

$$\text{(6)} \qquad \begin{cases} \mathrm{Z} = \mathrm{Z}_0 + \mathrm{C} \sin \dfrac{2\pi}{\kappa} x \,.\, \sin \dfrac{2\pi}{\tau}\left(t - \dfrac{z}{c}\right), \\ \mathrm{X} = \quad \mathrm{A} \cos \dfrac{2\pi}{\kappa} x \,.\, \cos \dfrac{2\pi}{\tau}\left(t - \dfrac{z}{c}\right), \\ \mathfrak{Y} = \quad \mathfrak{B} \cos \dfrac{2\pi}{\kappa} x \,.\, \cos \dfrac{2\pi}{\tau}\left(t - \dfrac{z}{c}\right). \end{cases}$$

This represents a ray of infinite wave surfce z=constant, whose direction is x=constant, since its intensity changes in the direction x. This change with x is sinusoidal.

* The velocity of longitudinal elastic waves in a compressible medium changes in the reverse order—viz., between ∞ and 0.

† This and the blue light space must not be confounded with the dark space sharply marked off towards the blue end of the discharge.

‡ H. Poincaré has shown (*C. R.*, December, 1895), that the rays of my theory follow this law of velocity under all circumstances. His conclusion that on that account the direction of these rays always coincides with the statical force is inadmissible.

* They also penetrate into the new medium, *e.g.* glass, and freely at normal incidence, but are subject to great absorption, not in the interior of the glass, but at the surface. This is easily calculated from the energy equation (III.), allowance being made for the change of η_0 in the surface layer from 0 to 1 nearly. Cp. observations by Wiedemann and Ebert.

† Phys. Med. Soc. Erlangen, December, 1891.

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The determinant of coefficients of the amplitude equation comes out as

$$(7) \qquad \left[c_0^2 - \left(\varepsilon_0\mu_0 - c_0^2\frac{\tau^2}{\kappa^2}\right)c_2\right]\cdot\left(c - \frac{\eta_0 - 1}{a_0}Z_0\right) = 0.$$

There are again three solutions. In the first place, a longitudinal wave of the velocity of propagation

$$c = \frac{\eta_0 - 1}{a_0}Z_0$$

is possible. Hence the sinusoidal distribution of the intensity in the section of the ray does not change its velocity of propagation. We may, therefore, assign any value to the width of strips κ in solution (6), and on composing a series of such solutions by Fourier's theorem we obtain the following thesis :—

Longitudinal rays of small amplitude are possible with any distribution of intensity in their section, and therefore also with a sharply-defined section without limiting conditions, for any period, and they have the normal velocity of cathode rays.—As seen from equation (6), there are no transverse components at the centre of a limited cathode ray, but they occur towards the edges (a radial electric and a tangential magnetic component), and they are displaced with respect to the longitudinal vibration to the extent of a quarter wave length.

Further, we obtain from (7) the two velocities of propagation

$$c = \pm c_0\sqrt{\frac{1}{\varepsilon_0\mu_0 - c_0^2\frac{\tau^2}{\kappa^2}}}.$$

These correspond to transverse rays with a sinusoidal distribution of intensity in the section. If $c_0\tau/\kappa$ does not vanish, *i.e.*, if the cross-division is of the order of the wave-length of the ray, these rays have not the normal velocity of propagation of the transverse rays.

We can therefore only compound a series of such rays of different width κ by Fourier's theorem to a sharply-defined pencil, when their sectional area is large in comparison with the wave-length.

Hence *transverse rays must always be ill-defined at the edges.* As seen by (6), *longitudinal light occurs at the edge of every transverse light ray* (even in air at ordinary pressures), and is displaced by a quarter wave-length with respect to the transverse portion.

Rotation of the Wave Surface by a Perpendicular Magnetic Force.—A pure longitudinal wave of infinite wave-surface under the influence of a perpendicular magnetic force only retains the direction of its electric oscillation, and has no need of a transverse magnetic component *if the wave surface rotates under the influence of the magnetic force.*

This follows from the equations

$$(I.'3) \qquad \varepsilon_0\frac{dZ}{dt} + Z_0\frac{d\varepsilon}{dt} = 0.$$

$$(I.'5) \qquad \mathfrak{Y}_0\frac{d\mu}{dt} + c_0\frac{dZ}{dx} = 0.$$

$$(II.') \qquad \frac{a_0}{\eta_0 - 1}\cdot\frac{d\varepsilon}{dt} - \varepsilon_0\frac{dZ}{dz} = 0.$$

$$(II.'') \qquad \frac{a_0}{\eta_0 - 1}\cdot\frac{\nu_0}{\nu_0}\cdot\frac{d\mu}{dt} - \varepsilon_0\frac{dZ}{dz} = 0.$$

Their solution is

$$Z = Z_0 + C\sin\frac{2\pi}{\tau}\left(t - \frac{mx + nz}{c}\right).$$

$$\varepsilon = \varepsilon_0 + E\sin\frac{2\pi}{\tau}\left(t - \frac{mx + nz}{c}\right).$$

For the cotangent of the angle of rotation of the wave surface we have

$$-\frac{m}{n} = \frac{\nu_0}{\eta_0}\cdot\frac{\eta_0 - 1}{a_0}\cdot\frac{\varepsilon_0}{c_0}\mathfrak{Y}_0.$$

Let the positive z direction be from left to right, and in this direction let the cathode ray proceed. Let the positive x direction go downwards, then the positive y direction will be towards us. When $\mathfrak{Y}_0$ is positive, the wave normal, by (8), is deflected *upwards.* This is the sense in which the direction of a cathode ray is known to be deflected by a perpendicular magnetic force. The following calculation will show that the direction of the ray and the wave normal are indeed identical.

Magnetic Deflection of the Cathode Rays.—Let us investigate the conditions under which a cathode ray describes a circularly curved path. This will, of course, only be possible approximately and for a short portion of its path. If a perpendicular magnetic force exists, a bent cathode ray is the simplest integral of equations (I.') and (II.'), and the only one which is consistent with the limiting conditions.

The equations shall be transformed to cylindrical co-ordinates, and let y denote the axial direction, x the radial direction, and ζ the polar angle. Let Z be the tangential, X the radial component of the electric force, $\mathfrak{Y}_0$ the axial magnetic force.

The equations are to be reduced to

$$(I.'1) \qquad \varepsilon_0\frac{dX}{dt} + X_0\frac{d\varepsilon}{dt} = 0.$$

$$(I.'3) \qquad \varepsilon_0\frac{dZ}{dt} + Z_0\frac{d\varepsilon}{dt} = 0.$$

$$(I.'5) \qquad \mathfrak{Y}_0\frac{d\mu}{dt} = c_0\frac{dX}{x\,d\zeta} - c_0\frac{dZ}{dx} - c_0\frac{Z}{x}.$$

$$(II.') \qquad \frac{a_0}{\eta_0 - 1}\cdot\frac{d\varepsilon}{dt} = \varepsilon_0\frac{dX}{dx} + \varepsilon_0\frac{X}{x} + \frac{\varepsilon_0}{x}\cdot\frac{dZ}{d\zeta}.$$

$$(II.'') \qquad \frac{\eta_0}{\nu_0}\cdot\frac{d\mu}{dt} = \frac{d\varepsilon}{dt}.$$

We only consider a thin pencil of the cathode ray, whose thickness $(x - x_0)$ vanishes in comparison with the radius of curvature x_0. The simplest solution is the following :—

$$Z = Z_0 + C\left(1 - \frac{x - x_0}{x_0}\right)\sin\frac{2\pi}{\tau}\left(t - \frac{\zeta}{w}\right),$$

$$X = X_0 + A\left(1 - \frac{x - x_0}{x_0}\right)\sin\frac{2\pi}{\tau}\left(t - \frac{\zeta}{w}\right).$$

The intensity of the ray somewhat decreases towards its convex side. The wave surfaces ζ = const. are radial. For the angular velocity w of the ray we have here only one solution.

$$(9) \qquad w = \frac{1}{x_0}\cdot\frac{\eta_0 - 1}{a_0}\cdot Z_0.$$

This solution applies to longitudinal rays. Transverse rays with this course are not possible, and cannot appear as a solution for the simple reason that no magnetic transverse component is provided for.

Further, we have, for the amplitudes A and C, the relation

$$(10) \qquad \frac{A}{C} = \frac{X_0}{Z_0}$$

i.e., the electric oscillations of the ray take place in every part of it in the direction there followed by the static electric force. Finally, we have

$$(11) \qquad \mathfrak{Y}_0 = \frac{\eta_0}{\nu_0}\cdot\frac{c_0}{\varepsilon_0}\cdot\frac{a_0}{\eta_0 - 1}\cdot\frac{X_0}{Z_0}.$$

This is the condition governing the circular form of the ray. If $X_0 = 0$, and therefore the total electric force has a circular path in any case, then by (11) $\mathfrak{Y}_0 = 0$, *i.e.*, the ray follows accurately a curved electric tube of force, unless deflected by a perpendicular magnetic force.

We may therefore attribute to cathode rays of small amplitude having no magnetic transverse components the tendency to follow the electric lines of force of the field, and hence to show electric deflection.*

Cathode rays, provided by the limiting conditions with magnetic transverse components, are more independent of the course of the lines of force, as far as their direction is concerned. This applies even more to cathode rays of high amplitude.

But supposing X_0 is not zero, and the electric force is not circular, then, by (11) a perpendicular magnetic force is necessary in order to deflect the ray from the electric tube of force into the circular path. The sense of the deflection results in the same way as before. The rotation of the wave surface by a magnetic force is, in fact, the same phenomenon as the curvature of the ray now dealt with.

But by (10) the direction of oscillation of the magnetically-curved ray is not influenced by the magnetic force, but takes place as usual in the direction of the electric force.†

The thin bent pencil of a cathode ray here considered corresponds to the axial portion of a limited cathode ray of greater thickness. The edges are more complicated, since they contain magnetic transverse components. Strictly speaking, there will be a magnetic transverse component also in the axial pencil at the points of strong deflection, caused by the change of the amplitude A by (10). This is, however, negligible owing to the short period of oscillation of the ray.

The accompanying figure (p. 688) represents graphically the behaviour of a cathode ray in a homogeneous electric field when deflected by a perpendicular magnetic force.

The parallel arrows proceeding from right to left denote the positive direction of the electric force. The strength of the magnetic force $\mathfrak{Y}_0$, which points from front to back, is indicated

* Huyghens' principle here represents the direction of the ray exceptionally well, but not the situation of the wave surface.

† Hertz compares the magnetic curvature of the cathode rays with the magnetic rotation of the plane of vibration of light. However characteristic this comparison may be, yet by the present theory it is exactly contrary to the actual conditions. This is an accidental circumstance which does not detract from the merit of the comparison.

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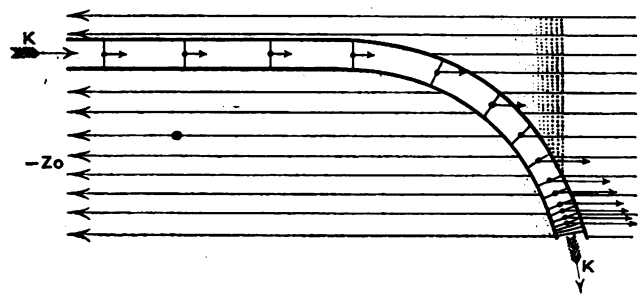
by the density of the dots. It is taken as very small in the left portion of the field, and as increasing towards the right, so that by (11) the ray is more and more strongly deflected, and follows a nearly circular path.

The cathode ray K K is rectilinear in the left-hand portion of the field, where no magnetic force acts, and runs in the direction of the negative electric force, whereas it bends away from this direction in the right-hand portion. By equation (11) the tangent of the angle between its direction and that of the negative electric force is everywhere proportional to the force $\mathfrak{Y}_0$.

Furthermore, the wave surfaces of the ray, everywhere at right angles to its direction, are entered, at such distances as correspond to the velocities of propagation of the ray. They decrease by (9) with the cosine of the angle of deflection. In the centre of each wave surface the electric oscillations of the ray are represented in direction and magnitude by an arrow. They preserve their direction in a homogeneous electric field. The magnitude of the longitudinal component c will be approximately the same along the whole course of the ray. But the radial component A must increase considerably by (10). Hence the intensity of the total oscillation of the ray must increase in proportion as the ray is deflected. But at the same time the velocity of the ray decreases, so that the amount of energy contained in a semi-wave length of the ray has everywhere the same value.

Mutual Repulsion of Cathode Rays.—The equations (I.), which apply to cathode rays of high amplitude, are capable of representing the mutual repulsion of two cathode rays. This is a non-superimposing phenomenon, and cannot therefore be explained by the approximate linear equations (I.'), but may be explained by the non-linear equations (I.). Let electric Z-oscillations be given as limiting conditions in the $x\,y$ plane, as they take place at the two cathodes of the Crookes tube. The integral of the equations (1) will then in any case represent two rays proceeding from these plates, and, by their non-linear form, not rectilinear rays, but approximately hyperbolic rays diverging from each other.



Graphic Representation of a Cathode Ray in a homogeneous electric field when deflected by a perpendicular magnetic force.

Magnetic Longitudinal Rays.—Purely magnetic longitudinal rays are impossible, owing to the asymmetry of equations (II.') and (II.").

An electric cathode ray proceeding in the direction of an electric and a coincident magnetic line of force shows, besides its electric longitudinal vibration Z, also a magnetic longitudinal vibration, $\mathfrak{Z}$.

This might conceivably have an indirect effect upon a coil along whose axis a ray proceeded. Such an experiment would occupy a special position among radiation experiments.*

V.—Longitudinal Light.

Longitudinal Portions of Ordinary Light.—As already shown, transverse light is accompanied (in dense air at its edges, at least) by *longitudinal rays*, which are coherent and displaced by a quarter wave-length with respect to the transverse light. In what follows, such longitudinal portions of natural light are proved to exist by Elster and Geitel's experiments.

For the detailed study of these, a closer investigation is necessary of the transition of light across a surface in which ϵ_0 and η_0 are changed. Such a layer occurs where the light enters rarefied air, and where it is reflected by it. In these bounding strata the light assumes longitudinal components. To give an only approximately valid example, we will suppose that the forces of the transverse ray fulfil Laplace's equation in this terminal layer also, and that η_0 is not unity in it, but constant.

Then equation (II.') holds good and assumes the form

$$(12) \qquad \frac{a_0}{\eta_0 - 1} \cdot \frac{d\,\varepsilon}{d\,t} = X\frac{d\,\epsilon_0}{d\,x} + Y\frac{d\,\epsilon_0}{d\,y} + Z\frac{d\,\epsilon_0}{d\,z}.$$

When the direction of the electrical oscillations of the transverse ray is perpendicular to the direction of the fall of ϵ_0, and then only, is $d\,\varepsilon/d\,t = 0$ and no longitudinal rays are formed.

The longitudinal vibrations formed have, as is evident on comparing (12) with (I.') a difference of phase of a quarter-wave length with respect to the transverse vibrations X, Y, Z. They have in fact the same phase as ϵ.

Elster and Geitel's Measurements.—When I received the recent work by Elster and Geitel* I saw at once that in their discharge experiments partly longitudinal light occurs, and that it has a phase displacement of a quarter-wave length with respect to the transverse light.†

This follows from my discharge layer by the first chapter, and is thus a purely experimental conclusion.

The photoelectric current J is by Elster and Geitel proportional to the intensity of illumination (*i.e.*, the square of the amplitude) and follows the law $J = A\cos^2 a + B\sin^2 a$, where a is the azimuth of the plane of electric oscillation of the light with respect to the plane of incidence. The constants A and B have the following values:—

Angle of incidence i.	70°	66°	40°	23°
A	149·6	144·0	161·3	96·8
B	3·2	4·0	7·1	28·1

In the form $J = (A - B)\cos^2 a + B$

the equation shows that B (the deviation from my prediction) is very small for large angles of incidence, but increases strongly at small angles.

With a constant angle of incidence, and variable azimuth, the light shows a *constant* deviation B from the effect it ought to have if my discharge law were right and the light were purely transverse.

Hence the light has a longitudinal component, and this is displaced by a quarter wave-length. Then the squares of the vibrations sent by the transverse and the longitudinal vibration of the light respectively into the electrode normal, will be added to form the square of the resultant vibration in the normal, which determines the photoelectric effect.

B stands to the amplitude L of the longitudinal vibration in the relation

$$B = L^2\cos^2 i.$$

(A − B) has the following relation to the amplitude T of the transverse vibration:—

$$(A - B) = T^2\sin^2 i.$$

This gives

$$\frac{L}{T} = \tan i\,\sqrt{\frac{B}{A - B}}.$$

From the results of measurements by Elster and Geitel we therefore have

Angle of incidence i.	70°	66°	40°	23°
$\frac{L}{T}$	0·411	0·381	0·181	0·275

Although the intensity of the light used at various angles of incidence was not the same, there is a fairly regular decrease of the ratio of the longitudinal portion L of the light and its exciting transverse amplitude T with the angle of incidence, which might complete the agreement with the theory.

The transverse light shows longitudinal components, whose phase is displaced by a quarter wave length, whose amplitude decreases with the angle of incidence, and which, in the measurements quoted, amount to about a third of the transverse amplitude.

Since then Messrs. Elster and Geitel have published figures,‡ from which it would appear that only in rarefied air these longitudinal portions have a considerable magnitude, as was to be expected.

The Society for the Advancement of German Science, Art and Literature in Bohemia has aided the completion of this work, for which I hereby express my thanks.§

* If Maxwell's equations (I.) are rigidly valid, the magnetic longitudinal ray could not indicate itself by an induction effect; but any small deviation from these equations would make that possible.

* "Dependence of the Electric Current upon the Azimuth and Angle of Incidence of Light" (*Berl. Ber.* p. 209, 1895, *The Electrician*, Vol. XXXV, p. 272.

† Elster and Geitel do not recognise that they have to do with longitudinal light, but assume that light vibrating parallel to the cathode surface also favours discharge. See *The Electrician* above, p. 629, first note.

‡ *Wied. Ann.*, 55, p. 695, 1895.

§ The following letter has just been received from Prof. Jaumann:—"Sir, I have been very pleased to see my Paper translated in your most esteemed journal, and I beg you to give a place to the following remark: My Paper bearing the title 'Longitudinal Light' was published for the first time in the *Sitzungsberichte* of the Imperial Academy of Science of Vienna, on July 4, 1895, that is five months before the celebrated Paper of Prof. Röntgen was published. I should like, too, to call attention to a Paper delivered by Prof. E. Dorn at the Naturforschende Gesellschaft of Halle February 27, 1896, where he shows—by investigating the discharging power of X-rays at various angles of incidence and with the aid of my law of discharges—that the X-rays are *sensibly transversal*.—I am, sir, yours truly, G. Jaumann, German University of Prague, March 17 1896."

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PHYSICAL SOCIETY.

At an ordinary meeting of the Physical Society held on March 13, 1896, Prof. Carey Foster (Vice-President) in the chair,

Mr. J. H. REEVES read a Paper on

"An Addition to the Wheatstone's Bridge for the Determination of Low Resistances."

The piece of apparatus described can be used for measuring the resistance of metre lengths of wires of low resistance, the only additional apparatus required being a sensitive galvanometer, a Post Office form of resistance box, and a metre bridge. It differs from the ordinary Kelvin bridge in that instead of balancing by varying the length of the standard wire between the two contacts, the distance between these contacts is maintained constant, as is also the length of the wire which is being measured, and balance is obtained by altering other resistances in the network. The author has made a number of tests which show that by his arrangement the resistance of metre lengths of copper wires between the limits of No. 22 S.W.G. and a stranded cable of seven No. 16's can be determined with an accuracy of 0·1 per cent.

Mr. REEVES also read a note on

"The Exact Value of Matthiessen's Standard."

Prof. A. GRAY (communicated) said that the author had in his arrangement combined the fixed standard employed in Matthiessen and Hocking's modification of the ordinary bridge with the greater celerity of working arising from the smaller number of operations to be performed when the Kelvin bridge is used. Prof. Gray thinks that he, and probably others, have used a method similar to that of Mr. Reeves, but that the Paper is of great utility, since it shows how time may be saved and existing apparatus utilised.

Prof. AYRTON said that the advantage of the method described lay in the fact that it was independent of the resistances at the contacts. In Carey Foster's method, however, the coils had to be interchanged and inaccuracy might be introduced owing to the varying resistance of the mercury contacts. Unless the mercury cups and the copper plates at the bottom were cleaned every day, and the contacts re-amalgamated, the resistance of the mercury cups was very variable. With regard to the question of Matthiessen's standard it is to be remembered that the specific conductivity of copper has been steadily increasing. This increase was particularly noticeable in the copper prepared by the Elmore process, where during the deposition of the metal an agate burnisher is kept continually passing over the surface. Fitzpatrick had explained the rise in conductivity of copper by supposing that the density of the copper now supplied was greater than that of the copper used by Matthiessen, and this explanation seemed quite satisfactory. Mr. Reeves's experiments, however, have conclusively shown that this is not the true explanation. It was now possible to obtain copper in large quantity, having a conductivity of 103 on Matthiessen's scale.

The CHAIRMAN (Prof. Carey Foster) explained how, when using his method, the accuracy of the result depends not on the elimination of the small resistances at the mercury cups but on the constancy of these resistances. Matthiessen and Dr. Russell found that the specific gravity of copper was apt to be low on account of the presence of dissolved oxide, and they were the first to pass hydrogen gas through the molten metal to remove this oxide.

Mr. APPLEYARD gave a simple diagrammatic sketch of the author's arrangement, and also pointed out that better results would probably be obtained with a galvanometer of 1 or 2 ohms resistance.

Mr. CAMPBELL said that it ought to be definitely settled whether Matthiessen's standard was the conductivity per unit volume or per unit mass. Since copper was always bought by weight, he, as a practical man, strongly advocated the adoption of the mass conductivity, for in this case the measurement of the specific gravity would be avoided.

Mr. REEVES having replied, a communication by Herr PULUJ, on

"Cathode Rays,"

was read by the secretary.

Herr Puluj contributed some Röntgen photographs, taken by means of a form of Crookes tube which he had described in a memoir published in 1889. With this tube he has succeeded in obtaining impressions with exposures of only 2sec. Herr Puluj considers that the particles of matter torn from the cathode, which convey negative electrostatic charges, by impact on the glass walls or on screens equalise their electric charges, and in this process call forth not merely a disturbance of the material molecules but also of their ether envelopes. Each portion of the glass or screen bombarded by the cathode stream becomes the starting point of ether waves, which, according to their oscillation period and oscillation character, are either visible rays (phosphorescence) or invisible Röntgen rays. The oscillations of the invisible rays may take place in the longitudinal direction, but no convincing argument has up to now been brought forward to support this view.

The SECRETARY also read a note on

"Permeability to Röntgen Rays,"

by Messrs. Ackroyd and Knowles.

The authors have exposed a plate on which a number of pieces of metal, oxides and sulphates were placed to the Röntgen rays in order to see whether the permeability of bodies to these rays depends on the atomic or molecular weight of the body. In each case it was found that the opacity increased with the molecular weight.

Mr. BLAKESLEY said that he considered the Röntgen rays to be the propagation of electrostatic strain through space. With reference to the non-refrangibility of these rays, he had observed in one of the photographs exhibited by Mr. Swinton a dark line at the edge of the shadow of a wooden pencil, which might have been due to the refraction of the rays thrown by the wood. Mr. Blakesley has, however, found that this line is due to the varnish on the pencil. Some Röntgen photographs of quartz and ebonite rods not only did not exhibit these dark lines, but there was a very slight indication of a bright line just on the edge of the shadow which would indicate that the refraction of these rays was less in the rods than in the surrounding medium.

Mr. EDSER exhibited some photographs taken with Mr. Jackson's form of tube, in which a concave cathode is employed. Mr. Edser said that the whole of the tube on the cathode side of the anode plate phosphoresced, so that the Röntgen rays seem to partake of the character of diffused light.

Prof. AYRTON said Mr. Jackson had found that the cathode rays form a parallel beam, and do not first come to a focus and then again spread out.

The CHAIRMAN said that some observations made by Mr. Porter agreed with those of Mr. Edser.

Mr. BLAKESLEY described the tube used by Puluj, in which a mica screen coated with green calcium sulphide is placed between the cathode and the anode.

Mr. GARDNER said that there seemed to be some confusion, for where a concave cathode is employed the cathode rays are brought to a focus and then again diverge. The phosphorescence on the inside of the glass had been shown by Lenard to be due to electricity travelling round the inside surface of the glass.

Mr. PIDJEON asked if any one had tried the effect of mounting the photographic film on a metal plate.

The CHAIRMAN said that Captain Abney had found that if the film was mounted on a ferrotype plate no action took place.

Prof. PERRY said that he for one was of opinion that the Röntgen rays were undulatory. Prof. Larmor had given an explanation which seems to agree with the observed facts. This explanation supposes that the intermolecular spaces respond to vibrations of a certain frequency. The reason no refraction or diffraction effects had been observed was probably because of the extreme smallness of the wave length of the undulation.

After some further remarks, the Society adjourned till the 27th March.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, March 20th.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

7:40 p.m. General Meeting in the Lecture Hall of the Subscription Literary Society, Fawcett-street, Sunderland. Papers to be read: (1) "The Determination of the Forces which produce Vibration with Three-Crank Engines at High Speeds." by R. M. Ferrier; (2) "Balancing High-Speed Engines," by A. E. Doxford.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting in the Library of the Institution. Paper to be read: "Some Distinctive Features of Continental Engineering Practice," by K. Edgcumbe and E. J. Fox.

SATURDAY, March 21st.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture (V.): "Light," by the Right Hon. Lord Rayleigh, F.R.S.

MONDAY, March 23rd.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting at the Palatine Hotel, Hunt's Bank, Manchester. Paper to be read: "The Regulation of Pressure and the Reduction of Light Load Losses in Alternating Current Systems of Electric Light," by E. W. Cowan.

TUESDAY, March 24th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "The Thermal Efficiency of Steam Engines." by Captain H. Riall Sankey.

THURSDAY, March 26th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper to be read "Telephone Exchanges and their Working," by Dane Sinclair.

FRIDAY, March 27th.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at St. James's Hall Restaurant.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "New Researches on Liquid Air," by Prof. Dewar.

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ILLEGAL STREET MAINS.

We have on some previous occasions recommended those who are interested in the electric supply business to study the ancient history relating to gas companies. The privileges accorded to these pioneers of public lighting have been regarded with a good deal of jealousy by electrical engineers, but it should be some compensation to them that they are able to obtain gratis the benefit of the experience upon various knotty questions which their predecessors have purchased at considerable cost. Thus when electric light men are in difficulty as to their rights or obligations under untried circumstances, a precedent can often be found in the records of gas companies, which, if it does not exactly fit the case, will at least afford a useful guide to assist in arriving at a right conclusion.

In the year 1852, when gas enterprise was in full swing, the town of Sheffield had for a good many years enjoyed the services of a gas company duly constituted by Act of Parliament, and having a large system of street mains. Whether they supplied indifferent gas, or their charges were higher than Yorkshiremen felt called upon to submit to, we know not, but there sprang up somehow a new company, a thing of altogether heterodox origin, unknown to Parliament, and owning no subjection to the Gas Works Clauses Act. But notwithstanding these defects this upstart company so gained the favour of the shrewd people of Sheffield that the Board of Surveyors of Highways, the then ruling authority of its streets, decreed that this free lance should be permitted to tilt at the orthodox purveyor of gas by laying mains in the streets to the extent of some 70

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miles or more. This was clearly a case for the grand inquisitor in the person of the ATTORNEY GENERAL, who was at once put in motion by the champions of the true faith bent on preventing misguided consumers from being perverted from their due allegiance. The thing was clearly illegal, the Highway Board had exceeded its powers. If a great many, possibly a majority, of the ratepayers were so blind as not to perceive that a serious public nuisance was caused by pulling up streets for laying and repairing mains, where none but Parliamentary mains should be, there was still a guardian of their better principles large hearted enough to spend money in order to safeguard public rights. The suit of Attorney General *v.* The Sheffield Gas Consumers Company, 22 *Law Journal*, Ch. 811, was therefore launched, claiming "that the defendants might be restrained from laying down mains or works in the streets of Sheffield and from breaking up the roads, &c., or doing any other act whereby the passage of Her Majesty's subjects along the said streets should be in any respects obstructed or rendered less safe." This was the forefront of the attack; but the "relators" who had obtained authority to use the ATTORNEY GENERAL'S name, having paraded their public spirit, had a trifle of their own to urge, and therefore further asked that the defendants might be restrained "from doing anything whereby their (the legal) mains might be injured." An injunction having been refused by the VICE-CHANCELLOR, the case was fully argued before the LORD CHANCELLOR and two Lords Justices on Appeal. But, alas for orthodoxy, the attack failed, and the majority of the Court declined to condemn the heretics to extinction. The interference with public convenience was pronounced to be "of a transient nature, and at no one spot or to no one individual more than a passing and almost imaginary evil." This decision was followed by the Court of Appeal in a later case (Attorney General *v* Cambridge Consumers' Gas Company, L. R., Chap. 4, p. 71.) where the local parliamentary gas company were again the "relators." Here it was held that the disturbance of the pavement of a town (even though dignified with a university) by an unincorporated gas company, without lawful authority, for the purpose of laying gas-pipes was not a nuisance so serious and important that the Court would interfere by injunction; also that the views of the governing body of a town and the motives of the persons instituting the suit are not immaterial where the complaint is of a public injury.

In these cases it was not denied that the proceedings of the unparliamentary company were illegal, nor that they were liable to indictment before a criminal court if anyone thought it worth while to take such a step, nor that the company was liable to pay damages to anyone who could prove he had sustained any; but the Court did not consider this included prospective injury to another company's mains. The interlopers would also have to contend with other difficulties, such as have usually rendered a permanent existence under such conditions impracticable; and it is remarkable that the law reports record the fact that one of them was subsequently mulcted in damages in respect of an injury caused by servants of its contractor under circumstances where an authorised company would have escaped. What became of the competitors for the honour of illuminating the metropolis of cutlery and the seat of learning respectively, and which of them, following the usual law of development, ultimately swallowed up its rival we have never inquired; but it seems to us that the justice meted out to them now nearly half a century ago will do well enough for application to some cases we occasionally hear of at present in connection with electric lighting.

We believe the laying of electric mains in streets without Parliamentary powers is quite as illegal as the laying of gas mains, no matter whether the Local Authority consent or not. We also believe that the power of the Court to stop such proceedings by injunction still remains; but that it is ever likely to be exercised in any case where the local authority have acted *bonâ fide* in giving permission for such mains to be laid, we take leave to doubt. But after all, have electric lighting undertakers much to fear from schemes of this description? The risks and disadvantages attending any extensive operations by persons acting without statutory powers are such as must necessarily preclude operations except over a very limited area. A company formed upon such a footing must be standing on a most insecure basis. Assume that they have laid their mains with the goodwill of a friendly Local Board. The consent so given could hardly be expected to bind the Board and its successors for all time, so as to give a permanent charter to a company freed from the trammels of the Electric Lighting Acts. The benevolent vestrymen who once directed the counsels of the Board may cease to reign, and may be replaced by new rulers who know not the freehanded company, and abhor its works. Mains laid under streets are valuable so long as you can get at them for repairs and making new connections, but should all right of access be taken away their value would be a very uncertain quantity. Such action by a Local Authority would be less likely to happen, or if happening might not be a very serious matter where the work consists merely of a main crossing a single street, but the case would be very different if it involved mains extending the whole length of one or more streets. We think, therefore, it is unlikely that authorised undertakers will ever suffer seriously by competition arising from such a source. Not much progress could be made without the protection of a Provisional Order; and should this be applied for, we hardly think the Board of Trade would be impressed by the argument that a footing gained by illegal means constitutes a claim to favour, as against another party who has observed the requirements of the law. The plan of getting mains laid somehow, and then applying for a Provisional Order, may have answered a good purpose in some cases, and might serve again where there is an open field; but it is not likely to prove good tactics as a means of starting a regular competition with existing undertakers—at all events, where the latter are able and willing to supply the requirements of the district. Where these conditions are complied with, the Board of Trade do not favour competition, and we believe that any attempt to secure an advantage in such a manner would probably bring disaster upon the promoters of the scheme. With regard to the attitude of Local Authorities upon this question, we trust it will be one of fairness and moderation. The owner of large premises, and particularly a factory, may find it convenient and economical to generate his own current, and if he has some spare power it would not be unreasonable to allow him to employ it by laying a line across the road so as to light his opposite neighbour. But if he should convert his premises into an electric lighting station, and for the purpose, not of economy in his own business, but for carrying on war against an authorised electric lighting company whose behaviour has not given reasonable cause for complaint, he certainly ought not to have the countenance of the Local Authority. But even if the parochial rulers were so misguided as to support "unfair" competition, we should not, for reasons already stated, envy the illegal competitor his precarious tenure. Brief life would probably prove to be his portion.

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REVIEWS.

Recettes de L'Electricien. By E. HOSPITALIER. (Paris: G. Masson.)

This eminently practical book comprises within its 350 pages a great variety of useful information. Commencing with the composition of fusible alloys, it concludes with a section on official documents or regulations relating to the use of steam boilers, electric plant, the laying down of underground mains, the use of electricity for lighting in theatres, &c., also instructions for the treatment of victims of electrical accidents, and a *résumé* of the patent laws of different countries, &c. An appendix gives the substance of a projected law relating to the erection of conductors for the transmission and distribution of electric energy, and a list of French customs duties on electrical materials and apparatus. An index and an alphabetical table of contents make the book easy of reference.

Among the receipts for alloys we notice solders for all purposes, including one to resist acids, and one which is said to adhere to glass, while a list is given of suitable alloys for fusible cut-outs with the melting points for each. On p. 215 we are told that copper is unsuitable for fuses, the reason given being that successive heating and cooling renders the metal brittle. It is within our knowledge, however, that tinned copper wire of the finer sizes is extensively used in this country with entirely satisfactory results. Among solders we notice one for aluminium which is said to be sufficiently malleable to bear hammering, turning and general working of the aluminium article after soldering; this is composed of 45 parts of tin and 10 of aluminium. Another harder solder for the new comer among our commercial metals consists of 52 parts of copper, 46 of zinc and 2 of tin; yet another, the components of which are to be melted together with borax, consists of zinc 70 parts, precipitated copper 15 parts, aluminium 45 parts.

Following chapters on bronzes, polishes and instructions for working in glass, we find practical instructions for making bobbins for electro-magnets. In the chapter on suspensions we find precise information for the making, fixing and attaching of quartz fibres, for which acknowledgment is made to Mr. Vernon Boys.

Passing to a chapter on dynamos we read: "It is frequently necessary to feel the bearings to ascertain that they are not heating dangerously." This is surely a relic of bygone days, when a dynamo was a piece of ill-constructed mechanism, and usually in charge of a fussy enthusiast who delighted in recounting his stupendous labours and the wonderful expedients he used to keep the lights going, or the pyrotechnic effect of spilling a box of tinned tacks into the rotating armature! In these days of large and well-proportioned bearings, sight feed lubricators, or self-oiling arrangements, and sparkless commutators, the amount of attention required by a dynamo of recent construction is as little as for any piece of apparatus running at the same speed.

For lubricating the commutator, M. Hospitalier recommends valvoline—a trace only—and this is a good lubricant for the purpose. We know of some engineers up North who put their faith in "commudine." According to them, the best treatment for the commutator of a modern dynamo is as follows:—Polish up the commutator with finest emery cloth, then apply "commudine" with a flannel until the surface is highly burnished. The brushes having been carefully bedded, the wearing surfaces should have a very small quantity of "grapholine" (a mixture of finest black lead with solidified oil or vaseline) spread upon them. The quantity of grapholine should not be sufficient to materially dim the lustre of the commutator.

The instructions *re* the construction of brush holders are generally good. We think something should have been said about the necessity for perfect bedding of brushes upon the commutator; also the very practical way of securing this—*i.e.*, the winding of a helix of emery tape over the surface of commutator, upon which the brushes are allowed to rest lightly until ground to the proper curvature—might have found a place among M. Hospitalier's very practical instructions.

With regard to carbon brushes, we believe that engineers in this country will endorse our view that even the lowest working density given in the book, *i.e.*, 7 to 8 amperes per square centimetre, is more than twice as much as it is advisable to take off with a carbon brush; even with 8 amperes per square centimetre the commutator gets to an uncomfortable temperature in a long continuous run. Having mentioned the use of emery tape for bedding metallic brushes, we may say that with carbon brushes all that is necessary is to insert a piece of emery tape or a strip of emery cloth between the commutator and brush. Let the brush rest on the emery surface with the usual tension, then pull the tape backwards and forwards a few times, making the direction of pull such that the tape lies on the curved surface of the commutator. The added thickness of the emery tape, of course, makes the curvature of the brush surface of slightly larger radius than it should be, but this is very trifling, and the result is far nearer perfect than can be obtained with a reasonable amount of labour by filing. The book should be found useful in the laboratory and test room.

Die Galvanoplastik. By JULIUS WEISS. Fourth Edition, revised, increased, and improved by JOSEF FRANZ BACHMANN. (Hartleben's Verlag: Vienna, Pest, Leipzig.)

Of the making of technical text-books there is no end, but they too often consist of a mass of ill-digested matter collected from previous works on the subject and from the technical press, and with little guidance supplied by the author to pilot the reader through the tangle of facts and fallacies. But occasionally we come across one of a different type, and such a one is "Die Galvanoplastik." The work is admittedly only a collection of information on the subjects of electro-plating and electro-typing which the author has made from current literature, supplemented by information supplied by firms, and by his own personal experience. So far, the book does not differ from many another compilation culled from technical literature; but there is this material difference: that, following the example of Dr. Langbein, Bachmann has stated which of the many processes he himself has tried. It is probably because so little attention is paid in this country to electro chemical industries that we have so few good works dealing with these subjects in our own language. But be this as it may, it seems a pity that electrical students should crowd into the electric lighting and traction industries to the neglect of all other branches of electrical work. Electro-plating had its industrial birth in this country, thanks to the foresight and enterprise of Messrs. Elkington, and for many years the problems involved in it occupied the attention of scientific men, with the result that the foundations of our knowledge of electro-chemical relationships were laid. With the advent, however, of a commercially useful dynamo, public interest was diverted to electric lighting and traction, while scientific workers turned their attention to the rich crops of interest and profit to be reaped in the electromagnetic field. The electro-plating and allied industries passed into the hands of the so-called practical man, and became stereotyped; but we hope that the great revival of interest in the scientific principles underlying these industries which has taken place in the last few years will result in a better state of things again prevailing.

"Die Galvanoplastik" is, nominally, the fourth edition of the well-known work by Julius Weiss, but may be practically considered as a new book, as it has been thoroughly rearranged and brought up to date by J. F. Bachmann, to whom the revision of the work was entrusted on the death of Weiss. The book is divided into four parts—the first dealing with physical and electro-chemical laws; the second with the practice of electro-plating and colouring, which latter includes the production of deposits of various hues by a suitable preparation of the bath (as in the case of gilding), or the production of the so-called "interference colours," which are caused by the deposition of very thin metallic films. The third part deals with electro-typing, and very full directions are given for the various processes involved in the reproduction of medals, coins, busts and plants, and the copying of engravings and photographs, &c.; whilst the fourth part is devoted to the chemicals and materials used in electro-plating, and some estimates are given of the plant required for different pur-

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poses and its approximate cost. In the introduction is given, in chronological order, the fullest list we remember to have seen of the workers in the field of electro-chemistry, with a brief statement of the most important advance in our knowledge of the subject for which we are indebted to each. The names of the most prominent workers at present employed in this branch of theoretical and applied science are also enumerated, which will be of advantage to the student.

In dealing with the science of electricity, and with the apparatus and means employed for generating, regulating and measuring the electric current, the author has confined himself to a statement of those facts which are of importance to the working electro-plater; but very full references are given to the literature of the subject, so that the reader can obtain further information on all points should he desire it. The space gained by this condensation is employed for a very thorough treatment of the electrical and chemical relationships on which all the electro-chemical processes rest. The aim has been to produce a work which, while scientifically accurate, shall be useful to the practical man, who too often has had small opportunity for mastering the scientific principles underlying his work, and for this reason the preparation of the baths is given in popular language and at some length. In describing the various processes one or two selected baths which the author has tested are given first, and then those which have been recommended by workers of repute, and which have been found reliable. The beginner is thus enabled to make a bath which will give fairly good results, while the experienced hand has a selection of recipes from which to choose one which is particularly adapted to his purpose.

The deposition of nickel is very exhaustively described, not only on account of the great importance to which the industry has attained in the last 15 years, but because the precautions to be observed in it are applicable to all electrolytic processes; therefore this chapter may be taken as a type of the whole book. Great stress is laid on the necessity of absolute cleanliness, for, as is pointed out, the careful worker will get good results from baths which are not theoretically the best, while the most scientifically-prepared solutions will only yield inferior work in careless hands. The author's remarks, too, on the subject of manufacturers who set up works, and are dependent on their workmen for the preparation of the baths, and on the workmen who undertake duties which they do not understand, will find an echo in this country, for we fear it is not in Germany alone that men are to be found seeking employment as electroplaters whose sole experience has been that of removing grease from the articles to be plated, and suspending them in the baths, and who are absolutely ignorant of the electro-plating process itself.

Electrical Engineering as a Profession: How to Enter it, and Guide to the Engineering Profession. By A. D. Southam, A.I.E.E. (London: Southam and Co.)

A careful perusal of the latest edition of Mr. Southam's *brochure* does not reveal to us any reason for altering the opinion we formed of it about a year ago. It professes to be a guide; it is nothing of the kind. Placed before an anxious parent it would be as helpful to him as an ordnance map in the hands of a yokel who had missed his way in a strange county. To those who want to have in a handy form information as to the fees and curricula, the aims and objects of some of our leading technical colleges and cognate institutions, Mr. Southam's compilation will undoubtedly prove useful. What manner of "guide," however, to a parent or guardian is a mass of contradictory opinions of engineering experts as to the best mode of entering the profession. What help to a proud father are details such as the following:—"Generally speaking, the instruments are upstairs. Among others may be mentioned a Thomson hecto-ampere balance, and a standard balance for one ampere. . . ." What advantage is it to him to know that the engine room in the basement is connected to the laboratory upstairs by "three pairs of leads and pneumatic tubes." If the author has an opinion as to the best way of becoming an electrical engineer, let him give his readers the benefit of it shortly, sharply and to the point, and if the parent must gauge for himself in a hazy way the relative merits and demerits of various institutions, he would be better assisted by a comprehensive table than by the numerous illustrations and the, to him, unintelligible details at present given. The author should also make it clear that some of the institutions he describes are purely private concerns, undertaken for purposes of personal profit, whilst others are more or less public and philanthropic. Even so the parent or guardian would probably be exceedingly puzzled by the fact that you can procure for a few shillings north of the Tweed, what costs a few hundred pounds just north of the Thames. Some idea should certainly be given of the social status of the students and the amount and mode of endowment of the various colleges. Another point upon which reliable information is invariably required by those about to settle their sons in life is the probability, given average abilities, influence and luck, of a decent livelihood being obtained in any particular profession. A parent does not need to be told that "much depends on the general ability of the intending pupil and the earnestness which he applies to his future career"; common sense will tell him that. Nor does the additional information that "there is always room for a good man and one who knows his business" mend matters much. What the purchaser of a "guide" has a right to expect in return for the purchase money is some clue as to the relative chances of success in different professions or in different branches of the same profession. It is admittedly a difficult matter to gauge, but it is not an altogether insoluble problem. For instance, no one would recommend telephony in England as affording much chance of a brilliant career to an eager young fellow with a *penchant* for scientific research work.

Mr. Southam's book cannot fairly be called a guide until it contains less undigested information and more plain advice. As a catalogue of engineering colleges and firms it will pass.

The Engineer's Year Book. 1896. By H. R. Kempe, A.M.Inst.C.E. (London: Crosby, Lockwood and Son.)

We are glad this compilation is not called a pocket-book, since a load of 18oz., occupying a space 7in. × 4¾in. × 1½in. is not suitable for the average pocket. At the same time the term year-book, notwithstanding the fact that the work is issued annually, seems also somewhat of a misnomer, since it implies that the information contained is such as requires annual revision; but as by far the greater number of the 634 pages are devoted to formulæ, tables, and constants, it is not easy to see where the necessity for annual republication comes in. The electrical section of the Year Book is distinctly inferior to the rest of the work. Memoranda likely to be of real use to an electrical engineer when away from his own note-books and works of reference, are conspicuous by their absence, and their place is taken up by manufacturers' lists and execrable and unintelligible illustrations of motor-car trucks, the whole being profusely and irritatingly interleaved with advertisements. On p. 508, by a slip of the pen, no doubt, we are told that electricity is more economically transmitted at a low than at a high potential. We trust advantage will be taken of the yearly publication of this volume to thoroughly reorganise this section at an early date.

Hazell's Annual for 1896. Edited by W. Palmer. Eleventh Edition. (London: Hazell, Watson and Viney.)

The great merit of this book of reference is that the contained data is all arranged alphabetically so that when looking up a reference in a hurry, as one always does, there is little danger of loss of temper and time in a wild fruitless hunt after a particular item of information; it is almost as easy to find what one wants in this Annual as it is to find a word in a dictionary. As to the value of the information when found it varies considerably. The section on engineering, for instance, which contains brief descriptions of the chief industrial engineering enterprises in progress throughout the world, is excellent, as is also the section on factory and workshop legislation. On the other hand the paragraph devoted to the inventions of 1895 is decidedly poor; it opens with the "Octopus" anti-incrustator, and concludes with an account of the horseless carriage show at Tunbridge Wells. The section on electricity is, quite rightly, mainly occupied with the opening of the Niagara Falls power-house and the develop-

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ment of electric traction, but these two items should not have been permitted to practically exclude everything else. However, taking it for all in all, it is a handy book of reference.

Griffin's Electrical Engineer's Price Book. Edited by H. J. Dowsing. New edition, revised throughout, and enlarged. (London: Charles Griffin and Co.)

The 1896 edition of this useful work is radically different in shape and general get up to the first edition published in the summer of 1893. Part I. consists of a well-arranged collection of the price lists of a large number of makers. Part II. comprises central table statistics, specimen reports, &c. To those who do not happen to keep a file of manufacturers' catalogues, or who wish to have the same information in a more portable shape, Mr. Dowsing's compilation should prove a decided boon.

Lockwood's Price Book. 1896. Edited by Francis T. W. Miller (London: Crosby, Lockwood and Son.)

A little over 20 pages of small type are allotted this year to the prices of electrical plant and accessories, exclusive of bells and batteries, which occupy another six pages. The information given is varied, accurate and useful.

Laxton's Price Book. 1896. (London: Kelly and Co., Limited.)

The 1896 edition of this work comprises 750 pages, some 80 of which are allotted to electric lighting. Although the editor informs his readers in the preface that "the important section of Electric Lighting has received special care and attention," there is no observable improvement. As in previous years this section is almost entirely given up to the price lists of two firms; it contains a good deal of ancient history, and no mention whatever is made of *the* high-speed electric lighting engine.

HIGH-VOLTAGE LAMPS, AND THEIR INFLUENCE ON CENTRAL STATION PRACTICE.*

BY G. L. ADDENBROOKE.

In the spring of 1891, which was the last occasion when the Alternating *v.* Continuous-Current controversy came prominently before this Institution, and when Mr. Crompton brought forward his feeder argument, I had the honour of opening the discussion, and subsequently continued the argument in the technical Press, besides going into it privately with Mr. Crompton. I was not, however, convinced of the superiority of *low-pressure* direct supply, and on the old premises I remain unconvinced still; but I saw that the advantages of the two systems were in many cases very nearly balanced, and if one or other was ultimately to prevail it would probably be for some other reason than lay in the arguments which had so far been brought prominently forward on either side. It was, in my mind, useless to say that the two systems were each the best for certain situations; for how was the line to be drawn? or, in some cases, were we to have both systems in one town? Though a possible, this did not seem to me a desirable solution.

The question is not merely an academic one; hundreds of thousands of pounds are every year now spent on electric lighting, and that a large portion of this sum should be spent in a way that is not the best and most permanent is a serious matter. Besides this, as a consulting engineer, I found my position an unpleasant one. What was I to recommend to my clients? and if I halted between two opinions, what would my clients think of me? I regret that in these matters I have not the assurance of some gentlemen who, I understand, circularise all town councils, keep their own touts, and are prepared to give cut-and-dried verdicts without hesitation on engineering points which, I must confess, I approach with a certain amount of awe and misgiving, and a very serious sense of responsibility.

Now, it struck me four years ago, as I daresay it did others, that, as the two methods had been argued over so carefully without any definite conclusion being arrived at, probably some outside and fortuitous circumstance which neither side had taken account of would ultimately turn the balance one way or the other.

Possible Sources of Influence on Central Station Practice.

I therefore made a careful survey of the field, and the only eventualities I could think of, or which seemed likely to have a very important bearing on the problem, were the following, viz: the introduction of (1) an altogether new form of lamp; (2) a cheaper material for mains than copper; (3) a high-voltage incandescent lamp; (4) a much more economical incandescent lamp of the present voltage; (5) an improved and much cheaper storage battery.

Respecting a new form of lamp: After having seen Tesla's experiments at the Royal Institution, and after having learnt privately the views of some of our leading investigators on the field which they opened, I must say, as a practical man, I did not see any immediate hope of commercial success in this direction, however interesting the results might be scientifically. As regards the chance of a cheaper conductor being forthcoming, I have dealt with this question at length in a recent article in the *Electrical Review*. Owing to the cheap rate at which aluminium can be produced, and will increasingly be produced in the future, and since the conductivity of aluminium is 56 per cent. that of pure copper of the same section, the chances of aluminium ultimately supplanting copper are strong, but the change will undoubtedly be a comparatively slow one. The possibility of this, however, points to a reduction in the price of conductors; and this, of course, would tell somewhat in favour of moderate pressures. Again, as even in moderate-pressure mains insulated with bitumen or other compounds the cost of insulating is twice the cost of the conductor itself, in the sizes usually employed, it is quite conceivable that very important economies may be effected in this direction. It is obvious that improvements of this character would probably tell more in favour of moderate pressure than of high.

Having thus disposed of the conductor question we come to the third and fourth alternatives I have mentioned as likely to influence central station practice, viz, the introduction of a lamp of higher voltage, or a more economical lamp of the present current-voltage. When thinking over the matter in 1891, I saw that, as fairly good lamps of 8 c.p. for 100-volt and 110-volt circuits were being made, two of them could be put in series, and that we should get very simply a 16 c.p. lamp of 200 to 220 volts. This, however, involved giving up 8 c.p. lamps except two in series, which, as the charge for current was then usually 8d. per unit, was a serious matter, and again, as there were two filaments in each lamp, the breaking of either of which would spoil the lamp, this also introduced an important objection, particularly as the Ediswan monopoly maintained the price of lamps at 3s. 6d. for ordinary voltages, and could hardly be expected to supply lamps which would be more expensive to make, except at an enhanced price. The prospect of obtaining high-voltage lamps, did not, therefore, at that time appear bright. Time has, however, brought about great changes in the lamp industry, due largely to the expiry of patents, which quickly led to numbers of good lamps being placed on the market at less than one-third the price formerly charged, and at the same time brought active and pushing competitors into the field.

Two years and a half ago, finding some disposition abroad to adopt higher voltages, I drafted an article pointing out the enormous gain which would accrue in the distributing system if higher voltage lamps were adopted, intending to send it to one of the journals. The question, however, then appeared somewhat problematical, and other business led to the article being put on one side. I did not, however, forget the matter, and last December year, finding that one or two firms were trying to introduce lamps of 200 volts, I looked over my draft again, and having somewhat elaborated it, sent it to the *Electrical Review*. The article attracted the attention of Mr. Baynes, then of Bradford, and he wrote detailing his experience, and the experiments he had made with high voltage. Since then the matter has advanced by leaps and bounds. Several lamp makers are undertaking to supply 16 c.p. lamps of voltages up to 230 and even above; and not only this, but Mr. Stearn and one or two other makers are offering lamps up to this voltage of 8 c.p. also, and guaranteeing a fair economy. The lamps are also being offered at moderate prices.

Low-tension central station engineers have not been slow to perceive the facilities these lamps offer. In some cases they have been adopted publicly, and in other cases private experiments are being made on them with satisfactory results. I also hear from those manufacturers who are catering for the market that the demand for high-voltage lamps is steadily and rapidly increasing. The adoption of these lamps is, of course, somewhat in the tentative stage; but so much progress has been made, and the results attained so far are so good, that no one can doubt that in a year or two they will become a permanent institution. It may also be noted here that since this paper was sent in I see that Prof. Kennedy has considered the 230-volt lamp sufficiently sound to recommend the Town Council of Edinburgh to adopt it.

Concurrently with this development there has been a tendency towards the use of lamps of ordinary voltage but of higher efficiency, and I must say that until recently I have been unable to quite make up my mind which was the best of the two lines to work on—whether it would be better to use lamps of 100 voltage and taking $2\frac{1}{2}$ watts per candle-power, or lamps taking 4 watts per candle-power with a voltage of 200 or 220. I think, however, the matter

* Paper read before the Institution of Electrical Engineers, February 27, 1896.

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now admits of being argued out pretty clearly. By a reduction of current per candle-power in the proportion of 2½ to 4, mains of a given capacity would do nearly double the amount of lighting with the same expenditure of energy. Energy in itself is very cheap, however, and any fair-sized central station could supply double the quantity of energy it is now doing at 1½d. per unit for the extra current, if this did not entail extra expense for mains. Now, by doubling the voltage, we reduce the size of the mains to one-fourth, other things being equal; consequently the mains for a station using 220-volt lamps consuming 64 to 70 watts per 16 c.p. lamp, to give the same percentage loss, would not be much more than half the size they would be if the station supplied 110-volt lamps consuming 2½ watts per candle-power, as the current would be nearly the same in both cases. As the cost of mains is such a very large proportion of the whole central station cost, and as energy can be generated so cheaply, I am fairly confident that, even if a good 2½-watt lamp were obtainable, it would pay better to use 220-volt lamps taking nearly double the current.

Conversations with lamp makers, and recent publications on the subject, have convinced me that a good 2½-watt lamp of 100 volts has yet to be attained, and will probably be a very difficult thing to achieve, unless absolutely even pressures in the mains can be guaranteed. The opinion of lamp makers appears universally to be that a 220-volt lamp at 3½ to 4 watts per candle-power is a more practicable and attainable object than a 100-volt lamp at 2½ watts. They seem also unanimous that if a good 2½-watt 100-volt lamp could be made, a good lamp of 220 volts, and of better efficiency than 4 watts, would be forthcoming. It therefore appears that by taking a 220-volt lamp now we shall get all the advantages of high voltage, and in time shall get nearly as efficient a lamp as if a lower voltage were used, while the high-efficiency lamp is even now in a far less forward state of development than the high-voltage lamp. Consequently, it seems clear that the high-voltage lamp is the better line of the two at present.

Besides this, we are anxious to cheapen the cost of current so that it may also be available for power purposes, and thus small economies in consumption will be of less and less moment. It is, therefore, obvious that not only in the present, but for the future, the high-voltage lamp is likely to be the better, and that it is safe to run the risk of being unable to use very economical lamps, provided decent ones of high voltage can be obtained.

I shall not pursue this branch of my subject further, as it would be more suitably dealt with by a lamp manufacturer in a special paper; but I think enough has been said, coupled with the knowledge members already have of the subject, to show that high-voltage lamps are thoroughly practical for central station work, and I therefore pass on to consider how far it is desirable to use them, and what effects they are likely to have on central station practice; this being more immediately the subject of my paper.

Life of High-voltage Lamps.

We can, of course, hardly expect the life of these high-voltage lamps to be as long as that of lamps of half the voltage, while at the same time they will be rather more expensive, consequently there will be a greater expenditure for lamp renewals when they are used; and it is advisable, I think, to try and arrive at a figure for this before proceeding further.

If the life of an ordinary 16-c.p. lamp of 100 volts is 1,200 hours, and it consumes 64 watts, during its life it will consume 77 B.T. units, which, at 6d. per unit, amounts to 38s. 6d. If the cost of the lamp is 1s. 3d., its cost per unit of current consumed is 0·2d., or ⅕d., or about 3 per cent. of the cost of the current. For an 8-candle lamp of 100 volts, lasting 800 hours and taking 36 watts, the consumption of current is 29 units; and at the same price for lamps, the lamp cost per unit of current consumed is about 0·5d., or ½d., or about 8 per cent. of the cost of the current. I have assumed the above life for these lamps because I think, after burning the number of hours indicated above, most lamps would be best thrown away; though I am perfectly aware lamps often last twice as long as I have assumed, and they can also be purchased for 20 per cent. less from reliable makers. 200- or 220-volt lamps will, of course, cost rather more, and their life would be rather less, but I believe I am putting the case more adversely for the higher-voltage lamps than is really true, in taking the cost as double the above rates for lamp renewals where high-voltage lamps are used. The cost of lamp renewals would then be 6 per cent. of a customer's bill if the current was 6d. per unit for 16-c.p. lamps, and 16 per cent. if 8-c.p. lamps were used. Supposing the number of 16 c.p. lamps installed to 8-candle lamps is about as 1 : 2—which is, I think, about a fair average—an all-round reduction of 6 per cent. in the charge per unit of current would cover the *additional* cost of lamps if lamps of high voltage were used; at 6d. per unit for current this is about one-third of a penny per B.T. unit.

Such figures as these can only be approximate, but I think you will agree that they would not be far out in practice, and may be improved upon, and also that they make it clearly manifest that the extra cost of using high-voltage lamps offers no appreciable bar to their introduction, providing that their other countervailing advantages are in excess, with which branch of the subject I will now deal.

Effect of using High-voltage Lamps on Distribution.

On this point I do not think I can do better, as a commencement, than quote from my article in the *Electrical Review* of the 11th of January, 1895:—"How great a gain there is in distributing current at a higher voltage, and how much it simplifies the distributing problem, is not at first sight fully apparent, though everyone recognises that there are advantages. The advantages may really be said to progress as the cube of the voltage, up to, say, about 200 volts. For let us suppose we have a station on all of whose circuits the lamps require 200 volts to incandesce them, instead of the usual 100 volts. In the first place, having doubled the pressure, we may extend our mains double the distance at the same current-density, with the same percentage loss; but at the higher voltage the same current-density in a given sized main will give us twice the energy and light twice the number of lamps. Consequently, without increasing the sectional area of the mains, we can do four times the lighting with the same mains, or the same amount of lighting at four times the distance with the same percentage loss. Then there is a further gain, for, since we can extend the mains four times as far from the central station with the same percentage loss, the area which can be served from a single station is 16 times greater at the higher pressure than at the lower. Presuming, however, that this argument is not pushed to its extreme limits, it is well within the mark to say that at 200 volts nine or ten times the area could be better served on the three-wire system from a single station than is now the case at 100 volts; not only is this the case with the feeders, but it extends in an even greater degree to the distributing system. At present there is no doubt that there is an inconvenient fall of voltage in the distributing mains, and the internal wiring of houses, which leads to irregular and unsatisfactory lighting, and which is under existing circumstances, whatever system is employed, exceedingly difficult to remedy. If by any means the voltage could be increased to 200 volts this would practically vanish, distributing mains might be carried three times their present distance from the feeding point, and the fall of potential in houses would be merely nominal on the present basis of wiring, instead of frequently amounting to 1-2 volts or more. By these means the number of feeding points in a given area would of course be much reduced. The same fittings and wiring as are now used would be applicable, and the voltage does not go beyond the Board of Trade limits."

This was a general statement, made largely with a view to point out to manufacturers what a field it would open if they could produce a commercially satisfactory high-voltage lamp. During the last eighteen months manufacturers have seen the advantage of exploiting this field, with results which have already been detailed above. Consequently it is desirable to look a little more closely at the distribution problem under its new aspect, and I will, therefore, ask your particular attention to the figures which I now propose to lay before you.

It is generally acknowledged that in the three-wire system at 110 volts it is not economical or very practical to distribute current at a radius of much more than three-quarters of a mile from the central station, except under special circumstances. The area which can therefore be economically served from such a station is about one and a-half miles each way, or about two and a-quarter square miles. In his well-known feeder paper Mr. Crompton gave figures which he argued showed that a feeder on the three-wire system supplying 110-volt lamps could be laid and maintained, and would involve the same loss of energy, taken over the same day, as would an alternating feeder, including transformers, instruments, and switching gear, the length of the feeders in each case being 2,400 yards. These figures were strongly attacked by the alternating party, myself amongst the number; the most legitimate point of attack being that Mr. Crompton had assumed a loss of 30 per cent. at full load on the low-pressure feeder, which was considered excessive on account of the extra plant it would entail at the central station. Had Mr. Crompton put the length of his feeder at about 1,400 yards, or a little over three-quarters of a mile, and had he used a density of about 500 amperes per square inch—which is about the practical density—the loss would have been 16 per cent. for the continuous-current feeder at full load, and few alternating men would have seriously combatted that on the whole the continuous-current feeder was as economical and desirable as an alternating feeder. The figures would then agree with the generally current comparison which I have mentioned above, and which I propose to use as a basis of argument in order to avoid disputes.

Now, from data I have collected, it appears that in such places as the centre of large towns there are perhaps 30,000 inhabitants per square mile, though ordinarily the population for a square mile of a town does not appear to exceed 16,000. A low-pressure station on the three-wire system with 110-volt lamps can therefore serve economically about 60,000 to 70,000 people in the centres of large

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towns, and about 35,000 in districts outside the centres and in provincial towns. If, therefore, we wished to light London, with its 4,000,000 population, on this basis, taking the average population at 25,000 per square mile, we should need, roughly, 70 to 80 stations to light the whole metropolis, not counting the extreme suburbs.

If, however, in the direct supply system the voltage is double, the position is altogether altered, and a comparison between the transformer and direct supply systems under these circumstances will lead to very different results from those so far given. Theoretically, if 220-volt lamps are used, we can extend the feeders four times as far as if 110-volt lamps are employed, and therefore the area which could be lighted from each station is 16 times as large. I do not intend to take full advantage of this facility in the calculations which I propose to lay before you, as I consider that the fall of voltage is too large in low-pressure central stations at present, and that the voltage of the lamps at different points of the distributing system is not kept as near the normal as it should be. In what I am about to say I shall therefore consider that, instead of four times, we extend our feeders a little over three times as far as before, thus securing better regulation and a smaller percentage drop in both the feeders and distributing system, together with the great saving in copper. If, then, we can extend the lighting radius three-quarters of a mile from a low-pressure direct supply station with 110-volt lamps, we can extend it, on the above basis, 2¼ miles at 220 volts, which means that we can cover an area of 5 × 5, or nearly 25 square miles from one station—that is, 11 times the area we could before. Instead, therefore, of serving 60,000 people in the central districts, one central station would serve 700,000, and over a quarter of a million in the less central districts. Taking, then, the population of London as 4,000,000, without extreme suburbs, about six or seven stations would comfortably cover the whole area. Now this is a number which is directly comparable with the number of stations at present being operated by the gas companies; and to my mind it is doubtful if it would be desirable to reduce the number of stations below this figure for so large an area, even if it could be managed.

It would be interesting to go into this metropolitan lighting problem further did time permit, but it does not, and I must ask you now to turn your attention to the provinces. Take maps of Birmingham, Liverpool, Glasgow and Manchester, and cut out a piece of tracing paper to represent 25 square miles on the same scale as the map. Lay the tracing paper over these maps, and you will find that two stations, or at most three, will cover not only the whole of these great cities, but the suburbs for a couple of miles outside. For the general run of large towns one station would amply suffice; and for the smaller ones one station would, of course, permit of lighting over the whole area at a very small expense for mains. Before a technical audience like this, however, it will doubtless be more satisfactory to investigate a particular instance than to proceed further with general statements.

At 220 volts pressure an ampere represents 220 watts; therefore, one-third ampere represents 73·3 watts. Now at 4 watts per candle-power a 16-c.p. lamp takes 16 × 4 = 64 watts, and an 8-c.p. lamp 32 watts. We shall therefore be sufficiently near for the purposes of this calculation, and shall be allowing a sufficient margin, if we assume that a 16-candle lamp takes one-third ampere, and an 8-candle lamp one-sixth ampere at 220 volts.

Next consider the distributive system. There are two points needing attention: the first is, How far, and over what area, can we spread our network from the feeder points? The second is, What drop should we allow on the feeders themselves?

But before going into these matters further we must settle what shall be our greatest drop from the feeder point to our furthest lamp on the network spreading from it. The variations which are permitted at present are too great, and would have to be reduced in time anyhow. I therefore do not intend to adopt the present practice as a basis, but to take as the limit an extreme fall of 2 per cent. on the distributing system from the feeder point to the furthest lamp at the tops of the houses; that is, lamps near the feeder would be 1 per cent. above their proper voltage at full load, and extreme lamps 1 per cent. below. This is, I think, as large a variation as good practice would allow, though it is less than half what is considered permissible now. Having settled this, the following data and table will enable us to see at a glance the best method of designing the mains and their cost.

1. A bar of copper 1in. in section and 1 mile long weighs approximately 9 tons, and its resistance is $\frac{1}{2}$nd of an ohm, or 0·045.

2. Therefore a double conductor 1 mile long and 1in. in section weighs 18 tons, and its resistance is $\frac{1}{11}$th of an ohm, or 0·090.

3. I do not think it will be necessary on the high-voltage system to have the third wire in a three-wire system more than one-fifth the section of the other two, except, perhaps, in the distributing system. In fact, I understand Mr. Crompton considers the third wire could be done away with altogether as soon as the feeder gets a good load joined up to it, so that only the distributing system would need the third wire, these wires being joined together at the distributing point.

Consequently, the weight of a set of mains on the three-wire system—the two outers 1in. section, and the inner one-fifth of an inch—would be 20 tons per mile; and the cost for copper at 6½d. per pound, would be £1,210 for the copper in the mile of mains. Now at 1,000 amperes per square inch a main this size would carry current for 6,000 16-c.p. lamps, if perfectly balanced on the above basis, and the fall of pressure would be 90 volts in the mile, or 17 per cent. Such a fall of potential as 17 per cent. in the mile is excessive, and therefore we must arrange to work at a smaller current-density.

To enable the best current-density to be judged I have arranged the following table:—

Data Relating to Feeders on Three-wire System Supplying 220-volt Lamps—$\frac{1}{3}$ Ampere per 16-c.p. and $\frac{1}{6}$ Ampere per 8-c.p. Lamp.

Current-density in amperes per square inch.	Loss in volts per mile of double conductor.	Percentage fall of potential at full load.	Kilowatts available per square inch section of outers = 2·2 sq. in. copper.	Number of lamps carried by mains 1 sq. in. section = 2·2 sq. in. copper.		Cost per mile of copper at 6½d. per pound.			
						Per lamp alight at once.		Per lamp installed = twice lamps alight.	
				16 c.p.	8 c.p.	16 c.p.	8 c.p.	16 c.p.	8 c.p.
		Per cent.				s. d.	s. d.	s. d.	s. d.
1,000	90·0	17·0	440	6,000	12,000	4 0	2 0	2 0	1 0
500	45·0	9·3	220	3,000	6,000	8 0	4 0	4 0	2 0
400	36·0	7·6	176	2,400	4,800	10 0	5 0	5 0	2 6
300	27·0	5·8	132	1,800	3,600	13 5	6 8	6 8	3 4
250	22·5	4·86	110	1,500	3,000	16 0	8 0	8 0	4 0
200	18·0	3·85	88	1,200	2,400	20 0	10 0	10 0	5 0

This table enables us to see the reduction in fall of potential which we get by reducing the current for a given section, and also the cost for copper which will be incurred for such density per mile run.

Now it is not unusual in some low-pressure central stations to have falls of even more than 16 per cent. at full load on the longest feeder; but this is an undesirably great fall, save on exceptional occasions, such as Christmas week, or during a fog in winter, and I think, with the immense reduction in copper cost which the use of high-voltage lamps gives, it is desirable to work with smaller falls. Suppose we accept 250 amperes per square inch as a basis, it will be seen that mains on the three-wire system will cost us 16s. per 16-c.p. lamp alight at once, and 8s. per 8-c.p. lamp per mile, and the drop of potential will nearly be 5 per cent. Now, if we assume that current is supplied 2½ miles from the station as an extreme, as we did before, our longest feeders will be about this length, the drop at full load on the feeder will be about 12 per cent., and the cost of copper 40s. per 16-c.p. lamp, and 20s. per 8-c.p. lamp alight at once for the longest feeder.

If we take the network as proceeding from the feeder points at the same current-density—namely, 250 amperes per square inch—and if we agree that it shall extend rather over a quarter of a mile from the feeder point, to allow for irregularities, so that each feeder will feed a network covering half a mile square, it will be noted that the drop, including extra lengths of main for going round angles and into the houses, will be about 1½ per cent., and the extreme cost of copper per lamp alight at one time in the network will hardly be more than 4s. per 16-c.p. lamp, and 2s. for an 8-c.p. lamp, while the mean cost will be about three-fourths of this, and the mean drop of potential only 1 per cent.,—and even this can readily be reduced by a little judicious adjustment.

We therefore see that for feeders extending about 2¼ miles, and a network extending a quarter of a mile further from the feeding point—that is, 2½ miles altogether—the extreme cost for copper per 16-c.p. lamp lighted at once will be about 44s., and for an 8-c.p. lamp under 22s.

This represents extreme lengths. The average length of feeders to cover the above area would hardly be more than 1¾ miles, or three-fourths of the above maxima, and the cost of the copper, on the average, in the distributing system will be reduced in like proportion. We shall therefore be correct in taking three-fourths of the above sums as the average cost of copper per lamp lighted at once from station to lamp, including both feeder and network, in a station covering a town area of equal density 25 sq. miles in area. This is, approximately: Per 16-c.p. lamp, 33s.; per 8-c.p. lamp, 16s. 6d. Further, from practice and the tables in *Lightning*, we know that there are usually at least twice as many lamps installed as are required alight at once; therefore we may put the capital cost of mains for copper only at about: Per lamp installed—cost of copper, 16 c.p., 16s. 6d.; 8 c.p., 8s. 3d.

Now it is fair to take 6 per cent. per annum as the sum to allow for interest and depreciation on the copper in the mains—say 3½ per cent. for interest, and 2½ per cent. for depreciation. At this rate, on the above capital cost, the annual cost for interest and

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upkeep comes out at under 1s. per 16-c.p. lamp, and 6d. per 8-c.p. lamp installed.

Further, on looking through the tables of consumption of current, it will be found that 18 units per 8-candle lamp installed is a fair all-round average—at least, it is the average from *Lightning* for London and most of the provincial stations. At this rate, therefore, it will be seen that the upkeep and interest on capital for the copper in the distributing system comes to 0·33d., or one-third of a penny per unit of current sold; or, supposing the sum actually received for current is 6d. per unit, the cost for interest and upkeep on the copper in the distributing system represents less than 6 per cent. of the cost of current. Out of this cost, it will be noticed that about three-fourths of the copper is in the feeders, and one-fourth in the distributing system.

I may say that Mr. Crompton objects to the method of taking the consumption per 8-c.p. lamp installed as a basis of comparison, and I quite agree that it is rough and unscientific; and it might be well if our friend the editor of *Lightning* would look into it, and see if he could not get a sounder basis for comparison. Mr. Crompton suggests the relation between the annual output in B.T. units, and the output which would be registered if the maximum load were continued day and night throughout the year. In this case he tells me the actual output would vary from the equivalent of full load for 700 hours in some country towns to 1,000 in parts of London, 1,300 in Kensington, and a much higher figure for the Pall Mall and St. James's Company. 1,300 hours corresponds to a load-factor of 15 per cent.; though it will readily be seen that it is a figure of more comprehensive nature, and not exactly similar. I leave this question here, however, as, though very interesting, to discuss it further now would be out of place in this paper. In order to complete the comparison made above, the cost of insulating and of laying the cables should, of course, be taken into consideration. In order to set this point at rest, Mr. T. O. Callender has kindly prepared for me data deduced from their experience in supplying and laying cables, which, as a result of a large amount of practice, are beyond cavil, and which show the average cost of cables laid as compared with the cost of the copper in them. These particulars are given in the following table:—

Table showing the Total Cost of Insulated Cables laid complete, as compared with the Cost of the Copper Contained.

Character of cables (separate.)	Amoured, laid direct.	Plain, laid in solid bitumen.	Armoured, laid direct.	Plain, laid in solid bitumen.
Area of Cable { Outer	Sq. inch. 0·50	Sq. inch. 0·50	Sq. inch. 1·00	Sq. inch. 1·00
Area of Cable { Middle	0·25	0·25	0·50	0·50
Area of Cable { Outer	0·50	0·50	1·00	1·00
Cost of cable laid complete, exclusive of excation	19s. per yd. £1,650 per mile.	25s. per yd. £2,200 per mile.	33s. per yd. £2,900 per mile.	42s. per yd. £3,700 per mile.
Excavation, cheap streets and lanes	s. d. 1 3	s. d. 1 3	s. d. 1 3	s. d. 1 3
Excavation per yard, average run of trench in towns under macadam or pavement	2 0	2 0	2 0	2 0
Ratio of cost of copper (at 7d. per lb.) to cost of complete cable laid, as 1	2·5	3·1	2·2	2·3

Under asphalte or wood the cost of excavation will run up to as much as 15s. per yard run, but this item will practically be the same whatever system is used. Moreover, as only a few of the main streets in large towns are so paved, this item is not one which need concern us particularly in a general comparison, but must be dealt with in accordance with local circumstances in each case. It will be noticed that in the above table the middle wire is half the section of the outers; in practice it would not be necessary to have this more than one-fifth for the feeders, and in some cases it might be omitted entirely. The actual cost of feeders should therefore come out about 10 per cent. under the prices given, though I have thought better to leave the table as it was, preserving Mr. Callenders's own figures.

At these rates, for a two-mile feeder of armoured cable, working at a current-density of 250 amperes per square inch, the cost, laid complete, would be about £55 per kilowatt for the maximum output; the fall of pressure being about 10 per cent. I think, therefore, [that the whole distributing system—consisting of feeders, branches, local services, service boxes, and every other item, also providing for a fair proportion of the cables being laid under asphalte or wood, from such a station as I have described above, with a service extending 2½ miles in all directions—could be laid complete for £60 per kilowatt.

This is a very moderate figure as compared with the sums now spent. If we assume that 8 per cent. is required to meet interest, upkeep, and depreciation on this outlay, and if we take the output of the station at 800 kilowatt-hours maximum load on the basis suggested by Mr. Crompton, it is evident that interest and upkeep on the distributing system would cost about 1½d. per unit of current sold for the whole distributing system; so that a charge of 1½d. per unit would cover all costs outside the station itself. From what we know of the cost of generating electric energy, it will, I think, thus be clear that, even in places where coal was expensive, a very good profit would be made by selling current at 4d. per unit for lighting, and 2½d. for power purposes. In making this calculation I have assumed the same density of population over the whole area; but it is evident that this would very seldom be the case, as in nearly all towns at two miles from the centre the density of population is greatly reduced, which would mean a smaller proportion of long feeders, and consequently a less average cost per kilowatt output than I have taken

I do not wish it to be assumed from what I have said above that the capital cost of a direct-supply station at 220 volts, with feeders and distributing system extending 2½ miles, as described above, would be as low as that for an alternating station at 2,000 volts, with transformers and 220-volt lamps, to cover the same area. It would not. Comparing feeders, I think, with the present prices of mains, and using the same class of insulation in each case (as is frequently done now)—that is, not using expensive rubber cables for the high tension—the two systems are equal in cost for feeders 1½ miles long. As the distributing system will extend a quarter of a mile further beyond the end of each feeder, a direct-supply station on exactly the same lines is as cheap in capital cost for an area having a base of at least 3½ miles and covering 10 square miles. Further, as something must be allowed to the direct-supply system on account of lower depreciation, and greater safety and freedom from restrictions, and ability to supply motors more easily, another quarter of a mile may easily be allowed on the feeders of the direct-supply station on this account; so that the systems compare together when the base of the area served is four miles and the area itself 16 square miles, even if no accumulators are used.

Although this is not as large as the area I have taken as a basis, what it means can be estimated from what has been said above as to the actual areas covered by large towns. I am, of course, assuming that 220-volt lamps are used on the transformer station as well as the direct. If we assume that the transformer station employs 100-volt lamps, of course the comparison would be much more decidedly in favour of the direct supply at 220 volts.

There is no need, however, to go very minutely into these figures, because, though thoroughly practical, they do not represent what it is clear will be central station practice in the future, as I do not think it probable that any direct supply station in the future will be operated without accumulators.

The Use of Accumulators.

This brings me to the fifth and last point mentioned at the beginning of my Paper when enumerating the possibilities likely to affect central station practice in the future—viz., *the use of accumulators*. In the earlier part of 1891 I did not see much likelihood of improvements in accumulators making any really fundamental alteration in central station practice. But I must confess that in this respect events have moved faster than I anticipated, although I have been brought sufficiently into contact with them to learn what was going on in the field and how batteries were doing as regards upkeep. Up till comparatively recently there is no doubt accumulators have been rather a luxury and convenience in central stations than a commercial or economical necessity; but during the last two or three years considerable changes have been taking place. The maximum safe discharge rate for accumulators has been going up, while the initial cost has been going down, as well as the cost of upkeep, and extended experience holds out the hope of much longer life for the newer and improved forms of positive plates than has hitherto been the rule. Owing also to the method of supplying accumulators at a maintenance rate adopted by the leading firms, an engineer need have less hesitation in recommending clients to incur a large expenditure on them, and the risk is much less than formerly. Patents are also expiring, and considerable competition is arising in this trade, which was formerly such a close one.

I have lately had to make careful inquiries about accumulators in connection with work on which I am engaged, not only as regards prices, but also as to their working, and, having got particulars about the batteries in several central stations, and held conversations with the engineers concerning them, have been considerably surprised at the progress which has been made. Taking quotations from leading makers for a battery suitable for a central station, I find that the capital cost of a battery to discharge at 1 kilowatt for three hours is as nearly as possible £13 for the battery alone. Several makers assure me that such a battery can be discharged at this, and even higher rates, every day regularly, without detriment or endangering the life of the positive plates. The above price does not include buildings to contain the accumulators, connections, instruments, or stands to hold them, which bring up

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the cost to about £19 per kilowatt on this basis for central station batteries. The makers tell me further that they are willing to enter into contracts to maintain such batteries in a state equal to new for about 6 per cent. per annum on their capital cost, and some makers will even go lower than this. It will be found that these costs and rates of renewal are a great improvement on those ruling until comparatively recently.

Now I should not quote these figures unless I had, by private inquiries and in other ways, fairly convinced myself of their substantial accuracy. Granting that they are so, it appears to me that they raise questions of very serious import in central station practice, particularly when coupled with the use of higher voltage lamps. If an accumulator will give a discharge for three hours—that is, sufficient to cover the period of heavy load, or the time during which the large portion of the plant has to be kept running—a kilowatt capacity of accumulators will be equivalent to a kilowatt capacity in engines and dynamos. In continuous-current stations, when an increase of output is required—which is from time to time the position of most stations—we are therefore brought face to face with this problem. Extra plant for 200 kilowatts output, say, is required. Which is the best way of providing for it—by adding engines and boilers, or by adding accumulators and charging them during off hours from the existing plant? Now, as I have said above, an accumulator for an extra kilowatt output will cost about £19 complete and erected, including buildings; and I think engineers will generally agree with me that engines, boilers, dynamos and steam pipes for a kilowatt output, including buildings and all other accessories, would cost about the same sum; if foundations, flues, chimney stalk and everything else were considered, the comparison would be slightly in favour of accumulators. However, for our present purpose, let us assume that they are equal. We have therefore arrived at the position that the capital cost will be equal, whether we provide extra plant or extra accumulators for the increased output required, charging the accumulators from the existing plant. As regards upkeep, if we can keep the accumulators in an efficient state for 6 per cent. on their cost, this is not greatly in excess of what would have to be allowed on plant if boilers are included; and, at any rate, the difference is not a matter of very great moment.

There is no need to say anything here on the extremely low cost at which energy can be produced if a continuous load is provided night and day. Considering the advantages accumulators give in a central station in providing for emergencies, reducing staff, and keeping the pressure even, it is, I think, doubtful if an engineer placed in the position indicated above—as many engineers will be placed shortly—would not be wise in recommending his Corporation or his Board to instal accumulators for 200 kilowatts output for three hours, instead of the extra plant, when the plant was a continuous one. How far this should proceed is a moot point, dependent upon circumstances, which would need decision in each case. Possibly somewhere about one-third the maximum full-load capacity would be about right now, but with a load-factor of 10 to 15—which is about that general in central stations—if the price of accumulators came down per kilowatt output, which I think it is likely to do in the future, or their efficiency increased, it might be found desirable to instal accumulators for as much as two-thirds, or even three-fourths, of the full load, which would place electric distribution nearly on a par with gas distribution in respect to storage. To go as far as that is, however, not a question of the present—at any rate in most cases—and therefore for our purpose this evening I propose to consider the accumulators as desirable for about one-third to one-half the full output.

It may be useful here to give a few general data relating to accumulators as they stand at present. The leading makers' prices of central station batteries work out at about £13 per kilowatt on a discharge for three hours, for the plates, cells, and acid only; whilst, including stands, erection, connections, and switching arrangements, the price works out about £17 per kilowatt, or, if buildings also are included, about £19 per kilowatt. In such a battery, I find the plates and lead cells alone would weigh about 8cwt. per kilowatt output on the three hours discharge basis; and that 1cwt. of plates and cells costs a little under £2—or the cost comes to about £40 per ton. Now, as lead costs under £12 per ton at present, and seeing how much almost pure lead, in a very simple form, there is in accumulators, it does not seem unreasonable to anticipate that in the future, when accumulators are made on a much larger scale, we may see the price gradually come down to, say, £25 per ton, with, perhaps, improved capacity and life. At least, it appears to me that there is as good hope in this direction as there is of reduction in price and improvement in quality in any other department of electric engineering. If such a consummation were attained, it is pretty clear that it might pay to use accumulators for power stations, as well as lighting, wherever an eight or nine hours day was in vogue, and that they may ultimately come to exercise a much wider influence on the future of the electric industry than most engineers have anticipated.

In order to gauge in some measure what has been the improvement in accumulators during the last few years, and since the question of the system of central-station supply was last prominently before this Institution, I lately took an opportunity of talking the matter over with Mr. Epstein, and I asked him if by looking up old contracts and catalogues he could give me anything definite on the subject; in reply, he has sent me the following letter:—"I have looked into the question of the prices of accumulators, and I find that, comparing the prices in 1890 with the present ones, there is, on an average, a reduction of 25 per cent. But another and more important point is this—that whereas the types then manufactured were only allowed to be discharged in about 10 hours, necessitating in the case of shorter discharges much larger batteries than required for the purpose, the discharge rate has since then increased very considerably. Taking one with the other, I think I am justified in saying that the reduction altogether amounts to quite 50 per cent." In view of these facts, and considering that it is now the custom to buy accumulators on a moderate maintenance agreement, and also all the added experience of the last five years' work, it will be at once evident on how much sounder a basis commercially accumulators now rest, and how much stronger the arguments in favour of their employment in central stations are than they formerly were.

Upon the three hours discharge basis, I find a kilowatt capacity of accumulators occupies approximately 4 cubic feet space, for the cells and connections, so that we get a kilowatt-hour into 1·33 cubic feet. Now a discharge of a kilowatt-hour, allowing for losses, will keep about 15 16-c.p. lamps going for one hour. Allowing that a gas burner using 6 feet of gas per hour is equal to a 16-c.p. lamp, the amount of space needed in a gasometer to store gas for the same amount of light is $6 \times 15 = 90$ cubic feet, or 70 times as much space. Of course this is not quite a fair comparison, because nothing is allowed for stands, access, &c.; but I think it will be quite fair if we allow ten times as much space for access, &c., as the accumulators take themselves. Even under these, the actual conditions, accumulators only occupy one-seventh the space which the equivalent gasometer would. We arrive, therefore, at the curious conclusion that, if the London gasometers were emptied of their gas and fitted up as accumulator rooms, sufficient accumulators for lighting London could easily be arranged under working conditions in one-seventh of the space which would be available. We have, therefore, nothing very enormous to fear in the way of accumulator houses, even if accumulators are used in the future on the most extensive scale for lighting or power purposes.

Interesting as these speculations are, it is desirable, however, to return to what is more specifically our subject. It is usual at present to place the accumulators in the central station, except in a few instances, such as in Mr. King's system at Chelsea, Mr. Parker's Oxford system, and a few special places. Usually under these circumstances the accumulator is subject to the heavy drop at full load, which decreases its efficiency by 10 to 15 per cent. With 220-volt lamps the drop on the feeders within a mile radius would be much less than is usual now, and therefore the value of the accumulators would be correspondingly increased. For longer distances from the central station than a mile, however, undoubtedly the right place in most cases for accumulators will be at the feeder points. This is the more feasible with 220-volt lamps than under present practice, because the distributing network is so much larger from each feeder, and each feeder becomes the centre of a serious amount of lighting, which will pay for individual attention. Although from the table I have given the cost of copper per lamp installed for feeders is very moderate, yet on a two-mile feeder it amounts to a considerable sum in the aggregate; and if, by installing accumulators at the end of the feeder for one-third to half the full output, the section of the feeder can be cut down by one-third or a half, a very important saving is effected; and, of course, if accumulators for two-thirds or three-fourths full load were installed, the cost of feeders would be correspondingly reduced. This has already been recognised in practice, and many devices have been brought out for charging accumulators in series, or by the help of motor transformers using a high-tension current; but I would point out that the use of 220-volt lamps on a three-wire system does away with the necessity for any of these complications. All that is needed is a continuous-current motor transformer of the "booster" type. In this, one armature circuit is across the mains, and wound with a high resistance and many turns, while the current to the accumulators passes through the second circuit direct; the second circuit being wound with a few turns, so that the voltage of the main current in passing through the armature is raised, say, 30 per cent. The motor transformer then need only be about one-third the capacity for the charging current, and the cells can be charged at any time, while the circuit is supplying lamps, so that continuity of supply without complication is ensured. By these means the cost of long feeders would be much reduced on the figures given above; which means also that it would be practicable to extend the lighting radius much further than was contemplated above at the same cost, should it be needed. An important factor

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is also brought in—that, having once laid a feeder of fair size, accumulators can be added at the outer end as the lighting grows, and thus a very large increase of lighting could be gradually met without relaying the feeder or disturbing the streets, which is always an expensive and troublesome operation.

In what I have said above I have indicated a feeder to each half square mile as an average, or four to the square mile; but it is clear that, if accumulators were employed, and it were desirable to concentrate them in order to save labour and attendance, it would be very simple to run short sub-feeders from a centre, so that one distributing point where accumulators were situated, and one feeder from the central station, could be economically made to serve a square mile or more.

It is further worth noting that at 220 volts the cutting in or out of a cell makes less than 1 per cent. difference in the voltage, and not 2 per cent., as at present. This is an important consideration in keeping the light steady, a point the importance of which is becoming more and more recognised.

The convenience of the system for arc lighting does not need pointing out, as nine arc lamps can be run in series. One more point is the effect which a general electric supply at 220 volts on the lines indicated above would have on the power supply question. There is no difficulty in procuring already motors of any size, from 50 watts upwards, to run on 220-volt circuits, the number of amperes they take being, of course, half what is usual now; while for larger sizes, say, above 3 or 4 kilowatts, they could, of course, be coupled across the two outers at 440 volts. If we then add the facts that the drop on the feeders would be less than at present, that the current-density in the distributing system on the basis I have laid down would only be about half what it is at present—and when we consider that there would only be 1½ per cent. fall of pressure at full load on the distributing mains, and that by cross-coupling even this would be reduced—then it seems to me that it goes almost without saying that motors could be used to a far greater extent than at present is possible without appreciably affecting the regularity of the lighting. Accumulators at the feeding points would also be an important aid in this respect; if they were so used, the fall of voltage from them to the motors would rarely exceed 2 per cent., and under such circumstances motors of considerable size could be started and stopped (even without special starting resistances) without the rush of current being perceptible on neighbouring lamps. In this respect, therefore, the use of 220 volts is likely to be very advantageous, and do away with the necessity of having to lay special power mains—for some years, at any rate.

The utility of having generators in the lighting stations giving the current and voltage which is needed for tramway work is also obvious; in fact, it looks as if one station in future would do all the power supply for a town, the lighting being only one adjunct of its business, and that, possibily, not the largest. With most of the lighting done by means of accumulators charged during the night, and the station supplying power to the tramways, &c., during the day, it ought to be possible to secure a very fairly even all-day load with one set of plant, instead of two as at present. This would, of course, lead to important economies in generating expenses. In fact, it looks as if we could already see far enough ahead practically to enable Mr. Preece's prophecy to be fulfilled in a moderate time—"that the electric light would ultimately be the light of the poor man as well as of the rich."

And now I must conclude. The title of my paper was "High-Voltage Lamps, and their Influence on Central Station Practice." In the first place, I have endeavoured to show that high-voltage lamps are thoroughly practical. Next, that high-voltage lamps are more desirable than lamps of the usual voltage and of high economy. I have also shown reasons why it is probable that the economy of high-voltage lamps may in time nearly approach that obtainable in ordinary voltage lamps.

Having thus tried to establish the soundness of the position of the high-voltage lamp itself, I went on to consider what influence the adoption of a high-voltage lamp would have on central station practice. I have shown how it simplifies and renders less costly the distribution of current, and how it improves the conditions of lighting. I think I have further made it fairly clear that for nearly all practical requirements of town lighting the direct supply system will prove simpler and less costly, as well as more advantageous, than any system, whether direct or alternating, in which transformers are used; in fact, the necessity for this class of apparatus, except for special cases, seems to vanish.

I think, therefore, that, when the facts are fairly faced, there does not seem much doubt that those engineers who have advised their clients to erect continuous-current direct supply stations in the past have done wisely, and will be found to have served their clients' best interests; and that for the future alternating-current stations, even for country towns and scattered districts, should only be erected after the most careful weighing of possibilities.

It is considerations of this character which have led me to keep very much in the background as regards central station lighting for the last four years. Having been associated from the early days with alternating currents, my predilections were in that direction; and although the position seemed secure, yet, seeing the possibility of great improvements in several directions which would tell strongly in the favour of direct supply (but the exact advent of which no one could actually foretell until it arrived), it seemed to me more prudent to turn one's attention to other things for the time than to incur the risk of recommending work which might soon have to be undone. I have always expected and looked forward to a time when there would be one system of lighting, with variations merely in details, and have felt that the rivalry between the two systems would some day end as the battle of the gauges ended in the early railway days, and I think there are signs of the end now. It seems as if the narrow gauge would win again—as if the tortoise would again beat the hare, though it is true that to do so the tortoise has had to improve its pace considerably.

TESTS OF RAIL BONDS.*

The following resistance tests of rail bonds were recently made at the power house of the Buffalo Railway Company, and the results will be of much interest to railway engineers:—

Type of bond.	Size of girder rails used. Lbs. per yard.	Current in amperes.	Drop in bond. Volts.	Condition of bond at end of test.	Remarks.
Copper bond.	90	125	0·0375		With one No. 00 bond 6in. long, through rail base. Contacts clean, tight and new.
		1,200	0·208		
		1,450	0·313	Very hot.	
Ditto.	Ditto.	200	0·028		With one No. 0 copper wire 30in. long, newly fastened with channel pins.
		1,200	0·178		
		1,500	0·21		
Plastic bond.	Ditto.	160	0·002		With standard type of plastic bond between web of rail and angle-plate on one side only.
		200	0·01		
		1,200	0·035		
		1,400	0·04	Cold.	
Plastic plug bond.	62½	190	0·00426		Rails on chairs with T-rail under joint; one pair of §in. holes through chair and rail base into top of T-rail; holes amalgamated and filled with plastic alloy.
		400	0·0201		
		1,200	0·0623		
		1,500	0·086	Cold.	
Ditto.	Ditto.	190	0·00186		Ditto, with one pair of §in. holes on each side of rail; amalgamated and filled with plastic alloy.
		1,200	0·0428		
		1,300	0·0422	Cold.	
Ditto.	Ditto.	200	0·0026		With horizontal hole §in. diameter in meeting ends of rails, with grooved steel dowel pin; amalgamated and filled with plastic alloy.
		1,000	0·038		
		1,300	0·0554		
		1,500	0·067	Cold.	

* Compiled from the *Electric Railway Gazette* of New York.

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ST. PANCRAS VESTRY WIRING RULES.

CURRENT WILL BE SUPPLIED AT 220 VOLTS.

Special attention is called to Rules Nos. 3, 4, 5, 6, 10, 11, 12, 13, 14, 17, 22, 33, 39 *and* 40.

1. *Conductors.*—All conductors must be of tinned copper, of not less than 98 per cent. of conductivity (by Matthiessen's standard). They must be so proportioned that the current density in no case exceeds the rate of 1,000 amperes per square inch of sectional area.

2. *Limit of Conductors.*—No conductor to be smaller than No. 18 S.W.G. Conductors larger than No. 16 S.W.G. must be stranded.

3. *Insulation Conductors.*—The insulation resistance of every cable or lead must not be less than at the rate of 2,500 megohms per statute mile, after one minute's electrification. All rubber-covered conductors must have a coating of pure rubber, and one of vulcanising rubber, and the whole properly vulcanised and braided, or otherwise suitably protected against mechanical injury.

4. *Conductors under Plaster.*—Conductors buried under plaster must be protected by iron piping (where practicable) or porcelain ducts.

5. *Conductors in Wet Positions.*—Conductors in wet situations should be, by preference, in porcelain ducts. If in wood casing, care must be taken to leave an air space of ⅛in. between the casing and the wall, and the vulcanised rubber-covered conductor must be further protected by a covering of lead.

6. *Casing Corners, Rounded.*—Where casing is used all corners must be well cut away and rounded to avoid damaging the insulation of the conductor.

7. *Conductors Outside Premises.*—Conductors outside buildings should be supported on porcelain insulators at frequent intervals, and kept about 8in. or 10in. apart.

8. *Naked Conductors.*—No naked conductors allowed.

9. *Staples Forbidden.*—No staples to be driven over conductors.

10. *Joints Soldered—Resin only to be used.*—All joints must be soldered and thoroughly sweated together, nothing but resin as a flux permitted. Soldering-irons are to be tinned with resin, *and no sal ammoniac used.*

11. *Insulation of Joints—Joints Vulcanised in Wet Positions.*—After soldering, each end for not less than 2in. on either side of the joint must have all tape, cotton, or braiding removed, laying bare a clean rubber surface, which is to be carefully tapered down. The whole of the joint and bared rubber must be covered with at least five lappings of pure rubber tape, and two or more of prepared vulcanising rubber tape; the whole to be tightly bound with prepared waterproof tape, and in damp positions, or covered by plaster, to be properly vulcanised or otherwise rendered permanently watertight. If the vulcanising be found impracticable in certain positions, the finished joint should be coated with shellac varnish. Rubber joints will not permanently resist moisture unless vulcanised.

12. *Joints Kept Apart.*—Every joint or branch tapping must be kept at least 8in. from those of opposite polarity.

13. *Preparation of Ends of Conductor.*—All ends of cables or conductors, before being connected with fittings, must have the tape or braiding removed, leaving a clean rubber surface for at least 1½in.

14. *Main Circuits.*—Should the current demanded exceed 25 amperes, two separate and distinct main circuits must be run in two casings to the terminals of the Vestry's supply. These circuits should supply alternate floors of the building, in order to keep them as far as possible distinct.

15. *Loop left for Meter.*—In every main circuit a loop having five feet of slack cable must be left at the proper position for the insertion of the meter.

16. *Main Fuses—Positions.*—The contractor must fix a main single pole fuse on every main conductor, at the point immediately after leaving the meters to the house. The fuses for the mains completing the circuits are to be inserted between the Vestry's main switches and the house side of the circuit.

17. *Tin Fuse Bridges Stamped.*—The fuse bridges for these main fuses must be adjusted to carry less than those fixed by the Vestry. They must be of flat tin, stamped, indicating the working current, *and have at least* 1½*in. of clear break.*

18. *Branches—Two Fuses For.*—Every branch circuit shall be efficiently protected by two distinct fuses, one on each pole, at the point of juncture.

19. *Fuse-Boards.*—If distributing fuse-boards are employed there must be two distinct boards—the one negative, the other positive—under separate covers, kept at least 4in. apart.

20. *Double-Pole Fuses Prohibited.*—Double-pole safety fuses will not be permitted on any account.

21. *Area of Fuse Bridges.*—All fuse bridges must be of tin, and must not, under any conditions, exceed the sectional area of the circuit they are intended to protect.

22. *Design of Safety Fuses.*—All safety fuses must be mounted on porcelain or vitrite bases, with covers of similar material. *The break must be not less than* ⅜*in., nor may the distance between any portion of the metal or conductor be less.*

23. *No Fuses under Floors.*—No fuses allowed under floors.

24. *Switches.*—Switches in close proximity *must be all of the same polarity.* All switches must be quick break, mounted on an insulated base of porcelain, vitrite, or slate boiled in paraffin wax. They must be so designed that the action is certain, either "on" or "off," and cannot possibly remain in an intermediate position. The handles and covers must be well insulated from the circuit.

25. *Switches for Arc Lamps—Main Switches.*—Switches controlling either arc lamps or main circuits should have at least one inch of clear break.

26. *Switches on Fittings.*—Switches forming part of fittings must be well insulated. The handles must also be insulated from the circuit. No combination fuse and switch allowed.

27. *Limit of Lamps for Switch.*—Not more than 10 16-c.p. lamps, or their equivalent, to be controlled by each switch, except by special permission in writing from the engineer. Lamps consuming more than the equivalent stated, must be provided with a switch to each.

28. *Arc Lamps Insulated.*—Arc lamps must be suspended by porcelain insulators. Four ordinary arc lamps are required in series for the 220 volt supply. If two only are required they must be of suitable design.

29. *Fix Incandescence Lamps in a Vertical Position.*—Incandescence lamps should be fixed with the bulb in a vertical position. For other positions lamps must be used in which the filaments are specially supported.

30. *Resistances.*—All resistances should be mounted on iron frames kept 18in. clear of all woodwork or inflammable material. They must be protected by a metal guard, and supported on insulators. The conductors leading thereto should pass upwards, and be connected with terminals at the lower portion of the frame, so as to avoid contact with any heated part. Resistances should be fixed on brick walls, or by preference hung outside of the building.

31. *No Exposed Parts Allowed.*—No portion of the electric circuit, or of metallic fittings or parts in connection with the circuit, more especially in switches and cut-outs, to be left exposed.

32. *Earth Connections.*—No metal frame work of any fittings shall be used as part of the electric circuit, or be in contact therewith, and no connection with gas, water pipes, or "earth" allowed.

33. *Combination Fittings.*—Combination gas and electricity fittings *must not be employed*, except by special consent of the Engineer, and under such precautions and conditions as he may direct.

34. *Wall Plugs, &c.*—Wall plugs, ceiling roses, and other fittings of the kind not specially mentioned, must be mounted on porcelain or vitrite, with covers of similar material. All slate bases to fittings must be soaked in wax. *All porcelain must be vitreous throughout.*

35. *Removal of Fittings—Ends Sealed.*—Should any fittings or apparatus need removal, the ends of the conductors leading thereto must be properly insulated and securely sealed up, and, if practicable, both branch fuses removed. All terminal ends of wires and cables must be thoroughly insulated and sealed up.

36. *Insulation of Complete Installation.*—The insulation resistance in ohms between "earth" and the complete installation, measured at the Vestry's main terminal fuses, with every lamp, fitting, or other apparatus connected, must not be less than the number found by dividing 10,000,000 by the total amperes required to feed the installation.

37. *Testing Fees.*—On receiving due notice in writing of the completion of the wiring, the work will be inspected and tested free of charge. If the first test fails to comply with the requirements herein specified, a second and all subsequent tests will be made on payment of 10*s.* at the offices of the department for every such test.

38. *Low Insulation.*—Should the insulation at any time fall below the standard specified herein, the Vestry may, after due notice, discontinue the supply of electricity to the premises.

39. *Examination of Work.*—The Vestry shall have the right to require the contractor *to open any joint, or to remove any casing, wires, or fittings, for the purpose of ascertaining if the work has been thoroughly executed.*

The contractor must reinstate, at his own expense, any work the Vestry may have examined in the manner set forth.

40. *Additions to Lighting.—No addition shall be made to any installation* that has been tested by the Vestry's officials, *until due notice has been given* on a form to be obtained at the offices of the Department; failing this, the supply is likely to be stopped.

41. *Cut off Current during Repairs.*—Before commencing any extensions, alterations, or repairs to the installation, the main switches must be turned off to avert accidents, and remain so until the work is completed.

42. *Fire Insurance Rules Observed.*—Work on consumers' premises must be strictly in accordance with the rules of the fire insurance companies and of the Institution of Electrical Engineers.

43. *Motors—Starting Resistance.*—Every motor must be wound to work at 220 volts. It must be provided with a suitable starting resistance, so arranged that *it is not possible to disturb the neighbouring lighting when stopping and starting; an automatic water resistance will be preferred.*

44. *Fly-Wheel to Motor.*—Motors driving lifts, cranes or circular saws must be provided with a suitable fly-wheel.

45. *Furnish Details as to Motors.*—Before commencing to fix any motor the following details must be sent to the Engineer:—(*a*) a descriptive drawing of the starting apparatus, giving full details of its action; (*b*) state horse-power; (*c*) purpose for which the motor is required; (*d*) state revolutions per minute; (*e*) diameter of fly-wheel proposed. Thickness and radial depth of rim.

46. *Current for Storage Batteries and other Purposes.*—If current is required for storage batteries or special purposes, the general arrangement of the installation must be submitted to the Engineer for approval.

47. *Non-liability.*—The Vestry do not take any responsibility for the proper execution of any work on consumers' premises, nor for any loss or damage which may be occasioned by fire or any accident arising from the wires, fittings, or other apparatus within the buildings.

48. *Amendments.*—The Vestry reserve to themselves the right, without notice, of altering these rules and regulations from time to time as they may deem necessary.

Previous rules cancelled.

SYDNEY W. BAYNES
Chief Electrical Engineer.

February, 1896.

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NATIONAL TELEPHONE COMPANY'S STAFF DINNER.

A gathering, numbering nearly 200, and consisting chiefly of members of the staff of the National Telephone Company, sat down to dinner in the King's Hall, Holborn Restaurant, London, on Friday last, the General Manager of the Company (Mr. W. E. L. Gaine) occupying the chair, supported by the Right Hon. Lord Harris (Vice-President of the Company), Sir Albert K. Rollit, M.P., Mr. W. C. Quilter, M.P., Mr. C. S. Agnew, Mr. Geo. Franklin, Mr. G. H. Robertson, Mr. W. A. Smith, Mr. Frank Crisp, Mr. W. H. Preece, C.B., Prof. D. E. Hughes, Mr. J. C. Lamb, C.B., C.M.G., Sir Robert Hunter, Mr. H. C. Fischer, C.M.G., Mr. D. Johnstone Smith, Mr. E. W. Chetwynd, Mr. H. E. Clare (Town Clerk of Liverpool), Mr. R. E. Fox (Town Clerk of Blackburn), Mr. J. Gavey, Mr. J. Hookey, Mr. Geo. Sutton, Mr. J. E. Kingsbury, Mr. Max Binswanger, Mr. James Taylor, Mr. G. Binswanger, Mr. J. T. Crowe, and of the prominent officials of the Company, Messrs. Albert Anns, Dane Sinclair, S J. Goddard, C. B. Clay, J. C. Chambers, R. H. Claxton, A. E. Cotterell, A. Coleman, F. D. Watson, C. J. Phillips, G. F. Preston, F. Gill, R. Shepherd, T. Fletcher, W. V. Morten, R. A. Dalzell, H. Davis, J. W. Ullett, A. Martin, W. A. Valentine, H. B. Sutcliffe, C. G. Wright, W. W. Cook, and many others well known in telephonic circles.

The proceedings were opened by the Chairman proposing the usual loyal toasts, which were cordially accepted. "The Houses of Parliament" was responded to by Lord Harris on behalf of the House of Lords and by Sir Albert Rollit for the House of Commons. An opportunity was taken by the latter speaker to express his views somewhat strongly on account of having been detained in the House until the very moment when, dinnerless, he was called upon to respond to the toast. Both speakers referred in cordial terms to the unanimity now prevailing between the Post Office Department and the National Company. Sir Albert's speech was in his happiest vein and the hon. member was heartily cheered upon resuming his seat.

The CHAIRMAN then proposed the toast of "The National Telephone Company," and in doing so expressed his regret, and that of all present, at the absence of their President, Mr. James Staats Forbes, who, as on the last occasion of their dinner, was strictly forbidden by his medical attendant to be present. Mr. Gaine referred to the serious loss the Company had suffered by the death of Mr. A. Calder, the metropolitan manager, who rose to the important position he filled in the Company's service purely by his own merit. During the past year the *clientèle* of the National Company had been increased by nearly 9,000 subscribers, after allowing for the loss by death and other causes of many who had ceased to subscribe to the Company's system. About 50 further exchanges had been opened during the year, and the total number of messages passing over the Company's wires represented 313,000,000 per annum. The officials of the Company had been engaged in perfecting the machinery and plant of the system and bringing it into a perfect and efficient condition. Much of the plant had been remodelled and brought fully up to date. He referred to the negotiations which had been proceeding with the Post-office for the acquisition by that department of the Company's trunk lines. They had now reached a position when the Government were taking these trunk lines over, and he was able to announce that on April 4th next the telephone trunk wires of the kingdom would begin to pass into the hands of, and belong to, the State. He took that opportunity of assuring the representatives of the Post Office who were present that the easy working of the trunk lines by the State would be assisted by the staff of the National Company by every means in its power. They could depend upon the most cordial and loyal support from all concerned. He was not prepared to say that if they had been left to themselves they would have invited the Post Office to acquire the trunk lines, but it having been determined by Parliament that this should be done, and the negotiations having now satisfactorily terminated, it would be the policy of the Company to render every possible assistance to the Department in the carrying out of this important work. This brought him to the future position of the National Company. They would still continue to undertake what might be termed the local telephone service of the kingdom, and he therefore regarded the relationship now to exist between the two bodies as in the nature of a partnership. The local service could be nothing without the trunk service, the trunk service could not exist without the local service. This position imposed upon the Company —upon its Directors and upon every officer of the Company—very grave responsibilities. He was happy to think that the Board of Directors had decided to take the most enlightened view of that responsibility, and were determined to join with the Post Office in making the telephone service as perfect as modern science and practice could make it. He desired to say that in all the great towns of the kingdom, if the Local Authorities were prepared to give the Company reasonable and adequate facilities, the Company on its part was prepared to place the whole service on the metallic circuit principle. It was an essential feature of the quasi-partnership between the State and the Company that the State Department should confine its attention principally to looking after that portion of the business which it had taken in hand, and not to look too carefully after or to enter on that portion of the business which it was the function of the junior partner (the Company) to conduct. He had stated at the last staff dinner that the very essence of the telephone service was a monopoly, in the sense that it could not be in more than two hands, and his opinion still was that, if the public was to be properly served, the "partnership" could not admit other bodies to the arrangement.

Lord HARRIS, in response, returned his personal thanks, and those of his colleagues, for the cordial response which had been been accorded to the toast, and desired to give expression to the feeling of comradeship which he and all associated with the administration felt existed with the staff connected with this great undertaking. Although the junior member of the Board, no one was more impressed with the spirit of loyalty that animated the staff of the National Company. The undertaking was an immense one, and when they realised the different and conflicting interests which had to be satisfied, he claimed for the Company a large measure of success. Not only had the public to be satisfied, but their large body of shareholders also claimed a full share of their attention. They were an important body, and it was due to their confidence and their commercial enterprise that the Company had attained its present successful position. The shareholders, at their recent meeting, had expressed no dissatisfaction with the system of administration. As to the public he did not claim that under the circumstances and the very material changes which were going on in the distribution of the material parts of the service that entire satisfaction had been given, but he believed that the result of the labours of their experienced engineers and officials would be that the public would ultimately have a service as perfect as human ingenuity and scientific methods could make it. They were striving their utmost to serve the public well and to give, in conjunction with the Post Office, the best possible means of intercommunication between telephone subscribers and other members of the public all over the country. In future instead of any jealous competition between the two branches of the telephone service the competition would be only as to zeal and efficiency. When he considered how great was the responsibility thrown upon the Directors and the Company for its efficient and successful working, he felt the more grateful to those who bore the heat and burden of the day, the Staff of the Company, chief amongst whom was their friend in the chair, Mr. Gaine. He could speak of the valuable services which Mr. Gaine had rendered to the National Company, and they were grateful to him as chief of the staff for the efficient service which was provided. His Lordship, in conclusion, referred to the vast numbers of employees of the Company, who were administering to the convenience of the public, and were doing their work honestly and well (the lady operators), and he appealed to those using the telephone to treat this hard-working and indispensable branch of the service with all possible courtesy and consideration. They were conducting an intricate service, and, upon the whole, were deserving of all praise for the success which attended their endeavours.

Mr. DANE SINCLAIR then proposed "Electrical Science," coupling the toast with the name of Mr. W. H. Preece. He referred to the successive steps, which since the middle of the seventeenth century had brought them to their present knowledge of electrical matters. When between the years 1821 and 1831 the development of electrical science brought in its wake the telegraph, many people thought that science had achieved all that could be expected of it. This was not, however, the view of such men as Franklin, Cavendish, Volta, Oersted, Faraday, Ampère, Davy, Henry, Thomson (now Lord Kelvin), Hughes, and many others whose names were familiar to them, who continued their investigations and brought electrical science up to its present point of perfection. Their thanks were especially due to such workers as Lord Kelvin, who had produced such splendid instruments as the syphon recorder, and had done so much to enable workers in the electrical industries to overcome the many difficulties which threatened their success at every turn. Looking to the marvellous progress which had been made by electrical science in the past few years there was no telling the wonderful achievements which would ultimately result from the experiments and discoveries of the present day.

Mr. W. H. PREECE, in response, said he was very proud to have his name associated with the toast of electrical science. For 44 years he had been working hard at the applications of this science. His earliest ideas were gathered at the feet of Faraday. From the day that electricity was regarded as a mystery to the present time, when it is regarded as a pure and distinct science, the spirit of Faraday had hovered over every electrician. He had himself been associated with almost every application of electricity to industrial purposes from the first introduction into this country of electric bells to the present time. He looked around him that night and saw so much youth working hard and striving hard to acquire further knowledge of the mysteries of electricity, and he could not help feeling that there was here a potentiality of invention which was going to mark a progress in the future far greater than that of the past. With regard to the remarks made by previous speakers as to the cordial arrangements henceforward to exist between the Post Office and the National Company in carrying out their joint undertaking, he was sure these sentiments would be reciprocated by the officials of the Post Office, not only those present, but those who were absent. The result would be that the telephone service of this country, controlled in one direction by the Post Office, and worked in the other by the National Company, would be, must be and should be the best telephone service in the world. They lived in a period of high pressure, and were going ahead at a break-neck pace, but there was one comfort behind it all—they had to aid them a branch of science that at any rate was going to cement friendship and add happiness, comfort, and health to their surroundings.

Mr. W. A. SMITH then proposed "The Post Office," and after paying a passing tribute to the memory of the late Sir Henry Calcraft, spoke of the good work done for the State by officials of the Post Office and to the satisfaction which all concerned felt at the happy termination of the negotiations between the Department and the Company.

Mr. J. C. LAMB, in reply, thanked them for the cordial manner in which the toast of "The Post Office" had been received. For himself, he looked upon the Post Office Department much in the same way as a sailor looked on a good ship; he was concerned in its reputation, and he wanted to see it standing as high in the estimation of everybody as possible. He was, therefore, not sorry to be allowed to respond to the toast. The Department brought him daily into contact with the representatives of the great commercial undertakings of the country, including the railway companies, the cable companies, and now the Telephone Company. Unfortunately it was not possible always to agree with the gentlemen who represented

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these important interests, but he was glad to be able to entertain the feeling that they were the representatives of legitimate and important British industries. He was expressing his own feelings and those of his colleagues, he was sure, in saying that they would be pleased and proud to work alongside the representatives of the National Company in conducting the telephone service of the country.

The remaining toasts were "The Board of Directors and other Guests," proposed by Mr. F. D. Watson and responded to by Mr. Quilter, M.P., and "The Staff of the National Telephone Company," proposed by Sir Robert Hunter and responded to by Mr. Albert Anns.

During the dinner an excellent selection of music was provided, and the company did not separate until a late hour.

PARLIAMENTARY INTELLIGENCE.

THE STRAND DISTRICT ELECTRIC LIGHTING.

Yesterday (Thursday) at the House of Commons, Sir J. Kitson's Committee on the Electric Lighting Provisional Orders (No. 4) Bill considered the Strand District Electric Lighting Bill, which has been sent down by the House of Lord's Committee. By the Bill it is proposed to confirm a Provisional Order made by the Board of Trade under the Electric Lighting Acts 1882 and 1888 to the Charing Cross and Strand Electricity Supply Corporation (Limited), in respect of the district of the Strand District Board of Works. Mr. Pember, Q.C., Mr. S. Wills, Q.C., and Mr. Claude Bagally appeared for the promoters. The Metropolitan Electric Supply Company (Limited) petitioned against the Bill, and were represented by Mr. Balfour-Browne, Q.C., and Mr. Fitzgerald, Q.C.

Mr. PEMBER, in opening for the promoters, said that in May, 1894, the Charing Cross Company sent a request to the Strand District Board of Works for their consent to a Provisional Order for the Parish of St. Paul's, Covent Garden, and for that district only. There were special reasons why that course should be taken, as he would show. The request was referred to the Works Committee, who in the same month made a report that the competive powers which were sought should only be given on condition that similar powers were sought for the whole of the district. That was an intelligible position to take up. The view was that if any part of the district should have the benefit the whole should have it, and that the benefit should be bestowed simultaneously, and not piecemeal. Conferences then took place between the Company and the Board of Works, and the former was recommended to amend their memorial. Ultimately, on October 3, 1894, the Works Committee reported to the Board to the effect that the Company should have similar powers to those enjoyed by the Metropolitan Electric Supply Company, which was established in the district. The Charing Cross Company naturally had no objection to embracing the entire area. In the month of October, 1894, the whole body of the Board of Works confirmed the report, and consent was given. The promoters then gave their notices, and a draft agreement was submitted. The negotiations were conducted on the basis of the clauses in their Provisional Order being substituted for the agreement which was originally asked for. These clauses were agreed to by the promoters, and the Company gave the ordinary undertaking to obtain the insertion of these clauses by the Board of Trade in the Provisional Order. In 1894, then, consent was obtained conditionally, and on April 10, 1895, consent was obtained on the undertaking that the Company would, to the best of their ability, secure the insertion of the clauses in the Board of Trade Provisional Order. Subsequently, however, a meeting of the Board of Works was held, attended by 26 out of the 49 members, and a resolution was passed revoking the sanction given, but the members present were not sufficiently numerous to render the resolution valid according to the bye-laws. That was a very strange change of front, and it was easy to understand that considerable pressure must have been used; and it was also easy to understand from what quarter the pressure came. A large and influentially-signed petition had been presented by the inhabitants of the district, who stated that they would benefit both in regard to price and quality by the advent of the Charing Cross Company. In 1889 Major Marindin, of the Board of Trade, held an inquiry concerning the advantages and disadvantages of the alternating system and the direct system of electric supply, and in his report he spoke favourably of competition, and recommended that where possible that competition should be between an alternating and a direct company. It was therefore to be hoped that the promoters would succeed in getting the Bill, and thus give the Strand the benefit of the two competing systems. The petition of the opponents was very much the same as that submitted to the House of Lords, except that one or two alterations had been made. The petitioners urged that under the Order of 1889 they had, at very great expense, constructed works and laid mains for the supply of electricity throughout the Strand district, and that by the exercise of the powers contained in the Provisional Order their undertaking would be injuriously affected: they would be subjected to a severe and unfair competition, and their mains, pipes, and lines would be liable to be altered, removed and interfered with to their great loss, and to the serious inconvenience of their customers and the public. Their expenditure had already reached the large sum of over £100,000 for the Strand district alone, and the shareholders had up to the present received but a very small return. In the years 1889, 1890 and 1891 no dividend was paid; in 1892 the first dividend was paid at the rate of 2 per cent.; for 1893, 2½ per cent. was paid; and for 1894, 3 per cent. Counsel, however, contended that that was no reason why the promoters should not have their Bill. The Board of Trade recognised the advantage of competition, and the consumers were of the same opinion. The laying of the mains through the streets was a matter of strict regulation, and the suggestion that the rival company's mains and wires would be injured was ridiculous. The petitioners also urged that there was no public necessity for the confirmation of the Provisional Order, as they were able and willing to supply with electricity any persons within the Strand district, and that their mains were actually laid in the streets mentioned in the second schedule to the Provisional Order. Therefore, any capital expended by the Charing Cross Company in laying duplicate sets of mains where one set was sufficient and already laid represented a wasteful expenditure, for which the public, in one shape or the other, would have to pay. He (Mr. Pember) thought there was no solidity in that argument. In the opinion of the consumers, the Metropolitan Company was not able to supply all that was required, and 700 of them had stated so by signing the petition which had been presented.

Mr. EDWARD WILMOT SEALE, examined by Mr. Wills, said he was General Manager and Secretary of the Charing Cross Company. They worked on the direct low-tension system, with 100 volts, while the Metropolitan Company used the alternating high-tension system with 2,000 volts. His Company had had several applications to supply in the Strand district, and that was the reason they had promoted the Bill. The petition to the House in favour of the Company entering the district had been signed by most of the influential ratepayers. He was sure there would be no difficulty in raising the additional capital which would be required, and they had already deposited £1,000 with the Board of Trade as a guarantee that they would carry out the works necessary. So far the operations of the Company had been attended by uniform success. In some districts his Company were already working in competition with the Metropolitan Company, and except in one trivial instance there had never been any difficulty connected with the laying of the mains. In the St. Martin's district they already had 22 miles of wires.

Cross-examined by Mr. Balfour-Browne, WITNESS said that in the event of any accident happening to the works of one company it was a great advantage to a district to have another company on which they could fall back.

Re-examined, WITNESS said his Company had not the slightest intention of combining with the Metropolitan Company.

Mr. W. H. PATCHELL, examined by Mr. Wills, deposed that he was chief engineer to the Charing Cross Company. The alternating current supplied by the Metropolitan Company was not suitable for motive power, and that was the reason why large consumers, who desired motive power, wished his Company to come into the district. In laying down their mains they used Callender casing, which enabled additional wires to be drawn through without breaking up the streets. There had been no difficulty between the two companies in the St. Martin's district, and he did not see why there should be any in the Strand.

Cross-examined by Mr. Fitzgerald, WITNESS said the original desire of the Company was to supply the St. Paul's district, Covent Garden, but now they desired to supply the whole of the Strand.

Other evidence having been given, the Committee adjourned.

CORRESPONDENCE.

RÖNTGEN RAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Last night I received the following telegram from Edison, which, I am sure, will interest your readers:—

"Just found calcium tungstate properly crystallised gives splendid fluorescence with Röntgen ray, far exceeding platino-cyanide, rendering photographs unnecessary.—(Signed) "EDISON."

—Yours, &c., KELVIN.

March 17, 1896.

ELECTRICAL STANDARDS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question of accuracy of electrical measurements is daily becoming of more importance. Now that electrical supply undertakings are settling down to economical work, the values of the three units of electromotive force, current and resistance require to be known to a much finer degree of accuracy than hitherto, and therefore users of standards begin to look to somebody whose opinion and certificate on such values shall be final, as is now the case with the yard and the pint pot.

Of the three units, that of resistance is the only one which can be made so to speak in "solid form," and I think in this country something has still to be done in the matter of certifying such units. Suppose that a maker has a piece of metal joined to two large terminals, and he says that when 100 amperes are passed through the arrangement there is a fall of potential of one volt between the terminals; in the case of some makers and some customers this statement is sufficient, but what happens if it is not?

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At the Cavendish Laboratory units of the original B.A. form, down to 0·1 ohm. are certified at a truly marvellous range of temperatures down to convenient values, such as 11·7°C., 13·1°C., &c., for a charge of 21s.; our Board of Trade Electrical Department courteously offer to test standards, but as yet unofficially and without fee. This, of course, makers cannot take advantage of, except to check their own standards from time to time.

A contrast to this is the Physikalische Reichsanstalt in Berlin, where standards of values varying from 0·0001 to 10,000 ohms are dealt with in a most businesslike style, at an average cost of 8s. only. Two values are given in each certificate, one at 15°C. and one at 25°C., and also the temperature coefficient between these limits. Surely, it is hardly fair to British manufacturers that the facilities offered to them by the Government departments destined to take care of their interests should continue in such a state in comparison to those abroad; and I hope that if you can find space for this letter, the influence of your paper may be the means of drawing the necessary attention to a somewhat neglected subject.—Yours, &c.,

G. W. B. ELPHINSTONE.

101, St. Martin's-lane, W.C., March 13, 1896.

A STANDARD ONE-VOLT CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In last week's article on "The Potentiometer," Mr. Fisher mentions some results he had obtained with nine specimens of a one-volt cell I submitted to him, and intimates that if they give equally good answers to time and high-temperature tests they are likely to be useful.

It may be worth while saying that I hope very soon to offer evidence on these and other points. Mr. Sewell, one of my students, and I have been working for 18 months to overcome the difficulties involved in making a practical standard volt, and we believe we may now offer it to the public with some confidence.—Yours, &c.,

W. HIBBERT.

14, Goldhurst-terrace East, N.W.,
March 17, 1896.

THE CLARK CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The extremely optimistic tone, with reference to the Clark cell, adopted by Mr. Fisher in his article on the Crompton Potentiometer which appeared on page 647 *et seq.* of your last issue, renders it advisable that a word of caution and warning be addressed to the users of these cells. It is no doubt comforting to hear, from one who can speak with the authority of experience, that such a useful piece of apparatus as the Clark cell is not the delicate fragile thing that so many of us once thought it. We should be careful, however, that the diffusion of this further knowledge is safeguarded, so as to prevent it becoming harmful knowledge. All that the writer of the article really urges is, that the treatment scheduled in his second paragraph is not permanently destructive to the cell.

One other remark may be made. The article is not quite accurate in stating that the Board of Trade adopted "The Clark cell as a standard of E.M.F.," or "Gave it the value of 1,434 Board of Trade volts at 15°C." The standard of E.M.F. is quite otherwise defined, and has no reference whatever to the Clark cell. It is possible that it might have been wiser policy with regard to the Clark cell had the Board of Trade refrained from adopting a "Specification"; or, perhaps, dropped the Clark cell altogether from consideration. That is a matter of opinion. It is a matter of fact, however, that Clark cells have been made in accordance with the Board of Trade specification, and have been found to give the stated E.M.F. with all the attainable accuracy. Not even the Board of Trade can embody in a specification all the manipulative skill and general laboratory experience required for the construction of a Clark cell. These are a necessary contribution by the maker of a cell to its efficiency and accuracy.—Yours, &c.,

"X."

THE SULLIVAN UNIVERSAL GALVANOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Some four months back you kindly published a letter on the success of my galvanometer at sea. The enclosed two further reports on the subject may likewise be of interest, the one being from Mr. George Keith, director and engineer of the Cuba Submarine Cable Company, and the other from Mr. Raymond-Barker. Both letters are sent to you by permission:—

[Copy.]

Cuba Submarine Company, 58, Old Broad-street, E.C.,
March 6, 1896.

DEAR MR. SULLIVAN: I duly received your note, and have great pleasure in saying I formed a very high opinion of your patent galvanometer from what I saw of its performance on board the "Silvertown" and "Buccaneer" during the laying of the Cuban coast cables. It is practically unaffected by the ship's movement; very sensitive, beautifully deadbeat, and enables accurate tests to be rapidly taken in all weathers. I consider it is an invaluable instrument on board ship, and far superior to the ordinary marine galvanometer. Wishing it every success, I remain, yours very truly, (Signed) GEORGE KEITH.

Silvertown, London, E., February 24, 1896.

MY DEAR MR. SULLIVAN: With all the pleasure in the world I hasten to assure you, in answer to your recent letter, that my experience of your marine galvanometer during our recent Cuba Coast Cables Expedition (I being—in the absence of our chief electrician—in charge of the electrical department), fully confirms the good opinions I formed of this apparatus from my own previous tests at Silvertown. . . . . An excellent opportunity was afforded for judging the practical advantages attaching to your galvanometer on board ship in a heavy sea—for on the way out we had bad weather, and for days rolled from 30deg. to 40deg. breaking the record one day with 44deg.—not to speak of severe pitching. . . . The little "Buccaneer," as you are aware, although an excellent seagoing vessel, can be, and often is, extremely *lively*, but in her testing-room the Sullivan galvanometer again gave extreme satisfaction, the reports I received of its performance from our Messrs. G. H. Bailey and J. F. Cooto being quite enthusiastic.

With regard to my own experience (o.b. the "Silvertown") during our voyage out, and during the laying of five sections of cable off Cuba, I will not trouble you with details, or tabulated figures. . . I must, however, just mention one excellent feature of your instrument to which, as far as I am aware, sufficient attention has not been drawn; I allude to your galvanometer in its capacity of *time saver*—for it allows of observations being made *far* more rapidly than is possible with the old ironclad "marines," thus—as frequently happened during our recent trip—*shortening the time during which the ship had to hang on to cable.* . . . With your delightfully simple device, a good balance for rolling and pitching was very soon accomplished.—I remain, with kind regards, yours very sincerely,

E. RAYMOND-BARKER.

P.S.—There is one obvious factor in the success of your galvanometer which I have not pointed out, viz., its *constancy of zero*, not only with changes in the ship's course, but under the numerous outside magnetic disturbances common on board ship, which so affect the working of the old marine galvanometer, its thick ironclad protection notwithstanding.—E. R. B.

I also enclose for your own perusal a further report, recently received from another source, and which, as you will see, confirms the foregoing, but this I am not at liberty as yet to publish.—Yours, &c.,

H. W. SULLIVAN.

29, Ladbroke-square, W., March 18, 1896.

LEGAL INTELLIGENCE.

The Dolbear Patent for Hollow-Core Air Dielectric Cables.

On Wednesday, before the Judicial Committee of the Privy Council, present Lords Watson, Davey and Hobhouse, and Sir Richard Couch, the petition was heard of Amos Emerson Dolbear, and of the British Insulated Wire Company (Limited), in the matter of letters patent No. 1,368 of 1882 [for abstract see *The Electrician*, February 14, 1896, p. 504] granted the former in respect of the invention of certain improvements in electrical cables, and subsequently assigned by him to the Company. The petition prayed that the term of such letters patent, which is about to expire, might be extended by 14 years or such term as might be decided upon. Mr. Fletcher Moulton, Q.C., Mr. W. R. Bousfield, Q.C., M.P., and Mr. J. C. Graham supported the petition; the Attorney-General, Sir Richard Webster, Q.C., M.P., and Mr. H. Sutton appeared on behalf of the Crown; while Mr. C. A. Cripps, Q.C., M.P., Mr. R. Wallace, Q.C., and Mr. A. J. Walter represented the caveators, the Fowler-Waring Cables Company (Limited), the National Telephone Company (Limited), and the Western Electric Company, of Coleman-street, and New York.

Mr. FLETCHER MOULTON, in opening, after briefly referring to the terms of the petition stated that the rapidity with which they could charge and discharge an ordinary insulated cable limited the number of messages that could be sent. The matter of the insulator, therefore, was of great

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importance. The patent which Prof. Dolbear took out in 1882 was for so constructing cables as to reduce to its smallest extent the surface contact between the internal conductor and the external covering. Prof. Dolbear thought they might support the wire inside the tube by means of a spirally-running string which would touch the sides of the tube and thus hold the wire centrally; by making the sheath hollow or tubular, so that the conductor would lie in it, touching only the bottom of the tube; or by placing some fibrous packing, with air spaces in it, between the conductor and the sheath. When the patent was taken out it was intended mainly for submarine cables, as the telegraph and telephone wires had not become so numerous as to necessitate their being laid underground. The cables, however, of the cable companies were laid, and naturally capitalists were unwilling to go to the expense of relaying them for the purpose of an experiment; and although Prof. Dolbear kept up both the English and the American patent which had been taken out, he was unable to get the thing taken up. At last, in 1892, he sold it to Mr. Atherton, an official of the British Insulated Wire Company, who subsequently purchased it of him for £1,000.

Lord WATSON: I understand that the Company wish the patent to be prolonged in order to remunerate themselves for their hitherto unsuccessful trading, as well as to remunerate the patentee.

Mr. FLETCHER MOULTON: Yes, my Lord. Continuing, he stated that though the patentee and Company had, up to the present, received very little remuneration, the value of the invention was now recognised, and the demand for air-space cables was greatly increasing. Counsel then went on to refer briefly to the opposition that was offered to the petition, and in conclusion to express a hope that, in view of the impossibility of getting any profit at an earlier date, and of the merits of the invention, their lordships would see their way to grant a prolongation.

Prof. A. E. DOLBEAR, the inventor, was then called. He stated that he was in England in 1882. There had been great trouble in connection with sending electric impulses for telephonic work. Cables, as they had been made up to that time, were so strongly absorbent of electrical impulses that it was impossible to use cables. When sending a signal or an electrical impulse along an ordinary cable the current had first to charge the dielectric, and then pass on; this affected the sending of telephonic impulses, because so much of the impulse was used in charging the cable. His attention was directed to this subject in connection with cables first by finding in England, in 1882, that there was great difficulty in doing telephonic work—in conveying telephonic currents to any considerable distance. It was in view of those considerations that he arrived at his invention; and, he added, a cable that would be useful for telephony would necessarily be useful for any other cable work. He applied the air-space principle; and to attain that he had some string which was wound, spirally, round the wire inside the tube. If they had a wire surrounded with gutta-percha as an insulator it would defeat the object of the air space. He laid great stress on the words in the specification: "The outer surface of the wire being in contact with nothing but the air filling the pipe," which formed the basis of the whole patent. None of the previous specifications alluded to by the objectors attained the results which his patent gave. So far as he knew the patent had never been used in connection with submarine cables; but within the last two or three years it had become to be generally adopted for telephonic cables. The witness then went on to detail the steps he took in 1882 to get his patent taken up in England, and to explain that it was not pushed in America because his partner lost his financial resources in litigation regarding other patents. Besides the deed of assignment of the patent to the British Insulated Wire Company, there was a recent agreement with that Company that if the present petition were successful he was to be given a quarter of the resulting benefit.

Cross-examined by Mr. Cripps: He did not know that his invention limited the tube to containing only one conductor. As a theory only was the principle of air isolation known before the date of the patent. When he was offered £10 for his patent he was glad to take it because it was £10 more than he expected to get then. The arrangement as to his receiving a quarter of the benefit of the present petition was come to in this month. His invention had been used in America, but he had had no benefit from it, and he had not taken legal proceedings for infringement owing to want of money.

Mr. GEORGE NISBETT, chief electrical engineer to the petitioning Company, stated that this Company had been making cables with a naked wire in an enclosed air space since 1892. They had a licence for making cables under the Felten-Guilleaume (otherwise Hardingham) patent, which was a contrivance for twisting wires in pairs. As compared with wire covered with gutta-percha the capacity of naked wire in an air space would be reduced by about a quarter. The Felten-Guilleaume patent was merely a convenient method of arriving at the end which the Dolbear patent pointed out as desirable. The reduction of capacity referred to was of enormous importance—it was the primary basis of all their calculations.

Lord DAVEY pointed out that although the Dolbear patent was acquired for £10, the petitioning Company had to pay 5 per cent. for the licence to work under the Hardingham patent, such payment to be not less than £10,000 in the first five years.

Continuing, WITNESS said he had had made specimens of cable according to Scott's, Pratt's and Dolbear's specifications, using similar wire in each case, and he found that the capacity of the three was ·33, ·7 and ·078 microfarads respectively per mile. He knew of no other cable which would give results so favourable as Dolbear's cable.

Cross-examined by Mr. Cripps: In the cable that his Company had been manufacturing the sheathing was not according to Dolbear's specifications; but, nevertheless, the cable itself was distinctly according to Dolbear. The Company had, since 1893, been manufacturing cable like the specimen handed in by the last witness, which was substantially like Dolbear's. They acquired Dolbear's patent in 1895. He knew the Fowler-Waring Company were manufacturing what was substantially the Dolbear cable; but no proceedings had been taken for infringement of the patent.

By the Attorney-General: The Company was manufacturing cable, in 1892, which consisted of wire wrapped round with paper, which acted as an insulator. It was true that Scott's patent pointed out the value of air spaces for insulating; but that was perfectly well known previously.

Lord WATSON stated that for 10 years from the date of the patent no attempt had been made to push the patent in England, and although, since 1893, cable like Dolbear's had been manufactured by the petitioners, it was at least doubtful as to whether that cable had been produced under Dolbear's or Hardingham's specifications. Those were two chief difficulties that had to be met.

Mr. FLETCHER MOULTON asserted that Hardingham's patent merely followed out Dolbear's patent, and as to the 10 years elapsing, he contended that until recently the demand for the cable had not arisen.

Mr. NISBETT was then further examined to show that the cable his Company was now manufacturing was practically in accordance with Dolbear's specifications.

Mr. S. Z. de FERRANTI, electrician and Director of the petitioning Company, stated that Dolbear's cable was of such great value because it allowed so much more to be transmitted in a given time than any other; its value was so great that it would be hardly possible, commercially, to use any other cable to lay underground. He had looked through the alleged anticipations of Dolbear's patent, but none of them would give as low conductive capacity as Dolbear's. In general his evidence corroborated the preceding evidence.

Cross-examined by the Attorney-General: He knew the cable which Messrs. Fowler and Waring were making, which had paper loosely wrapped round it, and which greatly resembled Dolbear's, but neither in that case nor any other had the Insulated Wire Company taken proceedings. As regarded Hardingham's patent, he believed that was an improvement in detail of Dolbear's, and the method was slightly cheaper.

Mr. EDWARD TRACY, secretary to the British Insulated Wire Company, gave some evidence, very briefly, as to accounts. On a sale of £5,000 worth of cable in 1895 there was a loss of £116.

Dr. HOPKINSON stated that the cable the Company were now manufacturing was substantially according to Dolbear's specifications. If cables were made according to specifications lodged previous to Dolbear's it would not be as useful as one made on Dolbear's lines.

Mr. FLETCHER-MOULTON, in reply to Lord Watson, informed the Committee that, beyond the evidence given by Prof. Dolbear, he had no explanation to give as to the delay in pushing the patent; and he could not carry the case further.

Lord WATSON then conferred with his colleagues, after which he announced the decision of the Committee. He stated that the patent was granted in March, 1882, and acquired by the petitioning Company in 1894, and in all that time no attempt had been made to push the patent. There had been no explanation of that delay; and the Committee were of opinion that the patent principally used by the petitioners was Hardingham's patent. In these circumstances they would advise Her Majesty not to grant the prayer of the petition, and that the caveators be allowed one set of costs.

The proceedings then terminated.

Clarke v. Julius Sax and Co.

Mr. Swinfen-Eady, Q.C., applied to Mr. Justice North in the Chancery Division for an injunction restraining the defendants from infringing the plaintiff's registered design for electric lamps. The learned counsel referred to the motion which had already been brought, in which his lordship held that the plaintiff's design was valid, but that the defendants had not infringed it. He contended that what the defendants had now done was to so exactly imitate the plaintiff's design that the two were hardly distinguishable.

Mr. VERNON SMITH, Q.C., for the defendants, contended that their lamps were no infringement.

His LORDSHIP, after hearing evidence, thought that this was a clear and palpable case of infringement, and granted an injunction restraining the defendants from using the lamps complained of or otherwise infringing the plaintiff's registered design.

Mr. VERNON SMITH asked if the defendants might be allowed to alter the lamps.

His LORDSHIP declined to accede to that application, and said that the injunction must be restraining the defendants from keeping the lamps complained of (which were placed in the Metropolitan Meat Market) without the leave of the plaintiffs.

Foote and Milne v. the Army and Navy Auxiliary Supply (Limited).

On Wednesday, in the Westminster County Court (London), the plaintiffs made a claim of £21. 6s. 1d. for electrical fittings and apparatus delivered to the defendants, who admitted receiving the goods, and paid about £5 into Court. The plaintiffs stated that the firm of Statter and Co. made arrangements with the defendants to carry out all their (the defendants') electrical installations. Statter and Co. joined the list of limited liability undertakings, and, like its predecessors, the Electrical Engineering Corporation, soon went into liquidation, the plaintiffs purchasing the present account with others from the Receiver. The fittings for the value of which the present action was brought, were left with the defendants on sale or return, and had not been returned. Mr. John Darch, surveyor of the electrical department of the Stores, stated that the arrangement with the Statter firm was that the goods should be left at the stores at their own risk, and everything except £5's worth

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was returned to the plaintiffs' predecessors. An assistant in the same department said that Statter's people often came and took fittings away, but he could not say that they did not replace them. His Honour gave judgment for the plaintiffs for £8 beyond what was paid into Court, and he was of opinion, after going through the items, that two ordinary business men could have come to terms, instead of bringing the matter into Court.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d., abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations issued February 6th.

NEW BOOKS AND EDITIONS.

The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices :—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.), Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue Dr. Gore's book is now ready, price 10s. 6d. post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables. 30s., post free.

TENDERS INVITED.—The Shoreditch Vestry invite tenders for (*a*) high-speed engines, dynamos, switchboards, instruments, and street lamps; (*b*) pumps, steam and water mains, water tank, and cast-iron work; (*c*) motor transformers and starting switches; (*d*) battery of accumulators and stands. Specifications, with forms of tender, can be obtained from the 23rd inst. from the Consulting Engineers (Messrs. Kincaid, Waller and Manville), 29, Great George-street, Westminster, S.W. Tenders must be sent in to Dr. H. Mansfield Robinson, Vestry Clerk, not later than 4 p.m. of Tuesday, April 14th. Some further particulars are given in our advertisement columns.

——— The Electric Light Committee of the Bedford Corporation invite tenders for the supply and erection of one 240 B.H.P. double-acting compound enclosed engine, and one 150-unit alternator with stationary armature. Tenders must be sent in to the Clerk to the Urban Sanitary Authority (Mr. T. S. Porter) by April 4th. Further particulars are given in our advertisement columns.

——— The Edinburgh Corporation require tenders for the wiring of the City Chambers. Tenders must be sent in to the Town Clerk, Mr. Thomas Hunter, W.S., by 10 a.m., on the 28th inst.

TENDERS INVITED.—The Corporation of Bradford invite tenders for batteries, surface condensing plant, cables, travelling crane and steam and exhaust pipes. Forms of tender and specifications may be obtained from the Electricity Office, and tenders, addressed to the Chairman of the Gas and Electricity Committee, must be delivered at the office of the Town Clerk (Mr. W. T. McGowen), Town Hall, Bradford, by the 26th inst. Further particulars appear in our advertisement columns.

——— The Municipal Council of Lima (Peru) invite tenders for the establishment and working of an electric lighting installation in the squares and streets of the city, with power to work the private service, under a contract for twenty years. A memorandum explaining the local conditions, &c., may be obtained at the Peruvian Legation, 13, Comeragh-road, West Kensington, London, W., and tenders will be received at the Legation up to the 1st June. Some further particulars will be found in our advertisement columns.

——— The Vestry of St. Pancras, London, require tenders for additional plant at the King's-road supply station, comprising engines, dynamos, connections, switchboard and other apparatus. Specifications, &c., can be obtained at the Electricity Department offices, 57, Pratt-street, N.W., and tenders must be sent to Mr. Albert E. Pycraft, chief clerk of the Department, by noon of Thursday, the 26th inst. Further particulars are given in our advertisement columns.

——— The Urban District Council of Wallasey require tenders for (*a*) steam alternators, switchboard and accessories, (*b*) high and low tension concentric cables, and (*c*) transformers. Copies of specification can be had of the engineer, Mr. J. H. Crowther, Gas and Water Works, Great Float, near Birkenhead. Tenders must be sent in to Mr. W. Danger, clerk to the Council, Public Offices, Egremont, Cheshire, by 4 p.m. of Monday, the 6th April. Our advertisement columns contain further particulars.

——— Tenders are invited for the supply of the necessary plant for the electric lighting of the County of Antrim Lunatic Asylum. Tenders to the Secretary of the Board of Control of Lunatic Asylums, Custom House, Dublin, by May 1st.

——— The Belgian State Railway authorities invite tenders for 180 dynamo brushes of various sizes, a quantity of mica, insulated copper wire, incandescent lamps, &c. Tenders to La Bourse, Brussels, by the 25th inst.

——— The Cardiff Corporation require tenders for supplying and fixing two dry-back marine or water tube boilers capable of evaporating about 6,000 lbs. of water per hour, and one 250 to 300 kilowatt direct-driven steam alternator. Specifications from the Borough Engineer, and tenders to be sent to the Town Clerk, by the 6th April.

TENDERS ACCEPTED.—The tender of Messrs. Johnson and Phillips has been accepted by the Tunbridge Wells Town Council for the supply of a Willans engine for the electricity works at £750.

APPOINTMENTS VACANT.—The Bolton Corporation invite applications for the appointment of borough electrical engineer. Salary £300 per annum. Applications must be sent in to Mr. R. G. Hinnell, town clerk, Town Hall, Bolton, by April 6th next. Further particulars appear in our advertisement columns.

——— The Vestry of St. John's, Hampstead, invite applications for the post of assistant electrical engineer, to work under the instructions of their chief engineer, at a salary of £2. 5s. per week. Some particulars will be found in our advertisement columns, and applications must be sent in to Mr. Arthur P. Johnson, clerk, Vestry Hall, Hampstead, by 10 a.m. of the 30th inst.

——— The Corporation of Ashton-under-Lyne invite applications for the position of consulting electrical engineer. Applications by the 23rd inst. to the Town Clerk.

——— A secretary is required for a provincial electric supply company who should have had experience in a similar position. Further particulars are given in our advertisement columns.

APPOINTMENT.—The Edinburgh Corporation has appointed Mr. F. A. Newington, the resident electrical engineer at the Millbank station of the Westminster Electric Supply Corporation, borough electrical engineer, in succession to Mr. E. W. Monkhouse.

BANKRUPTCY.—The examination of John H. Cox, electrical engineer, Kelly-street, Greenock, took place at the Sheriff Court, Greenock, on Friday last. The bankrupt stated that he commenced business in March, 1892, with a capital of £150. In August, 1895, he entered into partnership with Mr. T. D. Rorison, and the business had since been carried on under the firm of the Greenock and Glasgow Electric Company. He valued his half share in that business at £135, and he denied liability for the sum claimed by Mr. Rorison. His liabilities amounted to £945. 6s. 5d., and had been principally incurred in connection with experiments as to a

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patent for the electro-plating of large surfaces, for which he had obtained provisional protection. The debt due to Messrs. Denny Brothers (£593. 15s. 5d.) was for wages and material advanced to him for the copper plating of a vessel. If the plating of that vessel had been successful he would receive between £40 and £50, but he had not included that in his assets, because its success had not been proved, and neither had he included the value of the provisional patent, as it had now lapsed, although he thought the value considerable. Mr. J. Nicoll was appointed trustee.

——— The following are the principal creditors in the failure of William Gray, jun., lately trading as an electrical engineer under the title of the Scottish Electrical Engineering Company, at Frederick-street, Edinburgh :—

B. Verity and Sons	£91	0	4
W. T. Glover and Co.	49	10	11
Dick, Kerr and Co.	40	0	0
General Electric Company	36	10	3
J. Gibb and Son	29	5	9
William McGeoch and Co.	27	15	8
Acme Gas Engine Company	21	0	0
Thomas Scott and Co.	17	4	7
T. B. Campbell and Sons	13	14	0

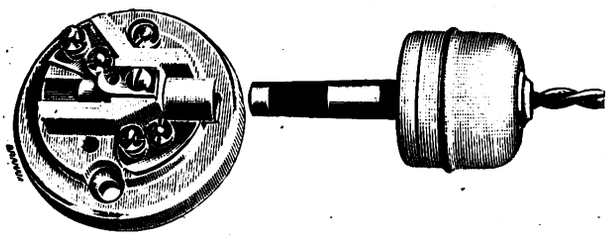
The liabilities amount to £2,700. 17s. 11d., and the assets to £2,291. 4s. 2d., subject to realisation.

——— Claims against the estate of George I. Reakes, lately trading as an electrical engineer, under the style of G. Reakes and Co., at Shrewsbury, must be sent in to the Official Receiver, Mr. T. Bullock, Shrewsbury, by the 30th inst.

Amendment of Patent.—Notice is given that Headland's Patent Electric Storage Battery Co. (Limited), have applied for leave to amend the specification of Letters Patent, No. 15,120, of 1892, granted to H. W. Headland, for "Improvements in or applicable to electrical accumulators."

Exports to South Africa.—Under the classification of electrical, the value of goods exported from this country to South Africa for the week ended March 7th was £1,385 : Cape Town, £744 ; Algoa Bay, £72 ; East London (cable), £551 ; Delgoa Bay, £18.

Side Contact Wall Plug.—We give particulars below of two types of wall plugs which are being placed upon the market by Messrs. Hodges and Todd, having been brought out by the Electrical Installation Company. In one (see illustration) the plug contact is inserted horizontally, in the other it is inserted vertically. In this type of wall plug it is impossible for the fuse wire in melting to fall across on the opposite pole and strike an arc or produce a short circuit. It is impossible to produce a short circuit by the insertion of the plug connector. A short circuit can only be made



intentionally, and then only with difficulty. One pole only is exposed. It is agreed that wall plugs should be of small size and neat appearance and as *flat as possible*. This pattern does not project from the wall more than 1¼in., and the plug connector can be inserted or withdrawn even with anything close against the socket. Being a side contact wall plug, it can be used behind bookcases and other articles of furniture. It can be used on skirting boards to great advantage, whereas ordinary wall plugs, owing to their projecting so far from the wall, are constantly in danger of being knocked and broken.

Lithanode Storage Cells.—The Lithanode Electric Storage Company (Limited) announce that, owing to increase of business, it has been found necessary to enlarge the works and to provide more adequate offices and show rooms. The new premises secured include offices, show rooms and laboratory in the Strand District, where arrangements have also been made for recharging and preparing portable batteries. A new price list of this Company's manufactures is now issued, and can be obtained on application.

High-voltage Fittings.—The Edison-Swan Company give notice that in order to meet the present requirements for fittings of a high insulation for high-voltage currents, they are now ready to supply, under Patent 18,162 of 1891, switches, cut-outs and holders with patent enamel liners. Samples of these switches, &c., can be seen at the head office in Queen-street, Cheapside, London, at the West-End branch in Parliament-street, and at any of the Company's provincial branches.

Arc Lamps and Accessories.—We have received from Mr. G. Braulik a copy of his catalogue of Messrs. Körting and Mathiesen's arc lamps and accessories, for which he is agent in this country. The catalogue gives particulars of various designs of these lamps, and some loose sheets give prices of carbons, measuring instruments, &c.

Catalogue.—A well arranged catalogue and price list of dynamos and electric motors for direct and alternating currents is just issued by the Electrical Company, of 122 and 124, Charing Cross-road, London, W.C. One of the conveniences of the list is that it is provided with a foredge index which divides the subject matter in a handy way. The tabulated matter relating to the company's various types of dynamos and motors is well arranged, and all required information can be obtained at a glance. The list is divided into thirteen sections, dealing with the various manufactures of the Company, including heavy machinery, instruments, arc and incandescent lamps, wires, cables, and accessories. The catalogue can be obtained as a whole, or, the sections being complete in themselves, any one section can be obtained separately. The binding and printing of the complete book, without being over-elaborate, are everything that could be desired, and the illustrations show the large variety of apparatus which is manufactured by the firm. An interesting feature is the use of the metric system of weights and measures throughout the catalogue.

Personal.—A farewell dinner was recently given at Charlton to Mr. Samuel Sudworth on the occasion of his departure from the firm of Messrs. Johnson and Phillips, where he has held the position of superintendent of the dynamo manufacturing department from the time the firm commenced the manufacture of that class of machinery. After so many years of association he leaves with the regret and goodwill of every one. He relinquishes the position he has held for so many years to take over the works managership of the Consolidated Telephone Construction and Manufacturing Company at Coventry.

——— The members of the staff of the British Insulated Wire Company (Limited), of Prescot, on Monday last gave a farewell dinner to Mr. H. M. Brigg, who is leaving England to take charge of important electric traction work in South Africa.

Electro-Harmonic Society.—A smoking concert takes place on Friday next, the 27th inst., at the St. James's Hall Restaurant (Banquet Room), Regent-street, W., at eight o'clock. As usual, an excellent programme has been provided.

Bohemian Concert.—Under the chairmanship of Mr. Frank Bailey, the staff of the City of London Electric Lighting Company will hold their fourth annual Bohemian Concert in the Pillar Hall of the Cannon Street Hotel, London, on Tuesday, the 31st inst., at 7:40 p.m. An interesting programme is provided.

Aberdeen.—For some time past the Harbour Board has been making investigations into the question of lighting the harbour electrically, and a deputation from the Board has recently visited the harbours at Liverpool and Manchester for the purpose of inspecting the electric lighting arrangements there. It has been decided to light the harbour electrically, and to take current from the Corporation mains.

Agricultural Hall, London.—At Tuesday's meeting of the London County Council the Theatres and Music Halls Committee notified the receipt of plans and specifications for additional electric lighting at the Royal Agricultural Hall, Islington. The additional lighting is to the ground floor and galleries, to the minor hall and King Edward's Hall, and to some of the offices adjoining. The committee recommended that the plans be approved, and this was agreed to, subject to certain conditions. We have many times referred to the singular absence of the electric light at this great building, where for many of the exhibitions it would be especially advantageous. Some portion of the building has lately been lighted electrically by arc lamps, and it would appear from the above that it is intended now to light the whole of the building, galleries and smaller halls by electricity. If sufficient current is available, the Hall authorities should be able to dispose of a large quantity to exhibitors whose stands are frequently very badly lighted at a time when the hall is thronged with visitors. Perhaps also some of our more enterprising electrical firms may now be disposed to rent space at the more popular exhibitions.

Battersea (London).—At the last meeting of the Vestry the Finance Committee recommended that the municipal buildings be wired and fitted up for the electric light ; but, after discussion, the matter was referred back.

Bolton.—At the meeting of the Gas and Electricity Committee on Friday last, it was decided to accept the resignation of the Borough Electrical Engineer, Mr. J. H. Rider, and to advertise for a successor. The receipts of the department for the past month amounted to £628, against £258 in the corresponding month last year, making a total of £2,583 for the 12 months. There is at present an equivalent of 9,378 8 c.p. lamps connected.

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BRIDGEND.—The Town Council, at their meeting on Monday last, considered the proposal of Mr. J. C. Howell to purchase their Provisional Order, and to establish electricity works in the town. After discussion, the Council agreed to the proposal conditionally.

BRISTOL.—At the last meeting of the Electrical Committee several applications were received for the supply of electric current for power purposes, including one from the Docks Committee for the Bristol Granary, and the electrical engineer (Mr. H. Faraday Proctor) was instructed to prepare a report on the matter.

CAPE TELEGRAPHS.—According to the *African Review* there is a dearth of skilled telegraphists in the Cape and the Transvaal. Last year between 60 and 70 clerks were sent to the Cape and 40 others are now on the way. These were all engaged in England, contrary to the usual practice of the Cape Telegraph Department, which recruits on the spot.

CHURCH LIGHTING.—The Parish Church of St Alban's, Holborn (the old cure of the famous Mr. Maconachie), is to be wired for the electric light.

CIVIL SERVICE ESTIMATES.—The estimates now before the House of Commons provide for the enlargement of the Government Telegraph Factory at Holloway, for the installation of the electric light in the new band stand, and along the footpath between Marble Arch and Albert Gate in Hyde Park, and for continuing the Patent Office extension.

THE CRYSTAL PALACE HORSELESS CARRIAGE EXHIBITION.—Applications for space at the forthcoming exhibition should be sent to the Manager of the Crystal Palace Company, but any engineering and technical queries should be addressed to the Executive Officer (Mr. A. R. Sennett, A.M.I.C.E., M.I.E.E.) at the Palace.

COMMISSION OF SEWERS (LONDON).—The engineer, Mr. Ross, has just presented his annual report on the works executed by the Commission during the year. Referring to the question of electric lighting, the report states that the number of arc lamps in use is 485. As to the question of lighting the minor streets of the City by electric lamps under the contract with the City of London Company, Mr. Ross states that, as the experiments with incandescent lamps and with alternating-current arc lamps in Basinghall-street and Aldermanbury did not prove satisfactory, the Streets Committee recommended that further experiments with arc lamps should be made, with the view to determine the description of lamp to be employed. This recommendation was agreed to, and arrangements are now being made to light Watling-street, Bow-lane, Bread-street, Friday-street and Old Change by continuous and alternate-current lamps, partly on brackets fixed against the fronts of the business premises and partly by lamps suspended across the centres of the streets.

COVENTRY.—Mr. Robert Hammond, consulting engineer to the Corporation, has presented a report upon the recently erected electricity works, and calls attention to the immediate necessity for further extensions to meet the demand for current. The expenditure to date is £23,485. The report gives particulars of the 150-kilowatt plant which has already been put down. The number of lamps of the equivalent of 8 c.p. now connected is over 3,000, and about 600 are awaiting connection. The demand by next year is expected to reach a total of 6,000 8 c.p. lamps. The total capacity of the two sets of plant now erected, Mr. Hammond reports, would probably meet the actual demand even when the 6,000 lights are connected, but would leave no reserve, and it is in order to provide this reserve (the importance of which he points out) that he recommends the prompt erection of further plant, suggesting that a 200-kilowatt plant should be put down at an estimated cost, including cables, of £8,900.

EXHIBITION.—In order to make known in Russia the progress made in other countries in the construction of light railways and river and canal boats, and the means adopted for propulsion, the Russian Government has decided that a special section of the Nijni-Novgorod Exhibition to open in May next shall be set apart for such exhibits, and that foreigners shall be allowed to show. A special building is to be erected at the cost of the exhibitors, who will also have to pay the cost of transport, &c.

FOLKESTONE.—The Town Council are applying for a Provisional Order, and at the last meeting a letter was received from Mr. Hopkins, a director of the Hotel Metropole Company, asking if the Corporation intended to carry out the provisions of the Order, as, in the event of their not doing so, he would be willing to form a company for that purpose. The Hotel Company intended to light their premises electrically, and unless the Corporation moved in the matter, they would have to take steps to carry out the work themselves. A letter was also read from Mr. C. C. Wampach offering £500 for the transfer of the Order. Both communications were considered at a special meeting of the Council on Wednesday.

GLASGOW.—The New Family Home in St. Andrew's-street is lighted throughout by the electric light.

HAMMERSMITH (LONDON).—The Electric Light Committee recommend the Vestry to accept the tender of Messrs. S. Z. de Ferranti (Limited), for the supply of the necessary machinery and plant for their proposed electricity station, and they also propose to appoint Mr. A. H. Preece consulting engineer for the work.

HUDDERSFIELD.—On the recommendation of the Watch Committee the Town Council have decided to obtain tenders for the erection of a new electricity station.

INDIA.—*Indian Engineering* states that there are several schemes afloat for introducing electric light and power into Bengal, and that the project for Darjeeling has been accepted by the City Commissioners. At Calcutta it has been decided to light "Belvedere," the official residence of the Lieutenant-Governor of Bengal, in addition to the Alipore Gaol and the Seebpore College. The project for lighting a portion of the city is being actively taken up, but the acceptance of schemes is stated to depend upon a complete schedule being incorporated in the Lighting Act, steps for which are in progress.

JAPANESE TARIFFS.—Under the recently-revised Japanese tariff law, which will come into operation shortly, an impost is made upon telegraph or galvanised wire of 0·256 yen per 100 cattirs (equal to 600grm. of the metric system of weights or 1·32277lb. English avoirdupois).

LEAMINGTON.—A letter from the Midlands Electric Light and Power Company, offering to tender for the public lighing, has been referred by the Town Council to the Watching and Lighting Committee for report.

LECTURE.—A lecture on "Water Power and its Applications" was delivered by Prof. D. S. Capper at Toynbee Hall on Saturday last.

LEICESTER.—The report of the Gas and Electric Lighting Committee, presented at the last meeting of the Town Council, stated that the gross profit on the revenue account of the electricity department for the half-year ended December 31st last amounted to £580. After paying interest and allowing for sinking fund, &c., there was a deficiency of £195. 7s. 2d. In moving the adoption of the report, the Chairman of the Committee (Alderman Lennard) thought the accounts submitted, which were for the second half-year's working of the station, were entirely satisfactory. After a brief discussion the minutes were approved.

LONDON SCHOOL BOARD.—Current for lighting the eastern portion of the head offices of the School Board on the Victoria-embankment has been obtained from the Metropolitan Electric Supply Company, but the remaining portions have been lighted by current generated by the Board's own plant. The cost of working this plant for the year 1895 was £806, while the cost of current for the eastern portion for the first five months of the year came to only £70. The Board has, it is stated, decided to abandon the policy of employing its own generating plant, and to obtain the whole of its supply in future from the mains of the Metropolitan Company. It is estimated that, under the new arrangement, the six winter months will cost £318 and the six summer months about £70, or £388 for the year. Under the old system the cost was over £900.

MANCHESTER.—The Town Council have decided to increase the salary of Mr. C. H. Woodingham, the city electrical engineer, from £500 to £600 per annum, and the salaries of Messrs. W. R. Wright, A. A. Day and G. G. Bell (electricians in their employ) each to £200 per annum. In view of the recent experiences of Bolton, Edinburgh, Hull, and other towns the Council have adopted a wise step.

MIDDLESBOROUGH.—Messrs. R. Craggs and Son have decided to adopt electricity instead of steam for driving the smaller machinery at their new yard.

NEWCASTLE-UNDER-LYME.—Major Marindin held a Board of Trade inquiry on Tuesday last respecting the objections made by the Corporation to the application for a Provisional Order to authorise the construction of an electric tramway between Hanley and Newcastle. Mr. Milward, who appeared for the promoters, said the total length of the proposed tramway was under three miles. He understood that one of the objections was in consequence of communication with Silverdale and Chesterton not being included in the present scheme, but he offered, if the opposition were withdrawn, on behalf of the promoters to apply for powers to extend the lines to Silverdale and Chesterton. Circulars had been sent to 4,055 ratepayers; 2,809 were in favour of the scheme, and 453 against. The Town Clerk opposed the proposed scheme.

NEWMARKET.—A lengthy debate on the electric lighting question took place at the last meeting of the Council. The Newmarket Electric Lighting Company are applying for a Provisional Order, and, in response to a letter from the Board of Trade, the Council recently instructed its surveyor to prepare a report on the matter. This report states that for a capital expenditure of about £10,000 the Council could establish profitable electricity works in the district. The Council have decided to apply for a Provisional Order and to oppose the application of the Company.

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PORTSMOUTH.—Electric motors are now used in the extensive range of stables belonging to the Corporation in Park-road for driving the chaff-cutting and other machinery.

SERVIA.—A concession has been granted to Maxi S. Antorijevitch, a Belgrade jeweller, for working a network of local railways intended to connect certain districts on the Danube with the existing railway main lines, and it is stated that the concessionaire is free to choose electricity or steam as the motive power.

SOUTHAMPTON.—The Town Council at their meeting on Wednesday discussed the report of the Works Committee, recommending the Corporation to purchase the undertaking of the Southampton Electric Light and Power Company, Limited, for £21,000, and that application be made to the Local Government Board for sanction to borrow £50,000 to complete the purchase and to carry out the necessary extensions. Mr. Lemon, the Chairman of the Committee, moved the adoption of the report, and pointed out the importance of the local authority having the electric lighting in their hands. Electricity was growing in favour, and he contended the Committee were more than justified in their decision to buy out the Company's undertaking. After a long discussion, the Council adopted the recommendations for the purchase of the undertaking, and also for the application for powers for borrowing £50,000 for purposes of extensions by 29 votes to 4. The Southampton Company was registered in April, 1888, and has a subscribed capital of £3,540 in £5 Ordinary shares, £250 in £5 Preference, and £5,000 in 5 per cent. debentures redeemable at par in 1901. A dividend of 2½ per cent. was paid on the Ordinary shares for 1894, and the net revenue for 1895 amounted to £1,166. The station is on the continuous current system, and supply was commenced in 1891.

SOUTH STAFFORDSHIRE TRAMWAY COMPANY.—This Company has applied to the Board of Trade for a further extension of time for the use of steam upon their tramways in the Wednesbury district until March, 1897. In making the application the Directors intimate that before the expiration of the extended term they hope to be in a position to introduce an improved system of traction. At a special meeting of the Wednesbury Town Council this week it was decided to consent to the Company's application.

TURKEY.—The *Revue d'Orient* states that it has been decided to reorganise the telegraphic service of the Ottoman Empire, commencing with the lines of Asia Minor, which will henceforth be divided into three principal sections. The Constantinople-Bagdad line will be extended to India, the Constantinople-Aleppo line to Egypt *viâ* Beyrouth, and the Constantinop'e-Castambol line will be connected with the Russian system *viâ* Trebizonde. The first section, which is the largest, stands in great need of repairs. The number of employés specially engaged in the superintendence of the lines is to be considerably increased.

WHITEHAVEN.—A lengthy report from Dr. Hopkinson on the present condition of the electricity works was discussed at the last meeting of the Town Council. The report recommended the enlargement of the present storage battery, and the provision of a new and more powerful battery. With such an addition the committee would be able to get along for some time without enlarging the present station building; but additional land would ultimately be required, preferably near the present station, for extension purposes. The recommendations were adopted.

YORK.—The Streets and Buildings Committee have now received Prof. Kennedy's report on the electric lighting of the city. He recommends the borrowing of £20,000 for the purpose.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

February 25, 1896.

4,174. J. A. SINCLAIR. London. Improvements in the method of fixing caps to incandescent electric lamps, and in joining the leading-in wires of such lamps to contact plates.

4,175. J. A. FISHER. Birmingham. The sparkless switch.

4,179. T. MACHIN. Birmingham. Improvements in electric road vehicles actuated by electricity.

4,207. W. THOMSON (Baron Kelvin). Glasgow. Improvements in instruments for measuring electric currents.

4,234. J. ZIMMERMAN. London. Improvements in electric lamps for vehicles*.

4,237. J. DEVONSHIRE. London. Improvements in continuous current electric motors and method of regulating the same. (E. Thomson, United States.)*

4,238. J. DEVONSHIRE. London. Improvements in windings for armatures of dynamo-electric machines and motors. (W. H. Knight, United States.)*

4,261. H. J. DOWSING and H. S. KEATING. London. A new or improved electrical lamp.

February 26, 1896.

4,345. J. H. DUNN and R. G. E. DALRYMPLE. London. Improvements in the production of gas by means of electricity.

February 27, 1896.

4,369. C. J. WIGHTMAN and A. HUDSON. Bradford. Improvements in wooden casings or mouldings for electric conduit wires and cables.

4,371. A. D. HUGHSON. London. Improvements in the construction of standards of electrical resistance.

4,393. G. BAMBERG. London. Improvements in filaments for electric incandescent lamps.

4,404. B. M. DRAKE and J. M. GORHAM. London. Improvements in electric switches.

4,406. E. A. MCLACHLAN. London. Improvements in and connected with electrical storage batteries.

4,427. H. F. PARSHALL and THE BRITISH THOMSON-HOUSTON (LIMITED). London. Improvements in the construction of armatures for alternators and such like machines.*

4,432. W. J. DAVY. London. Improvements in electrical resistances.

4,434. F. KING. London. Improvements in or connected with moulds for use in the manufacture of secondary battery plates or supports.

February 28, 1896.

4,490. H. B. WHITE. London. A compensated hot-strip ammeter for the measurement of electric current.

February 29, 1896.

4,617. C. COERPER. London. Improvements relating to electric railways.

March 2, 1896.

4,632. F. H. ROYCE and E. A. CLAREMONT. Manchester. Improvements in dynamo electric generators and motors.*

4,701. J. NEUHOLD. London. Improvements in electrically and automatically actuated shooting targets or butts.

4,709. S. M. FOLK and D. S. ELLIS. London. An improved method of and electrical apparatus for automatically reducing and cutting off the steam from and thus preventing the "racing" of marine engines.

March 3, 1896.

4,748. A. J. BEAUMONT. York. An arc lamp for optical lanterns, stage and yacht projectors, or other purposes.

4,761. F. H. COULSON. London. New or improved device for facilitating the fixing, adjustment, and removal of electric incandescent lamps.

4,773. J. GLARET and O. VUILLEUMIER. London. Improvements in electric traction.

4,774. C. B. CALLOW and H. BEVIS. London. Improvements in and connected with automatically operating variable resistances in electrical circuits.

4,778. B. F. DA MOTTA. London. An improved method of obtaining electricity.

4,788. W. W. JACQUES. London. An improved method or process of converting the potential energy of carbon or carbonaceous materials into electrical energy.*

4,805. J. P. WETHERILL. London. Improvements in method of and apparatus for magnetic separation.*

4,806. J. P. WETHERILL. London. Improvements in magnetic separators.*

4,807. J. DEVONSHIRE. London. Improvements in monocyclic electric generators. (E. Thomson, United States.)*

4,808. J. DEVONSHIRE. London. Improvements in safety appliances for electric brakes. (W. B. Potter, United States.)*

4,817. E. LAVENS. London. Regulating mechanism for electric arc lamps.*

4,837. J. NEWTON. London. Improvements in or connected with circuit closers for electric bells.

4,844. T. E. ADAMS. London. Improvements in electric arc lamps.*

4,845. T. E. ADAMS. London. Improvements in electric arc lamps.*

March 4, 1896.

4,864. F. M. LEWIS. Leeds. Improvements in or in connection with electric motors, specially applicable to electric motors for tramway cars.

4,870. A. DENNY and J. KEMPTON. Dumbarton. An improvement in the method of forming the electrical connection between portable electric table lamps and the current conductors.

4,910. R. NIEWERTH. London. Improvements in magnetic regulating and actuating mechanism.

4,913. G. R. HUGHES. London. Improvements in type casting and electro-coating same.

4,937. E. CLARK, W. CLARK and F. KING. London. Improvements in plates, grids, or supports for the elements of secondary batteries.

4,944. J. G. LORRAIN. London. A new or improved electric arc lamp carbon, and apparatus for the manufacture of the same. (T. M Foote, United States.)*

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4,059. A. G. EDWARDS and J. BAKER. London. Improvements in electric arc lamps.

March 5, 1896.

4,964. J. CARTER and J. W. WHITING. Birmingham. Improvements in the brackets or supports of incandescent electric lamps.

4,996. F. BATHURST. London. Improvements in jointing boxes for con duits carrying electrical conductors.

5,008. W. W. WARDLE. London. An improvement in commutator brushes.

5,018. S. S. BROMHEAD. London. An improved electric bobbin or solenoid. (A. Dorez, France.)

5,023. G. C. FRICKER. London. Improvements in or relating to electric railways and tramways.

5,028. G. MARCONI. London. Improvements in telegraphy, and in apparatus therefor.

March 6, 1896.

5,041. J. SWINBURNE. London. Improvements in conductors for telegraphs, telephones, and electrical distribution.

5,069. G. BAMBERG. London. Improved moderating electric incandescent lamp, and apparatus for that purpose.

5,098. G. B. BALDO. London. Improvements in electrolytic processes and apparatus therefor.*

5,113. S. PITT. London. An improved electro-plating bath. (W. B. Hollingshead, United States.)*

March 7, 1896.

5,168. A. C. BROWN, R. BURN and L. G. TATE. London. A method of effecting electrical communication with a train, and apparatus for that purpose.

5,171. B. R. BAKER. London. Improvements in lifting and lowering gear for electric arc lamps, electroliers and the like.*

5,178. E. LEVER. Liverpool. Improvements in or connected with locomotives, also applicable to tramcars, electric cars, carriages and other vehicles.

5,191. A. PETZENBÜRGER. London. Improvements in arranging underground electric current conductors for electric railways, and in means for making contact therewith.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1895.

530. TONKING. Electric-current reverser, &c.

2,805. CROWLEY and OTHERS. Electrically-connected mechanical instruments.

4,490. DE FERRANTI. Dynamo-electric machines.

4,577. ACKROYD and BEST. Electrically lighting miners' safety lamps.

5,058. RAE. Arc lamps.

6,010. DRAKE and OTHERS. Magnetic clutch.

6,630. URQUHART (Decker). Telephonic, &c., exchange systems.

6,654. KOTYRA. Telephonic transmitters.

6,791. P. R. JACKSON AND CO. (LIMITED) and OTHERS. Dynamo electric machinery.

7,319. FLETCHER and OTHERS. Electrical hot plates.

9,273. TAYLOR. Electro-magnets.

10,903. STONE and BARNES. Electric currents.

14,485. DEVONSHIRE (Harthan). Arc lamps.

14,486. DEVONSHIRE (Case). Motor switches.

15,225. DEVONSHIRE (Potter). Electric brakes.

18,034. LEITNER. Electrical accumulators.

19,837. ADAMS. Arc lamps.

19,860. DEVONSHIRE (Potter). Regulating electric motors.

21,381. ROUBAL. Arc lights.

22,574. GRIST. Electrical insulating compositions.

22,936. TRUSS. Electric commutators, &c.

24,706. MARKS (Cooley). Electric telegraphy.

24,905. RORKE. Telephone transmitters.

1896.

130. GÜLCHER. Electric accumulators.

265. BICKERTON. Reflector for glow lamps.

452. LAKE (Fiske). Controlling electric motors.

964. SCHWARZE. Telephonic apparatus.

EASTBOURNE ELECTRIC LIGHT COMPANY (LIMITED.).—The ordinary general meeting of this Company was held at Eastbourne on Monday last. The Chairman, in moving the adoption of the report and accounts, referred to the position of the Company, and to the satisfactory progress that had been made during the past year. He concluded by moving that a dividend of 7½ per cent. per annum be declared, which was agreed to.

ROYAL ELECTRIC LIGHT COMPANY OF MONTREAL.—Coupons on the £154,000 Four and a-Half per Cent. Debenture loan of this Company will be paid on and after April 1st, by the Bank of Montreal, 22, Abchurch-lane, E.C. Coupons must be left three clear days for examination.

COMPANIES' MEETINGS AND REPORTS.

W. T. Henley's Telegraph Works Company (Limited).

The seventeenth ordinary general meeting of this Company was held at the offices, 27, Martin's-lane, Cannon-street, London, on Friday last, Mr. Sydney Gedge, M.P., presiding.

The SECRETARY (Mr. A. E. Salmon) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, I have a very pleasant duty before me to-day. I cannot call it a task, because I have to call attention to and move the adoption of what I think you will all agree with me is a satisfactory report and balance sheet. We have in our past history had to meet when we were obliged to tell the shareholders that the dividend we were looking forward to was still in the future—at one time in the dim and distant future. That time has now passed, We began to pay with a 5 per cent. dividend; we then paid 6 per cent., and now we are going to ask you to adopt the recommendation of the Directors to pay 8 per cent., and that upon a statement of accounts as to which the only thing I am afraid of is a murmur of not unnatural dissatisfaction on your part because we are not paying 10 per cent. or 12 per cent. instead of 8 per cent. I hope, however, before I sit down, that I shall be able to satisfy you that it is in your own interests—and our interests are identical with yours—that we only propose to pay you 8 per cent. instead of more for the past year. In the first place I should like to call attention to the profit and loss account, and to show you how it contrasts with what was a very good profit and loss account last year. Last year we brought forward £5,187—I mean that in 1894 we brought forward £5,187 from 1893. At the end of 1894 we carried forward £8,624, being an increase of £3,437. At the commencement of last year we brought forward that £8,624, and we are now carrying forward £13,367—a very considerable increase over the other amount. We have also set apart £5,000 to reserve, and we have written off nearly twice as much as we did in the previous year for depreciation, the amount so written off being £1,964 instead of £1,000. We have also spent on maintenance of our works during the last year about twice as much as usual, so as to ensure their being in first rate condition. The volume of our sales has increased over those of the year before by nearly 47 per cent., and this has not been by any means through our having had any large submarine cable work bringing in a large profit, but by the steady growth of our business. There is only one thing not earned in the year—that is the final dividend on the shares of the International Cable Company—£1,600. 7s. 9d. I think that, if you remember, I told you last year we might not have to pay anything on that account, but that we might get a small return, and we have got more than we expected, £1,600. The charges on that account were all brought against profits at the time, and we are therefore now justified in bringing this amount into the profit that we have to deal with. You will see that we have now in hand to deal with £18,942. 16s. 11d. That is the balance of our profit earned, and if we add to that the £8,624 brought forward from the profits of the previous year it gives us a total of £27,567 to deal with. Then came the question for the Board, what was the best thing to do with the money. After full consideration we decided—and we hope you will approve our decision—that it was best to keep the strength of our Company up, and not to go on dividing to the last farthing, or anything like the last farthing, but to keep a good balance in hand for two purposes. The first purpose is to create a reserve fund, wherewith in any possible time of difficulty we may be enabled to equalise our dividends, and the second is to have working capital amply sufficient for our wants. This is an exceedingly good way of dealing with money in hand. Some people say it would be better left to fructify in the shareholders' pockets. I doubt very much whether, if we paid a larger dividend—say 12 instead of 8 per cent.—the other 4 per cent. would fructify in the shareholders' pockets; but in our hands it does fructify, because we are able to make our purchases on much more favourable terms with cash than we could do if we gave the Company's acceptances. If you will look to your balance sheet you will find on the credit side bills receivable in hand £4,985, but you will not find any bills payable on the other side, because we have had money in hand with which to make our purchases in cash for the most part. There are therefore no bills running against us, and I think that in the transactions of a Company like this that is a very good feature. After making provision for bad and doubtful debts we have in bills receivable and debtors a sum of about £45,000, and cash at bankers and in hand £15,000—or, together, over £60,000. If you look at the debit side of the balance sheet you will find that all we owe is £17,525, and what is due to us exceeds what we owe by £42,841. I hope you will approve our keeping in hand this money as we propose to do, in order that it may fructify and with a view to our being able permanently to pay you a good dividend in case of bad times, and to pay you at least 8 per cent. next year, tho' I hope we may find it prudent to pay more. No promise can now be made as to that, but we have already profit in hand which we carry forward, if you confirm what we propose, which will enable us, if we do not earn a penny this year, to pay you the interest on our debenture stock, the dividend on our Preference shares and 8 per cent. on our Ordinary shares. We should be able to make those payments with the amount we now propose carrying forward, and we could do so without touching the reserve fund. That I think is a very strong position for a company to be placed in. The next point to which I desire to call your attention is this—that we have a gross profit on trading of £36,967, and that has been earned at an expense, including Directors' fees, of £14,176, or about 38 per cent. of the gross profit. That amount includes the salaries of the engineer and of the Managing Director, the rent of offices, the maintenance of works, and the salaries of

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clerks, as distinct from the wages paid to working men and artisans, both at North Woolwich and here, and all that we may call general expenses not chargeable against particular jobs. If you look at the balance-sheet you will find that we show an increase in capital of £30,000 and an increase in stock of £5,450. The bulk of that capital has gone to the enlargement and improvement of our works and machinery. You find among our assets debentures and shares held in other companies, £2,766. 5s. That money has been invested for the purpose of extending your business, and with great advantage. Of this amount £2,500 represents shares in one company which has paid us a dividend of 3 per cent. You will see among the liabilities an entry "reserve under cable repairing contract invested in the joint] names of trustees for the Company and the Crown agent for the colonies," £2,927. That is not brought into account but is stated as a fact. You will be glad to hear, although the price of all trust securities is so high that we have been unable to invest the money to make the return we hoped for in the way of accumulation, yet the value of all these stocks has risen so greatly that that £2,900 has increased about £300 more. Although we have not been able to accumulate quite so much interest as we had hoped to do, yet the rise in the price of the stocks has made up for the small amount we have put by; and I have moreover, the great pleasure of again reporting to you that that cable, like the Halifax and Bermuda cable, is still as perfect as it was on the day it was laid, and we have not had to pay a shilling for repairing it. That, I think, speaks well for us and the work we turn out. There is only one other subject to which I desire to refer. According to the terms on which our preference capital was issued, the holders of it have the option until July 2nd next of giving six months' notice to convert into ordinary share capital. It will be for the convenience of the Company if the holders of the Preference shares avail themselves of that option, because it is clear that for the simplifiation of the accounts and any future financial operations, it is better to have £130,000 of Ordinary stock of one description than two stocks. The time may came when our business may so extend that we may want more capital, and may wish to raise it by the issue of Preference stock. A second Preference stock is not put on the market on the same advantageous terms as a first Preference stock, and therefore, although £30,000 is but a small amount, we should have probably to pay a higher rate of dividend if we issued a second Preference stock for obtaining more capital than we should have to pay if we had the £130,000 behind and no Preference stock. If we get rid of this £30,000 of Preference shares, we may be able to issue other Preference stock at 5 per cent. instead of 7 per cent. I think, therefore, that our Preference shareholders will do wisely to exchange their Preference shares at par for our Ordinary shares. They will themselves gain in the benefit to the Company. I now propose:—

"*That the report and the balance sheet now presented to the meeting be and hereby is adopted.*"

Major-General GEORGE HUTCHINSON, C.B., C.S.I., seconded the resolution, which was carried unanimously, as was the resolution declaring the dividends of 5 per cent., free of income tax, on the Ordinary and 7 per cent. on the Preference shares.

Mr. JENKINS proposed the re-election of Mr. Gedge as a Director, which was seconded by the Hon. R. STEWART and carried.

In acknowledging the compliment, Mr. GEDGE thanked the Directors for the support they had accorded him in the conduct of the business, and to Mr. Sutton (the Managing Director), to whom it was impossible to pay too high a tribute for the manner in which he conducted their business. A strong word of praise was also due to Mr. Hatton, their manager at the works, for the way in which he had discharged his duties. Their thanks were due, in fact, to all their officers and the staff for the excellent way in which they performed their respective duties. They had been able to enter into new arrangements with Mr. Sutton and Mr. Hatton, whereby the services of those gentlemen were secured to the Company for a term of years, and their friends would participate, as they ought to do, liberally in the Company's good fortune.

Mr. NEWTON was re-elected as a Director, and the retiring auditors having been again appointed, a vote of thanks to the Chairman and Directors terminated the proceedings.

Birmingham Electric Supply Company (Limited).

The annual meeting of this Company was held on the 12th inst., at the offices, Dale End, Birmingham, Mr. H. Buckley presiding.

The CHAIRMAN, in moving the adoption of the report and accounts, said the Directors were thoroughly satisfied with the progress made during the past year. The issue of new shares to the amount of £50,000, authorised by an extraordinary general meeting, had been carried into effect, twice the amount required being applied for by shareholders. The premium was used for wiping the item for preliminary expenses out of the balance-sheet, and further sums had specifically been placed against the cost of Provisional Orders. The reserve had also been materially strengthened. The policy of reducing the charge for current which, of course, had materially affected their revenue at first, had been justified by the result. The loss in revenue had been overtaken by the increase in consumption, and the prospects for the current year, as shown by the returns for the first two months, were eminently satisfactory. Not only were they getting fresh customers, but their present customers were increasing their consumption. The report of the Birmingham Old Library showed that last year, when the establishment was lighted by electricity, the cost (including repairs and renewals of lamps) was £75. 9s. 9d., against £77. 3s. 9d., for gas in 1893. This result was attributed to the fact that the electric light was better distributed and could more readily be economised. The Birmingham Library was not the only concern that had had such an experience with the electric light. The supply of current for the district of Edgbaston was only available at the beginning of November, and was not available for the jewellers' quarter till January. This was caused by the non-delivery of the plant for the distributing stations, due to the destruction of the electrical engineering works at which it had been constructed. At the present time they had 20 miles of mains in the streets of the city, and there was a fairly steady increase both in the summer and in the winter consumption, while the increase in the number of lamps was quite steady.

A dividend of 4 per cent. was declared, and the retiring Directors, Mr. H. Buckley and Mr. F. W. V. Mitchell, were re-elected.

In reply to a question, the CHAIRMAN said that they were unable to declare an interim dividend because during one-half of the year their revenue was small as compared with that for the other half, but whether they would be able to do so in the future would depend largely upon the extent to which electric motors came into use in the city, as it was a day load they required.

Direct Spanish Telegraph Company (Limited).

The report and accounts of the Directors of this Company for the year ending December 31st last will be presented at the yearly general meeting of shareholders, held on Tuesday next, the 24th inst., at Winchester House, London, E.C., at 12 o'clock:—

The accounts show a balance to credit of revenue of £13,239. 12s. 9d. After providing for interest on and redemption of debentures, and adding £5,000 to the reserve fund, the balance of revenue amounts to £5,801 6s. 9d., and the Directors recommend the declaration of dividends for the past year of 10 per cent. on the Preference shares and 4 per cent., free of income-tax, on the Ordinary shares, absorbing £5,486. 4s. Half of this amount was distributed on October 1st as an interim dividend, £315 2s. 9d. is carried forward. The reserve fund now amounts to £28,498. 8s. 8d.

The traffic receipts show an increase of £4,571. 14s. 6d. as compared with the year 1894, and the ordinary working expenses are £238. 4s. 11d. in excess of those for the year 1894.

The Company's cables, and the land-lines in connection with them, have continued in good working order throughout the year. The report refers to the loss the Company has sustained by the death in June last, of Señor Don José Aparicio, who had been the highly-valued representative of the Company in Spain since its formation. Señor Don Vicente Coromina has been appointed his successor.

Mr. Edmund Etlinger and Mr. J. Denison Pender offer themselves for re-election as Directors, as do the auditors, Messrs. Deloitte, Dever, Griffiths and Co.

Sheffield Electric Light and Power Company (Limited).

The report of the Directors of this Company, to be submitted at the ordinary general meeting of shareholders, to be held on Monday next, the 23rd inst., at the Cutlers' Hall, Sheffield, at noon, states that there is a balance of profit for the year of £3,391. 9s. 4½d., to which must be added £531. 17s. 0d. from last account, making a total of £3,923 6s. 4½d.; and after deducting £1,119. 19s. 10d. for interest on Debentures, £220. 16s. 11d. proportion of formation expenses written off, and £750 transferred to depreciation fund, there remains a balance of £1,832. 9s. 7½.

The Directors recommend the payment of a dividend of 5 per cent. per annum out of this sum, which will absorb £1,744. 10s. 8d., and propose to carry forward the balance of £87. 18s. 11½d. The total sum now standing to the credit of depreciation fund is £2,000, and the whole of the machinery and plant is in excellent condition. In 1893 the gross revenue of the Company amounted to £3,555. 11s., in 1894 to £4,849. 9s. 4d., and in 1895 to £6,935. 4s. 1d.

During the year £16,426. 18s. 7½d. was expended upon machinery, mains, and other apparatus, and in order to provide the necessary capital for the further development of the Company's business, the Directors have decided to offer to the present shareholders 3,375 shares at a premium of 10s. per share.

Accompanying the report is a circular letter inviting subscriptions for 3,375 shares of £7 each. The nominal capital of the Company is £98,000 in £7 shares, and £25,000 Four and a-Half per Cent. Debentures, and the subscribed capital amounts to £41,875 plus the debenture issue.

MEMORANDA—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31⅜d. per oz. (March 19th). Consols (2¾ per cent.) 109⅜—109⅝ for money, 109¼—109⅜ for account; 2½ per cent. 105⅞—106⅛ (March 19th). Stock Exchange Settling Days: Consols, March 30th; Stocks and Shares Continuation Day, March 25th; Ticket Day, March 26th; Pay Day, March 27th; Mining Share Carry-over Day, March 24th.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment on April 14th next of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum, on the Preference shares of the Company, for the quarter ending 31st inst., and the usual interim dividend of 2s. 6d. per share on the Ordinary shares, free of income tax, in respect of profits for the quarter ended December 31st last. The transfer register will be closed from the 7th to 14th April inclusive.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—Notice is given that the thirteenth drawing for payment of the Five per Cent. Australian Government Subsidy Debentures (409 in number) will take place on April 1st next at the offices of the Company, at 11:30 a.m.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—The ninth ordinary general meeting of this Company will be held at noon on Tuesday, the 31st inst., at Winchester House, E.C. The transfer register is closed from the 21st to the 31st inst. inclusive.

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NEW COMPANIES, STATUTORY RETURNS, &c.

In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1896, pages *318-346, &c., &c.*

COTTONWOOD WATER POWER AND ELECTRIC COMPANY (LIMITED).—This Company was registered on March 13th, with a nominal capital of £210,000, in 105,000 Preference and 105,000 Ordinary shares of £1 each, to enter into an agreement with John E. Condict to carry on in the territory of Utah (U.S.A.) and elsewhere the businesses of a power and electric supply company, to generate, accumulate, sell, supply and distribute power or energy, and to develop, accumulate, sell, supply and distribute electricity for lighting, heating and manufacturing purposes. The first subscribers are: F. Williams, Col. A. J. Filgate, H. R. Savory, R. A. Fairclough and J. Boustead (250 shares each); and E. A. King and Frank Stuttaford (with one share each). The first Directors are: J. Boustead, Col. A. J. Filgate, R. A. Fairclough, H. R. Savory and F. Williams.

J. S. LEACH AND COMPANY (LIMITED).—This Company was registered on March 11th, with a nominal capital of £10,000, in £1 shares, to acquire the business of a mechanical and electrical engineer, millwright, machinery manufacturer, &c., now carried on by Mr. E. W. Donovan under the style of "J. S. Leach and Company," at Harpurhey and Slaford. The first Directors are: E. W. Donovan (governing) and Harry Statham (managing).

LONDON ELECTRO-PLATING AND REFINING COMPANY (LIMITED).—This Company was registered on March 13th, with a nominal capital of £1,000, in £1 shares, to acquire the business carried on under the style of the London Electro-Plating and Refining Company, by Messrs. A. V. Pittar and A. Soden, and to carry on the business of electro-platers, electro-typers, enamellers and metal refiners. The first Directors are: Edgar W. Beckingsale, A. V. Pittar and A. Soden. Mr. A. V. Pittar is to act as Managing Director at a salary of £65 per annum and 15 per cent. of the net profits.

SILICON ELECTRIC LAMP SYNDICATE (LIMITED).—This Company was registered on March 16th with a nominal capital of £8,000 in £1 shares, to test, experiment and develop certain inventions connected with the manufacture of electrical lamps, for which letters patent have been granted to R. Langhans, A. Berrenberg and E. D. Chaplin (which are under an agreement of sale to the Langhans-Berrenberg-Chaplin Patents, Limited), to carry on the business of manufacturers of incandescent and other lamps, and of filaments, wires, bulbs, or other parts or requisites of such lamps, and to carry on the business of an electric light company, and electricians, mechanical engineers, suppliers of electricity and manufacturers of electrical apparatus. The subscribers, with one share each, are: H. L. Pilkington, P. J. Miller, Templer L. Down, A. F. da Costa, F. D. Summers, W. H. Smillie and J. G. Bristow. First Directors are: Hon. R. C. Parsons, A. A. Campbell Swinton and Capt. H. L. Pilkington.

BRITISH ELECTRIC TRACTION (PIONEER) COMPANY (LIMITED).—The statutory return to March 5th has just been filed. The nominal capital is £100,000 in £10 shares, of which 5,000 have been subscribed for. A call of £2 per share has been made.

LITHANODE ELECTRIC STORAGE COMPANY (LIMITED).—The statutory return to November 21st has been filed. The capital is £12,000, in £1 shares, and 7,007 of these have been taken up; 5,500 have been issued as fully paid, and the full amount has been called on the remainder.

LONDON ELECTRIC SUPPLY CORPORATION (LIMITED).—The annual return to May 23, 1895, was not filed until February 26th last. The nominal capital is £1,250,000, in 200,000 Ordinary and 50,000 Preference shares of £5 each. 110,000 of the former, and 48,050 of the latter, have been taken up, and the full amount called. £3,740 has been received in respect of 1,950 forfeited shares.

LONDON ELECTRIC WIRE COMPANY (LIMITED).—The annual return to February 11th has been filed. The capital is £50,000, in 5,000 Preference and 5,000 Ordinary shares of £5 each; 4,188 of the former and 4,597 of the latter have been taken up, and 3,860 shares of each class have been issued as fully paid. The full amount has been called on the remaining 28 Preference and 737 Ordinary.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return to March 5th has been filed. The capital is £350,000, in 50,000 Ordinary, 10,000 First Preference, and 10,000 Second Preference shares of £5 each; 15,000 Ordinary, all the First Preference, and 2,500 Second Preference have been taken up, and 5,000 of the Ordinary have been issued as fully paid. The full amount has been called on the remainder.

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).—The annual return to March 4th has been filed. The capital is £400,000, in £5 shares; 68,000 shares have been taken up, and the full amount called.

POOLING ARRANGEMENTS.—It is stated that an agreement has been entered into by the General Electric Company and the Westinghouse Electric and Manufacturing Company of the United States providing for the pooling of patents and dual control in the management of the business by a joint board of directors, the object of the arrangement being to save administration expense.

CITY NOTES.

APOSTOLOFF AUTOMATIC TELEPHONE PARENT SYNDICATE (LIMITED).—The statutory general meeting of the shareholders of this Company was held in private on Monday last.

BARCELONA TRAMWAYS COMPANY (LIMITED).—An extraordinary general meeting of the shareholders of this Company is to be held on Friday next at Winchester House, E.C., to confirm the resolutions increasing the capital of the Company from £150,000 to £300,000, the increase being required for the conversion of the Company's system from horse to electric.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended March 15th were £949, against £912 in the corresponding week of 1895, an increase of £37. The total receipts for the half-year amount to £10,786, against £10,823 for the corresponding period of 1895, a decrease of £37.

COTTONWOOD WATER POWER AND ELECTRIC POWER COMPANY (LIMITED).—A prospectus has been issued in London this week of the above Company, which is a concern formed to acquire works and conduct operations at Little Cottonwood Creek, near Salt Lake City, U.S.A. No powerful reason is assigned in the prospectus why capital should be sought in this country for this enterprise rather than in the United States, except that several more or less well-known names are associated with the conduct of the Company. The present application is for 70,000 Seven per Cent. Preference shares and 70,000 Ordinary shares, both of £1 each. The vendor receives £200,000 for his share in the transaction—£35,000 in fully-paid Preference shares, £35,000 in fully-paid Ordinary, and the balance of £130,000 in cash, or partly in cash and partly in securities of the Company. The list of applications closed yesterday (Thursday). The Board of Directors include Col. A. J. Filgate (Chairman of the Hove Electric Lighting Company), Mr. H. R. Savory (a Director of the Salt Lake and Ogden Company), and the consulting engineer is Mr. J. S. Raworth, of the Brush Company.

IMPERIAL TRAMWAYS COMPANY (LIMITED).—At the ordinary general meeting of this Company on Saturday last the Chairman (Mr. Geo. White), in referring to the condition of the tramways of the Dublin Southern Company, is reported to have said that the general power station was in a very advanced state, and the equipment of the lines, as well as the overhead construction, practically completed. The sub-stations were so well in hand that they could be used at any moment, and the whole of the cars, both motor and trailer, had been built; but the contractors had assured them that the main obstacle to the actual completion of the installation was the non-delivery of the alternators and transformers, which were being built by Armstrong, Mitchell and Co. It seemed annoying to be told that had this order been placed in America the machines would have been delivered and the line opened months since, and that it was simply the desire to encourage home manufacture which had resulted in this annoying and unlooked-for delay in the completion of the electrical equipment. Matters were now, however, in such a state that they might confidently look forward to the completion and opening of the line during next month. So far as those lines were concerned, which had been approved of by the Corporation and the Townships of Pembroke and Rathmines, they had made all arrangements to start the works the day their Bill passed through Parliament.

ISLE OF MAN TRAMWAYS AND ELECTRIC POWER COMPANY (LTD).—At an extraordinary general meeting of this Company on Wednesday, the resolutions to purchase the Snaefell Mountain Railway for £72,500, and to increase the capital of the Company to £175,000 by the creation of 25,000 new £1 Preference shares, were approved.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 15th inst. amounted to £1,095. The amount for the corresponding week last year was £975. Increase £120.

OXFORD ELECTRIC COMPANY (LIMITED).—This Company invites subscriptions at par for 1,414 shares of £5 each. The authorised capital of the Company is £100,000 in £5 shares, and 6,586 fully paid shares have already been issued. There is also £25,000 Five per Cent. Debentures. The Company commenced to supply electric current in the city of Oxford in June, 1892, and has recently declared a dividend of 3½ per cent. for the year 1895. Applications must be sent in to the London and County Banking Company, Oxford, by the 31st inst.

ROCKHAMPTON (QUEENSLAND) GAS AND COKE COMPANY (LIMITED).—The report of the Directors of this Company (which also owns the electricity works) for the half-year to December 31st last states that the consumption of gas for the period under review fell off 39 per cent., and this is partly attributed to the shrinkage resulting from the encroachment of the electric light. There was also a slight drop in the quantity of electricity supplied during the half-year. The Directors state that "strenuous care has been exercised to avoid a too rapid development of this section of the Company's operations, to avoid an unnecessary clashing with the gas interests." Several additional consumers have been added to the list, and the general expenses are, with the aid of a battery of accumulators about to be installed, likely to be considerably reduced, and the prospect for the current half-year looks encouraging.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended March 13th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,805.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half-month ended March 15th are £2,592, against £3,107 in the corresponding period of 1895 The November, 1895, receipts (estimated at £4,253) realised £4,288.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Mar. 11.	Price Wednesday, Mar. 18.	Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done during Week Ending Mar. 14. Highest	Lowest
			TELEGRAPHS.						
£1,012,880	Stock	18/0	Anglo-American	46 48	46 48	5 4 2	Jan., Apr., July, Oct.	47⅞	47
£2,993,560	Stock	36/0	Do. Preferred	87½ 88½	87½ 88½	5 13 6	" "	88½	87½
£2,993,560	Stock	5/0	Do. Deferred	7 7½	7½ 7½	.. ..	.. ..	7⅞	7⅞
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	100 104	100 104	3 17 6	January and July	102	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	10½ 11	10½ 11	.. ..	.. ..	10⅝	10½
130,000	£10	2/0	Brazilian Submarine	14½ 14⅝	14½ 14⅝	4 14 11	Mar., June, Oct., Dec.	14⅝	14⅛
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	111 115	111 115	4 7 9	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	160 170	160 170	4 3 2	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12½ 13½	12½ 12⅝	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 18 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	4 5	4 5	4 0 0	April and October	4	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	105⅝ 108⅝	106⅝ 109⅝	4 3 6	" "	..	..
60,710	20	2/0	Direct United States Cable, 1877	9⅛ 9⅜	9⅛ 9⅜	4 3 1	Jan., Apr., July, Oct.	..	..
400,000	10	2/6	Eastern	17 17⅛	17 17⅛	3 14 4	" "	17⅛	17
70,000	10	6%	Do. 6 per Cent. Preference	18 18½	18 18⅛	3 4 10	" "	18⅛	18
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	129 132	129 132	3 1 2	May and November	..	..
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	105 108	105 108	4 12 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17⅜ 18⅛	17⅜ 18⅛	3 16 9	Jan., Apr., July, Oct.	18⅛	18
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128 131	128 131	3 1 4	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900	101 105	101 105	4 15 11	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb.,1900	101 105	101 105	4 15 11	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	105 108	105 108	3 14 1	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 115%	3 10 2	May and November	..	..
180,227	10	1/6	Globe Telegraph and Trust	10⅜ 10⅝	10⅜ 10⅝	3 16 9	Jan., Apr., July, Oct.	10⅝	10⅜
180,042	10	6%	Do 6 per Cent. Preference	16⅜ 17⅛	16⅜ 17⅛	3 9 7	" "	17 7/16	16 15/16
150,000	10	5/0	Great Northern	22½ 22⅝	22½ 23	3 14 0	Jan., April, and July	..	..
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue	102 105	103 105	4 15 3	March & September	105	..
17,000	25	12/6	Indo-European	47 50	47 50	5 0 0	May and November	..	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	.. ..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	105 108	106 109	5 10 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	108 111	108 111	3 12 7	" "	..	..
11,839	8	4/0	Reuter's	5 6	5 6	.. ..	April and October	..	..
3,321	£100 Cert.	2/0	*Submarine Cables Trust 6 per Cent.	132 137	132 137	4 7 7	" "	136	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	.. ..	January and July	..	..
£238,300	100	5%	* Do. 5 per Cent. Debentures (red.)	101 104	101 104	4 16 2	March & September	..	..
30,000	10	2/0	West Coast of America	1 2	1 2	.. ..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	94 99	94 99	8 4 1	June and December	..	..
38,321	10	1/8	West India and Panama	1 1½	1 1½	.. ..	.. ..	1	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10½ 11½	10⅝ 11⅛	5 6 8	May and November	11 1/16	10⅝
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108 111	108 111	4 10 8	June and December	..	..
64,248	15	3/0	Western and Brazilian	8⅜ 9⅛	8⅛ 9	5 5 8	May and November	9 1/16	8⅝
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6½ 7	6⅛ 6⅜	.. ..	—	6⅜	..
33,129	7½	1/6	Do. Deferred Ordinary	2⅜ 3	2⅛ 2⅝	.. ..	—	2⅝	2⅛
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	102 106	102 106	5 13 2	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	102 106	102 106	5 13 2	" "	..	..
8,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	113 118	113 118	6 0 0	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	102 105	102 105	5 14 3	March & September	..	..
			TELEPHONES.						
44,000	5	2/0	Chili Telephone (fully paid)	3 3½	3 3½	.. ..	—	..	..
224,650	10/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16 1/8	1/16 1/8	.. ..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	1/16 1/8	1/16 1/8	.. ..	Yearly	1/16	..
484,597	5	3/0	National	6½ 7	6½ 7	3 18 7	June and December	6⅞	6⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	16⅞	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	16½ 17½	16½ 17½	3 8 7	" "	16⅞	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅜ 6½	6⅜ 6½	3 12 9	—	6⅝	6⅜
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	104 107	105 108	3 5 3	January and July	106⅛	105
58,000	5	3/0	United River Plate	3½ 4	3½ 4	.. ..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	95 100	97 102	4 19 0	" "	..	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	10/0	City of London Electric Lighting (fully paid)	14 15	14 15	3 6 8	—	14⅜	14⅛
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	16 17	16 17	3 10 7	—	17	16⅜
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	134 138	134 138	3 13 0	June and December	136	..
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	.. ..	—	..	..
£30,000	£5	3/0	Charing Cross & Strand Electricity Supply Corp.	6½ 7½	7 7½	.. ..	—	7 1/16	7
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	.. ..	—	..	..
24,475	£8	..	County of London & Brush Prov. Ord. (fully paid)	8 9	8 9	.. ..	—	..	..
10,000	£10	9⅜d.	Do. Pref. (£8 paid)	10 11	10 11	.. ..	—	10⅛	10⅜
8,322	£5	..	House-to-House Electric	.. ..	.. ..	.. ..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	.. ..	.. ..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	.. ..	January and July	..	..
45,000	£5	3/6	Liverpool Electric Supply (fully paid)	7⅜ 8	7⅜ 7⅞	3 16 2	—	..	..
111,000	5	..	London Electric Supply	.. ..	.. ..	.. ..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	12⅜ 13½	13 13⅛	2 5 3	—	13⅜	13⅛
£150,000	Stock	4½%	* Do. 4½% Debs.	116 119	118 120	3 15 8	June and December	116⅛	..
6,452	£10	4/0	Notting Hill Electric	8⅜ 9⅛	8⅜ 9⅛	.. ..	—	..	..
..	..	..	Rand Electric	1/16 1/8 prem.	1/16 1/8 prem.	.. ..	—	..	..
12,980	£5	5/3	St. James and Pall Mall	9⅜ 10⅛	9⅜ 10⅛	.. ..	—	10⅛	9⅞
20,000	£5	7%	Do. 7 per Cent. Preference	9½ 9⅝	9½ 9⅝	3 11 10	—	9⅝	9⅜
59,900	5	4/6	Westminster Electric Supply (fully paid)	9⅜ 10	9⅜ 10	3 10 0	—	9⅝	9⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1⅜ 1⅝	1⅜ 1⅝	5 8 8	—	1 1/16	1⅛
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝ 1¾	1⅝ 1¾	3 4 0	—	1⅜	1⅛
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	110 113	110 113	3 19 8	March & September	..	..
28,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2½ 2⅝	2½ 2⅝	.. ..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1⅜ 1⅝	1⅜ 1⅝	.. ..	..	1 1/16	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	103 105	103 106	4 5 9	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	— —	.. ..	.. ..	..	—	—
110,000	2	..	Electric Construction	1⅜ 1⅝	1⅜ 1⅝	.. ..	..	1 1/16	..
12,845	2	2 9⅜	Do. 7 per Cent. Cumulative Pref.	2⅜ 2⅝	2⅜ 2⅝	5 1 10	..	2⅛	..
91,195	2	10/0	Elmore's Patent Copper Depositing	1⅝ 1¾	1⅝ 1¾	.. ..	..	1 1/16	..
20,000	5	..	Fowler-Waring Cables (fully paid)	1 1	1 1	.. ..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	19 20	19⅜ 20⅜	4 17 7	February & August	20	19⅜
£244,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 7 5	March & September	..	..
15,993	£10	..	International Okonite Ordinary	.. ..	.. ..	.. ..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	— —	.. ..	.. ..	December and June	..	..
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	⅜ ½	⅜ ½	.. ..	..	..	..
37,350	12	24/0	Telegraph Construction and Maintenance	39 42 xd	38 41	4 7 10	March and July	41⅜	38
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	102 105	4 16 2	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	.. ..	—	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	.. ..	—	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	15½ 16½	16 17	3 10 7	—	16⅜	15⅞
£30,000	10	7/0	Do. 7 per Cent. Preference	16½ 17⅜	17 18	3 17 9	—	17⅜	17⅛
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	107 112	107 112	4 0 4	—	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway Con. Ordy.	40 42	40 42	2 19 6	May and November	41⅜	40
7,650	10	5%	Do. 5% Perpetual Preference	14½ 15	14½ 15	3 6 8	.. ..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	132 134	132 134	3 0 8	May and November	133½	..
37,500	£10	2½%	Liverpool Overhead Railway	13⅜ 14	13⅞ 14⅛	2 2 6	—	..	..
10,000	10	5%	Do. 5% Preference	15⅞ 16	16⅛ 16⅜	2 10 8	—	..	..
145,000	Stock	4%	Do. 4% Debenture	114½ 116½	114½ 116½	3 10 2	January and July	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

In our correspondence columns will be found a remarkable communication from Prof. G. M. Minchin. It is needless to say that it relates to X-rays. Prof. Borgman, of St. Petersburg, was the first to announce in this country (see *The Electrician*, February 14th, p. 501) that Röntgen rays electrified bodies, Prof. Righi, of Bologna, following closely on his heels (see *The Electrician*, February 21st, p. 552); but whilst the former found *negative* the latter found *positive* electrification. To day this discrepancy is explained by Prof. Minchin's discovery that different bodies are differently charged by X-rays; some, such as iron, platinum and gold, being positively charged, others like sodium, magnesium, tin, lead and zinc being negatively electrified. As Prof. Minchin remarks, this phenomenon would seem to dispose of the projected electrified particle hypothesis. Perhaps the most curious observation made by Prof. Minchin is that X-rays, when they impinge upon a negative substance such as magnesium, do not merely add to any negative charge it may possess, but rearrange it, so to speak, until by addition or subtraction it amounts to the charge they would independently have given it. If this observation stands the test of time and repetition, the X-rays will have developed yet another puzzling property of exceeding interest.

We are reminded by a contribution from Mr. Fournier-d'Albe on the classification of physical experiments that the use of symbols as abbreviated expressions of magnitude and, qualitatively, of things in general is of very early date; and that probably the second-named use is even older than the first. The Chaldeans and Hindus were among the first to employ algebraic and trigonometrical symbols; and the sciences of alchemy and astrology were media for the invention of a host of qualitative symbols. Close and extended reasoning about magnitudes is practically impossible without symbols, as anyone would discover who should attempt to work out a series of mathematical operations without them; but it has not been so universally admitted that symbols are advantageous when dealing with concrete things or qualitative abstractions. Logicians have long used symbols to denote certain qualitative processes of reasoning; and Boole has devised an almost complete system of "logical calculus," whereby mental operations might always be carried on symbolically, as they are in mathematics.

It has more than once occurred in the history of the physical sciences, that a system of symbols which originated only for qualitative use has gradually developed into an indispensable system for quantitative work. This happened, for example, with the symbols for the chemical elements. At the time when these were merely abbreviations, representing indefinite amounts of certain substances, it would have been impossible to predict the enormous accession of usefulness which they would receive from the discovery of the laws of atomic combination. Just in the same way, we are inclined to believe there are latent possibilities in the ingenious symbology which Mr. E. E. Fournier-d'Albe has applied to the classification of physical experiments. That some such code is gradually being forced upon us by the increasing scientific output due to increasing scientific activity, is evident from the kindly way in which such code phrases as "$\theta\phi$ diagram," "**B-H** curve," &c., have been received. And as the ever-increasing bulk of scientific research swells to more and more unmanageable dimensions, the question of the universal adoption of some code similar to that proposed by Mr. Fournier-d'Albe wil persistently press for solution.

The economic law for current density of distribution mains and feeders has been written in a variety of forms according to the particular view taken, yet we think that Mr. James Whitcher's investigations now published are made from a fresh standpoint. In his working equation, derived from the differential equation, he states the current density in terms of a constant multiplied by a quantity under a radix in the usual form; but the annual cost of energy instead of being expressed per horse-power per annum is expressed as the cost of one kilowatt-hour in pence. This is a figure the value of which is more easily grasped than that of the larger quantity, and lends itself more readily to comparison with the published figures of electric supply stations. Mr. Whitcher proceeds to point out that this quantity is not the average or mean cost per kilowatt-hour, but that it is the cost of adding another kilowatt to the rate of output. He finds that it follows a law which may be expressed as the summation of the rates per cent. of interest, maintenance and depreciation charges chargeable to the conductor when laid, plus a constant charge depending upon the stand-bye and constant losses, which are proportional to the capacity of the plant. For most practical cases the cost of an additional kilowatt-hour appears to vary between 1d. and 2d.;

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so that 1·5d. may be taken as a first approximation. Mr. WHITCHER, making certain assumptions based upon the ruling prices of cables as generally used, and averaging capital charges at 7 per cent., gives two practical equations for the maximum current density in high-pressure feeders and low-pressure distributors, both bare and insulated. It is interesting to note that the economic current density does not vary at the same rate as the load factor. It appears from these figures that the maximum current density for high-pressure constant current feeders varies from 800 to 500 amperes per square inch between the limits of 500 and 4,000 hours per annum. With high-pressure feeders, with load factors of from 0·01 to 0·3, the current density varies between 830 and 600 amperes per square inch, and with low-pressure feeders from 750 to 550. With low-pressure distribution circuits the variation is from 1,400 to 1,000, and with bare copper distribution mains from 900 to 700, for the same load factors. These figures are averages based over the whole of the systems to which they apply, and require modifying if some of the conductors are worked at different times from others. For example, if one pair of feeders is fully loaded when the rest of the mains are lightly loaded, then the density in the pair should be greater than that over the rest of the system, and the cost of an additional kilowatt-hour in them will probably work out at about ½d., because practically independent of the fixed charges, and probably of the labour charges also.

AMONG the remedies which have been adopted for vibration troubles at generating stations the three-crank engine has played an important part. As a practical solution of an annoying and pressing difficulty this form of engine has already proved a decided success. But, from a strictly scientific point of view, there still remain in every three-crank engine forces which are not continuously in equilibrium, and which must tend to produce vibration. Three equally-spaced cranks are only mathematically in equilibrium when they move around a common axis in one and the same plane, and when the forces acting on the crank pins are always parallel and constant in magnitude, or when some equivalent condition obtains. In a three-crank steam engine the conditions are not equivalent; the cranks are in different planes, the obliquity of the connecting rods (usually very short in high-speed engines) throws the forces considerably out of parallel, and the steam pressures are not constant, but vary, as shown on the indicator diagrams. Moreover, the auxiliary moving parts, such as the valve gear, supply additional unbalanced forces. A valuable Paper on "The Determination of the Forces which Produce Vibration with Three-crank Engines at High Speed" has been read by Mr. R. M. FERRIER, B.Sc., before the North-east Coast Institution of Engineers and Shipbuilders. The subject is treated particularly in relation to marine engines, and Mr. FERRIER'S Paper would have to be modified somewhat before it would square with electrical engineering practice. Nevertheless, it is a useful contribution to the subject. Marine engines receive a not inconsiderable fraction of their vibration from the propeller; electric light engines certainly receive none from continuous-current dynamos, though the periodic variation in the reaction of alternators may supply a certain amount of vibration-generating force. All electric light engines are fitted with flywheels, which are absent from marine engines, and it is indisputable that a flywheel, although not supplying a balancing force in the strict sense, does, by virtue of its great inertia, tend to prevent small unbalanced forces from setting up actual vibration of the engine.

How many members of the Institution of Electircal Engineers ever "mark, learn and inwardly digest" that modest financial statement which is annually sent them under the protection of a halfpenny wrapper. Those who may have inadvertently deposited this document in the waste-paper basket may be interested to learn that the total receipts of the Institution for the past year amounted to £4,533, and the current expenditure to only £2,641; the satisfactory balance being practically all carefully invested. The Institution now possesses in all the substantial sum of £10,543 in safe investments, and its building fund amounts to £3,500. The *Journal*, comparatively humble production though it be, nevertheless costs the Institution nearly £500 nett. The finances of the Institution do not indeed involve big figures, but they involve much trouble, and great credit is due to those in charge of them for having placed the Institution on a financially sound basis.

AT a recent meeting of the Royal Meteorological Society a Paper on "Turner's Representations of Lightning" was read by Mr. R. INWARD. The author showed the truth to Nature of TURNER'S lightning by comparing the great painter's flashes with photographs of actual flashes. We are quite in agreement with the author of this Paper in regarding the Turnerian wavy flash as being more "correct" than the orthodox zigzag display At the same time, and without wishing to appear to criticise such a master as TURNER, we cannot refrain from pointing out that what the camera reveals does not necessarily conform to the canons of good art, nor look natural when depicted on canvas. Mr. MUYBRIDGE'S photographs of animals in motion reveal their actual postures, but these would be ludicrous if introduced into a picture, say, of a steeplechase or of a busy street. In like manner one may appreciate Turnerian lightning from the electromagnetic-theory point of view; but, for all that, to the plain man it has none of the vividness of the zigzag conventional counterfeit.

Sir John Pender.—We learn on inquiry at Arlington-street that there is no foundation for the rumour that Sir John Pender suffered a relapse last evening.

Cable Interruptions :—	Date of Interruption.
Puerto Plata—Martinique	December 19, 1895
Aden—Zanzibar	March 16, 1896

Appointment Vacant.—The post of Assistant Professor of Applied Physics is vacant at the Heriott Watt College, Edinburgh. Applications must be made to the Principal at the College on or before April 2nd. Salary £125 per annum.

Erratum.—On page 678, column 1, line 41, of our issue last week, for "the first term in the expression $H + 4\pi I = B$ should become *but* an inconsiderable fraction" read "the first term in the expression $H + 4\pi I = B$ should become *not* an inconsiderable fraction."

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The National Telephone Company's Payments to the State. The amounts received by the State during the past five financial years from the National Telephone Company are:—1890-91, £44,007; 1891-92, £50,403; 1892-93, £57,620; 1893-94, £65,443; 1894-95, £72,693—a total of £290,166.

New Edition.—We have received an early copy of the syllabus of Vol. I. of the new (third) edition of "Electric Lighting and Power Distribution," by Mr. W. Perren Maycock, M.I.E.E. The work will be in two volumes, the first of which is to be published by Messrs. Whittaker and Co. soon after Easter.

Iron and Steel Institute.—The autumn meeting of the Iron and Steel Institute will be held this year at Bilbao. For the service of members wishing to attend the meeting a P. and O. steamer will be detailed, and the vessel will be used as a floating hotel during the stay in Bilbao. Visits will be made to iron mines and iron and steel works in the neighbourhood.

Flywheel Accidents in America.—With reference to our reproduction of an article from an American contemporary, tracing the cause of the Albany accident to a compound-wound dynamo having motored, Mr. Mordey has pointed out to us that the explanation is only correct for the case of compound machines connected parallel at the brushes only—that if the brushes are properly connected as well as the terminals an accident cannot occur in the way described.

Traction Currents in Houses.—On Tuesday morning last week considerable damage was done to house wiring in the suburbs of Hamburg by the accidental switching on of the tramway current at 520 volts pressure on to the electric light mains. Several fires occurred in consequence of the short circuits produced in the fittings and in casings. Where fittings were adapted for gas and electric light the current burned through the gas-pipes and set the gas on fire.

Electric Motors in Workshops.—At a meeting of the Manchester Association of Engineers on Saturday, the 21st inst., Mr. Daniel Adamson read a Paper on "Electric Driving," in which he detailed his experience of electric motors for driving cranes and other machinery. Mr. Adams testified to the superior economy and convenience of this method of driving, which has been extensively used at Messrs. Daniel Adamson and Co.'s engineering works at Hyde.

Cost of American Power Stations.—In an article on "Electric Power Stations," in the current issue of *Cassier's Magazine*, Mr. C. J. Field gives the following figures as the average cost per kilowatt of a 5,000-kilowatt power station:—Steam plant, including engines, boilers, pumps, heaters, condensers, piping, &c., £17; electric plant, including generators, switchboards, cables, &c., £6; power station, building under average building conditions of good foundations and no rock excavation, including foundations, buildings, stack, &c., £3; sundries, £2. These make a total of £28 per kilowatt, exclusive of real estate.

Merchant Venturers' Technical College.—Mr. Arnold Philip, B.Sc., has been selected for appointment as Professor of Electrical Engineering and Applied Physics in this College, in place of Prof. W. Wilson, M.A., who will shortly vacate the chair in consequence of his appointment to the post of Principal of the Salford Municipal Technical School. Prof. Philip received his early training in the laboratories of the Royal College of Science, and subsequently studied electrical engineering at the City and Guilds of London Central Technical College. He at present holds the post of Assistant-Professor of Applied Physics and Electrical Engineering at the Heriot Watt College, Edinburgh.

Pacific Cable Schemes.—The Ottawa correspondent of *The Times*, under date March 24th, states that advices received by the steamer Warrimoo to the effect that the Hawaiian Government have refused the application of Mr. Audley Coote for exclusive landing rights on the Hawaiian Islands for the proposed Americo-Japanese cable. Mr. Coote assured the Hawaiian Government that capital had been secured in Japan with which to construct the line immediately. He asked to be delegated to represent Hawaii in concluding a contract with Japanese principals on the basis of a draft contract submitted. This proposal was also declined by the Hawaiian Government as being beyond their power.

Expiring Patents.—On Sunday next, the 29th inst., will expire patent No. 1,516 of 1882, granted to the Société Anonyme des Cables Électriques (Système Berthoud, Borel et Cie.) for "An Improved Manufacture of Material for Electrical Insulation." The invention relates to the "manufacture of material for electrical insulation, consisting of linseed oil converted into a solid elastic body by the application of heat, with or without admixture of colophonium."——On Friday next, the 3rd. prox., will expire patent No. 1,614 of 1882, granted to Edward Weston for "Improvements in Magnets or Dynamo Electric Machines." The claims are for (1) "An armature wound with two or more independent continuous conductors, the adjacent sections of which are connected to alternate segments of the commutator"; and (2) "a cylindrical or annular armature core having grooves or recesses for the reception of the coils, and two or more independent continuous conductors wound therein, in combination with a commutator to whose segments the said coils are alternately connected."——On Friday next, the 3rd prox., will also expire patent No. 1,619 of 1882, granted to Hiram S. Maxim for "Improvements in the Manufacture of Carbon Conductors for Electric Lamps and in Apparatus Therefor." The invention relates to a process for manufacturing carbon filaments from plastic carbonisable substances by means of a carbon press cylinder and a die of centrally perforated stationary block and adjustable plates or slides, arranged to vary the aperture through which the material is expelled.

Röntgeniana.—The following addendum to Lord Kelvin's letter, which appeared on p. 702 of our last issue, arrived too late for insertion:—

Dr. Macintyre, of Glasgow, tells me that he finds platino-cyanide of potassium better in respect to colour than the platino-cyanide of barium mentioned in Röntgen's original Paper. He finds, however, that both salts give satisfactory pictures, visible instantly to the eye. It is well understood, of course, that both in Röntgen's original work and in trials and developments of it by others, it is only for recording results that photographs are necessary. Dr. Macintyre has constructed an arrangement for use in the Royal Infirmary of Glasgow by which already in his own house he has examined bones of patients suffering from disease. A young friend of mine, not troubled with any illness, was allowed to see the bones of his own foot without taking his boot off.

——Mr. A. A. Campbell Swinton will give a lecture in the Governor's Hall of St. Thomas's Hospital on Tuesday next on X-rays. Tickets can be obtained at the hospital, and the proceeds of their sale will be devoted to the Special Appeal Fund.—An interesting Paper was read before the Falcon Works Engineering Society, on the 18th inst., by Mr. E. H. Cozens-Hardy (student of the Brush Company), on "Röntgen Rays," in which, besides illustrating the subject by numerous lantern slides of very high quality, taken by himself and Mr. L. Cumming, of Rugby School, including one of the bones of the foot of a mummy, he also showed that he had made a close study of the subject since its first appearance before the world, and far from confining himself to merely following in the path of others, his Paper bore evidence of considerable independent research. Amongst other interesting points, he drew attention to the fact that the bulb of the Crookes tube, although containing no carbon, blackens in a similar way to that of an incandescent lamp, with this interesting difference, that the blackening takes place only in front of the cathode disc; whereas, on the contrary, on that part of the bulb behind the cathode disc a gradual whitening of the glass goes on; the tube, moreover, during the time that it is excited becomes distinctly positively electrified behind the cathode disc, and negatively so in front. The author also drew attention to experiments he had made by means of photographing coins placed at different angles to the tube and at different distances from the plate, which, after careful measurements, demonstrated that the source of the rays was at the inclined anode disc of the Crookes tube. He also stated that he had discharged a gold leaf electroscope at about 6ft. distance by means of the Crookes tube, a wooden partition wall intervening. A candle flame was found to be quite transparent to X-rays, and a possible trace of double refraction was found with the use of a rhomb of calcite.—An interesting letter from Prof. G. M. Minchin will be found in our Correspondence columns.

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ELECTROMAGNETIC THEORY.—LXXXIV.*

BY OLIVER HEAVISIDE.

(*Continued from page 578.*)

§ 336. The next thing to be done is to show how the Bessel solutions in general are generated by waves. This was done before in the case of a uniform cable, leading to Fourier series. We take a source at a point, and construct the double wave it generates, going to right and left. Then we add on, one after another, terms representing the reflected waves generated at the terminals by the incident first waves and their successors and overlappers. The complete set of waves, when in operational form, makes a geometric series, which, when summed, expresses the operational solution in condensed form. Conversion to series of normal functions then follows by the expansion theorem. So we prove that the series of waves and the series in terms of normal functions are equivalent.

To do this for the Bessel series is not a useless mathematical complication, but is of fundamental importance, both from the physical and the mathematical side. From the physical side because in Maxwell's theory all disturbances of electric or magnetic force are propagated at a speed v settled by the inductivity and permittivity, which property is not interfered with by the simultaneous existence of conductivity (electric or magnetic). All solutions involving change are, therefore, ultimately of wave nature. This is also true when, by artificial restrictions, we make v be infinite. In such limiting cases we do not see any succession of waves in time, for they are made simultaneous, but there is no essential difference in the principle. The waves are there, all the same. Also, from the mathematical side, the question is important in casting light upon the connection between the two kinds of Bessel formulæ, the convergent and the divergent.

The wave analysis and synthesis is nearly as easily done for the Bessel waves of m^{th} order as for the zeroth, and is made plainer by the extension. Therefore, let

$$-\frac{dV}{dx}=\frac{Z}{x^n}C, \qquad -\frac{dC}{dx}=Yx^nV, \tag{1}$$

be the circuital connections of voltage and current, Y and Z being preferentially $K+Sp$ and $R+Lp$, so that the resistance and inductance per unit length of circuit vary as x^{-n}, and the leakage and permittance as x^n. The characteristic of V is

$$\frac{1}{x^n}\frac{d}{dx}x^n\frac{dV}{dx}=q^2V, \quad \text{or} \quad \frac{d^2V}{dx^2}+\frac{n}{x}\frac{dV}{dx}=q^2V, \tag{2}$$

where $q^2=YZ$.

This is the theory of the propagation of plane waves in a medium whose specific properties vary as the n^{th} or $-n^{\text{th}}$ power of the distance from a fixed plane; or of cylindrical waves when the variation is as the $(n-1)^{\text{th}}$ power, and so on to other dimensions. But n is not restricted to be an integer; it may be fractional if we like.

The first step is to find the wave operators. Let

$$H_m(qx)=\left(\frac{2}{\pi qx}\right)^{\frac{1}{2}}\epsilon^{qx}\left\{1+\frac{1^2-4m^2}{\lfloor 1\ 8qx}+\frac{(1^2-4m^2)(3^2-4m^2)}{\lfloor 2\ (8qx)^2}+\dots\right\}, \tag{3}$$

$$K_m(qx)=\left(\frac{2}{\pi qx}\right)^{\frac{1}{2}}\epsilon^{-qx}\left\{1-\frac{1^2-4m^2}{\lfloor 1\ 8qx}+\frac{(1^2-4m^2)(3^2-4m^2)}{\lfloor 2\ (8qx)^2}-\dots\right\}, \tag{4}$$

These are to define the functions H and K. It may be readily tested that $x^{-m}H_m(qx)$ and $x^{-m}K_m(qx)$ satisfy the characteristic (2), provided $n=1+2m$, or $m=\frac{1}{2}(n-1)$.

Now H and K are divergent series, that is, when qx is numerical. They are, nevertheless, actually the fundamental Bessel formulæ, because they are the wave generators. It is not difficult to see this. Suppose there is no waste of energy by resistance. Then $q=p/v$, and ϵ^{qx} is a mere translation operator, turning t to $t+x/v$ in any time function on which it works. Similarly ϵ^{-qx} turns t to $t-x/v$. Therefore, by § 276, the H operator belongs to an inward wave, and the K operator to an outward wave, if there is nothing else to interfere with this property. Now, in the case of a homogeneous medium $n=0$, and $m=-\frac{1}{2}$. Then H is simply proportional to ϵ^{qx} and K to ϵ^{-qx}, indicating propagation at constant speed without distortion. In other cases, H is $\epsilon^{qx}F$, and K is $\epsilon^{-qx}G$, where F, G are as in (3). The translation is still done by the exponential operators, but the operand is altered first by F or G. So these operators do the distortion, or deformation of the waves.

When there is resistance, q is not p/v. But the exponential operators may still be reduced to $\epsilon^{px/v}f$ and $\epsilon^{-px/v}g$, when f and g are other operators also concerned in producing distortion. Thus, from the fundamental fact that disturbances travel at speed v, the forms of H and K prove that they are the wave operators, H for an inward, and K for an outward wave. If this general reasoning is not convincing, I may add that the algebrisation of (3), (4) with an operand added is quite easily effected in various simple cases (and the extension to the general case is only a matter of complication) with the results as above described. Some cases will be given in Chap. VII.

Having settled this point, use H and K to show the primary waves generated by a source. Let there be a source h at y. Then

$$V_1=\frac{\pi}{4}Zh\frac{H_{mx}}{x^m}\frac{K_{my}}{y^m}, \qquad V_2=\frac{\pi}{4}Zh\frac{H_{my}}{y^m}\frac{K_{mx}}{x^m}, \tag{5}$$

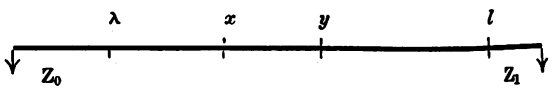
show the waves, V_1 to the left of y, and V_2 to the right. To prove this, note first that the proper operators containing x are used for the waves. Next, that $V_1=V_2$ at y. Thirdly, that $C_2-C_1=h$ at y. The last is done by the conjugate property of the H, K functions, which is

$$(HK'-H'K)_x=-\frac{4}{\pi x}, \tag{6}$$

if the accent means differentiation to x.

In (5) the operand is h, which may be any function of the time, but if we take it to be constant, beginning at the moment $t=0$, then V_1 and V_2 represent waves of V starting from y at that moment, and travelling to right and left at speed v.

§ 337. If there are no terminal impositions—that is, if the characteristic is valid (except at the source) all the way from $x=0$ to ∞, the V_2 wave goes on to infinity. But the V_1 wave, when it reaches the origin, generates a reflected wave, which also travels out to infinity. There are no more waves than these. But should there be a boundary on the right of y, say at l, both the outward waves, primary and secondary,



generate reflected waves there, and both these inward waves generate outward waves when they reach the origin, and so on for ever. It is the same when the origin is not in question, but the place of inner reflection is at $x=\lambda$, on the left of x and y. It is now easy to construct the wave series.

Let $x=\lambda$ and l be the boundaries, and the point x where V is wanted be on the left side of the source h at y. The first wave is

$$v_1=\frac{\pi}{4}Zh\frac{K_{my}}{y^m}\frac{H_{mx}}{x^m}, \tag{7}$$

by the first of (5). Put $x=\lambda$ to produce its value at λ. Multiply by a reflection coefficient, say a', to produce the value of the reflected wave at the same place. Then multiply by $(x^{-m}K_{mx})/(\lambda^{-m}K_{m\lambda})$ to express the reflected wave at any point, because this operator is 1 at λ, and has the right x function in it. The result is

$$v_2=\frac{\pi}{4}Zh\frac{K_{my}}{y^m}\left(a'\frac{H_{m\lambda}}{K_{m\lambda}}\right)\frac{K_{mx}}{x^m}=\frac{\pi}{4}Zh\frac{K_{my}}{y^m}a_1\frac{K_{mx}}{x^m}, \tag{8}$$

if a_1 is the operator in the brackets.

Put $x=l$ to give the value of v_2 at l. Then multiply by a reflection coefficient, say b', to give the value at the same place of the third (inward wave) generated by v_2. Finally, multiply by $(x^{-m}H_{mx})/(l^{-m}H_{ml})$ to produce the complete third wave anywhere. The result is

$$v_3=v_1\left(a'\frac{H_{m\lambda}}{K_{m\lambda}}\right)\left(b'\frac{K_{ml}}{H_{ml}}\right)=v_1a_1b_1, \tag{9}$$

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if b_1 is the operator in the second brackets. After this, it is the same over and over again. Thus,

$$v_4 = v_2 a_1 b_1, \quad v_5 = v_3 a_1 b_1, \quad v_6 = v_4 a_1 b_1, \quad \&c. \tag{10}$$

The sum of all these waves is

$$\Sigma v = \frac{v_1 + v_2}{1 - a_1 b_1}, \tag{11}$$

which expresses V at x (less than y), so far as it arises from v_1.

But there is also the initial wave to the right to be considered. It does nothing at x itself directly, but only by reflection at l. Initially the primary wave is the V_2 in (5). Put $x = l$, and multiply by $b'(x^{-m}H_{mx})/(l^{-m}H_{ml})$, to produce the first inward reflected wave, say w_1, which can act at x. It is

$$w_1 = \frac{\pi}{4} Zh \frac{H_{my}}{y^m} b_1 \frac{H_{mx}}{x^m}. \tag{12}$$

After this it is to be treated in the same way as v_1 was, for both v_1 and w_1 are inward waves. Therefore

$$w_2 = \frac{\pi}{4} Zh \frac{H_{my}}{y^m} b_1 a_1 \frac{K_{mx}}{x^m} \tag{12A}$$

is the next outward wave, and the rest are

$$w_3 = w_1 a_1 b_1, \quad w_4 = w_2 a_1 b_1, \quad w_5 = w_3 a_1 b_1, \quad \&c., \tag{13}$$

Consequently the sum of the w waves is

$$\Sigma w = \frac{w_1 + w_2}{1 - a_1 b_1}, \tag{14}$$

and the complete V_1 at x is $\Sigma v + \Sigma w$; that is

$$V_1 = \frac{\frac{1}{4}\pi Zh}{1 - a_1 b_1} \left(\frac{H_{mx}}{x^m} + a_1 \frac{K_{mx}}{x^m} \right) \left(\frac{K_{my}}{y^m} + b_1 \frac{H_{my}}{y^m} \right). \tag{15}$$

It only remains to find a_1 and b_1, or a' and b', the reflection coefficients. Let $V = Z_1 C$ at l, and consider any outward wave and the reflected wave superposed. They are represented by

$$\frac{K_{mx}}{x^m} + b_1 \frac{H_{mx}}{x^m}, \tag{16}$$

multiplied by a factor not containing x. The corresponding currents are

$$\frac{x^{m+1} q}{Z} \left(K_{m+1,x} - b_1 H_{m+1,x} \right), \tag{17}$$

by the first of (1), and using these properties of the functions,

$$\frac{1}{q} \frac{d}{dx} \frac{H_m}{x^m} = \frac{H_{m+1}}{x^m}, \quad \frac{1}{q} \frac{d}{dx} \frac{K_m}{x^m} = -\frac{K_{m+1}}{x^m}, \tag{18}$$

which are easily verified by the definition of H and K above. The ratio of (16) to (17) is therefore Z_1 when $x = l$. So

$$Z_1 = \frac{K_{ml} + b_1 H_{ml}}{(l^n q/Z)(K_{m+1} - b_1 H_{m+1})}, \tag{19}$$

and therefore

$$b_1 = \frac{-K_{ml} + BK_{m+1,l}}{H_{ml} + BH_{m+1,l}}, \quad \text{if} \quad B = \frac{l^n Z_1 q}{Z}. \tag{20}$$

In a similar manner, let $V = -Z_0 C$ be the condition at the other boundary λ, then we shall find by the proper change of symbols that

$$a_1 = \frac{-H_{m\lambda} + AH_{m+1,\lambda}}{K_{m\lambda} + AK_{m+1,\lambda}}, \quad \text{if} \quad A = \frac{\lambda^n Z_0 q}{Z}. \tag{21}$$

We may therefore write (15) symmetrically thus:—

$$V_1 = \frac{\pi Zh}{4x^m y^m} \frac{(H_{mx} + aK_{mx})(H_{my} + bK_{my})}{b - a}, \tag{22}$$

where a stands for a_1 as in (21), and b for the reciprocal of b_1 in (20), so that a is derived from b by turning l to λ and Z_1 to $-Z_0$. We have only to interchange x and y to obtain V_2 on the right side of the source, and the results are explicit in terms of the terminal resistance operators. They are derived entirely from the initial waves from the source, by the addition of the reflected waves. The divergent series are therefore essential to a proper understanding of the matter.

§ 338. Now consider a radically different way of viewing the subject. Besides the divergent series there are convergent series satisfying the characteristic. Thus $x^{-m} I_{mx}$ and $x^{-m} I_{-mx}$ are convergent solutions of the characteristic (2), if

$$I_m(qx) = \frac{(\frac{1}{2}qx)^m}{\underline{|0}\,\underline{|m}} + \frac{(\frac{1}{2}qx)^{m+2}}{\underline{|1}\,\underline{|m+1}} + \frac{(\frac{1}{2}qx)^{m+4}}{\underline{|2}\,\underline{|m+2}} + \ldots, \tag{23}$$

and I_{-mx} or $I_{-m}(qx)$ is got by turning m to $-m$. These I functions are always finite at the origin when m is positive or zero, and infinite when m is negative. It follows that

$$V_1 = \frac{I_{mx} + rI_{-mx}}{x^m} A_1, \quad V_2 = \frac{I_{mx} + sI_{-mx}}{x^m} B_1, \tag{24}$$

are general solutions, and represent V on left and right of a source h provided r, s, A_1 and B_1 are properly found.

First, $V_1 = V_2$ at y, the place of the source h, makes

$$B_1 = \frac{I_{my} + rI_{-my}}{I_{my} + sI_{-my}} A_1, \tag{25}$$

so B_1 is eliminated. Next, A_1 is to be found by $C_2 - C_1 = h$ at y. Now the C's corresponding to (24) are

$$C_1 = -\frac{q}{Z} x^{m+1} (I_{m+1,x} + rI_{-m-1,x}) A_1,$$

$$C_2 = -\frac{q}{Z} x^{m+1} (I_{m+1,x} + sI_{-m-1,x}) B_1, \tag{26}$$

because

$$\frac{1}{q} \frac{d}{dx} \frac{I_m}{x^m} = \frac{I_{m+1}}{x^m}, \quad \frac{1}{q} \frac{d}{dx} \frac{I_{-m}}{x^m} = \frac{I_{-m-1}}{x^m}, \tag{27}$$

as may be quickly tested by the series (23). So, applying the h condition just mentioned, we find

$$A_1 = \frac{hZ(I_m + sI_{-m})}{qy^{m+1}(r-s)(I_m I_{-m-1} - I_{-m} I_{m+1})} \tag{28}$$

at the point y. In the denominator a conjugate property is involved of voltage and current, in the manner of § 331, and the value of the quantity in the second brackets in the denominator is easily seen to be $x^{-1} \times$ constant. To find the constant, use the series (23), writing down the first terms of I_m, I_{-m-1}, &c.; and pick out the terms involving x^{-1}. There is only one. The result is

$$I_m I_{-m-1} - I_{-m} I_{m+1} = \frac{2}{qx\,\underline{|m}\,\underline{|-m-1}} = -\frac{2}{\pi qx} \sin m\pi, \tag{29}$$

because

$$\underline{|-m} = -\underline{m}\,\underline{|-m-1}, \quad \text{and} \quad \underline{|m}\,\underline{|-m} = \frac{m\pi}{\sin m\pi} \tag{30}$$

are elementary properties of the $\underline{|m}$ function, which we shall come across again in Chapter VII., to be there proved. Thus

$$A_1 = \frac{\frac{1}{2}\pi Zh}{y^m} \cdot \frac{I_{my} + sI_{-my}}{(s-r)\sin m\pi}, \tag{31}$$

and therefore, finally,

$$V_1 = \tfrac{1}{2}\pi Zh \frac{(I_{mx} + rI_{-mx})(I_{my} + sI_{-my})}{x^m y^m (s-r)\sin m\pi}, \tag{32}$$

in a symmetrical form, is another way of expressing V_1. If we determine s and r by the same terminal conditions as before, namely $V = Z_1 C$ at l, and $V = -Z_0 C$ at λ, we find

$$s = -\frac{I_{ml} + BI_{m+1,l}}{I_{-ml} + BI_{-m-1,l}}, \quad r = \frac{-I_{m\lambda} + AI_{m+1,\lambda}}{I_{-m\lambda} - AI_{-m-1,\lambda}}; \tag{33}$$

where A and B are as before, (20) and (21) above. So now the solution is, like the old one, explicit in terms of the terminal operators.

§ 339. We have thus, in (22) and (32), obtained two entirely different forms of solution of the same problem. In one way we built it up with the primary waves and their reflections—and it is certainly right (barring possible working errors). The other way ignores waves altogether, or indeed any sort of elementary component solutions, but is entirely operational, using formulæ which are convergent, when numerical. But the form (32) may be expanded by the expansion theorem into a series of normal functions of the subsiding or vibrating kind. We may therefore for the present regard (32) as representing this normal expansion, in the same way as we may regard (22) as representing the series of waves, for every wave given in operational form may be algebrised if we like. We

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therefore prove the strict equivalence of the series of normal solutions and the series of waves, arising out of (32) and (22) respectively.

But, besides that, we may regard the investigations algebraically and numerically. For q may be a positive constant, namely, when $Z=R$ and $Y=K$. It is then the steady state due to h that is in question throughout, which is instantly assumed when h varies, because the speed v is infinite, and there are no time differentiations concerned in the various operators, which become constants or functions of x. So we prove the numerical equivalence of (22) and (32), when qx is positive number, apart from their equivalence as operational formulæ. What are then the relations between the divergent functions H, K and the convergent functions I_m and I_{-m}? They are involved in (22) and (32) of course, but it is not clear at first how they are to be exhibited. We must either rearrange (32) to show identically the same form as (22), or else the other way. But a trial with the sum and difference of I_m and I_{-m} used in (22) shows the way. Thus, keeping entirely to (22) at present, let

$$H_{mx}=I_{mx}+I_{-mx}, \qquad K_{mx}=\frac{I_{-mx}-I_{mx}}{\sin m\pi}. \tag{34}$$

These are merely to define H and K, without present reference to the former meanings. Then (32) becomes

$$V_1=\frac{\frac{1}{2}\pi Zh}{x^n y^m(s-r)\sin m\pi}\{\tfrac{1}{2}(1+r)H_{mx}+\tfrac{1}{2}(r-1)\sin m\pi\, K_{mx}\} \times\{\tfrac{1}{2}(1+s)H_{my}+\tfrac{1}{2}(s-1)\sin m\pi\, K_{my}\}, \tag{35}$$

which is expressible as

$$V_1=\frac{\frac{1}{2}\pi Zh}{x^n y^m}\frac{(H_{mx}+aK_{mx})(H_{my}+bK_{my})}{(s-r)\dfrac{4\sin m\pi}{(1+r)(1+s)}}, \tag{36}$$

if

$$a=\frac{r-1}{r+1}\sin m\pi, \qquad b=\frac{s-1}{s+1}\sin m\pi, \tag{37}$$

in the numerator of (36). Here r and s are given in (33) according to which (37) become

$$a=\frac{-H_{m\lambda}+AH_{m+1,\lambda}}{K_{m\lambda}+AK_{m+1,\lambda}}, \qquad b=-\frac{H_{ml}+BH_{m+1,l}}{K_{ml}-BK_{m+1,l}}. \tag{38}$$

Next, there is the denominator in (36). Putting it in terms of a and b in (37), we find its value is $2(b-a)$. So

$$V_1=\frac{\frac{1}{4}\pi Zh}{x^m y^m}\frac{(H_{mx}+aK_{mx})(H_{my}+bK_{my})}{b-a}. \tag{39}$$

This being merely a modification of (32), compare it with (22). They are identical; for the present a, b given by (38) are identical with the a, b of the divergent investigation, viz., a_1 in (21) and the reciprocal of b_1 in (20). But in (22), H and K are defined by the divergent series, whilst in (39) they are defined in terms of the convergent series, through (34). It follows apparently that (34) express the equivalence between the divergent and convergent formulæ.

But it is not a rigorous proof. For there is just this possibility in a proof by comparison. However improbable it may be, it is possible (unless proved to be impossible) for some other combination of the functions I_m and I_{-m} to behave in the same way as regards reducing (32) to identically the form (22). If it did, we should soon find out something anomalous by the impossibilities which would arise on further pursuit. However, I may mention here that in Part 3 of my Paper on "Operators in Physical Mathematics" (May, 1894), I have given an investigation which transforms the I_m and I_{-m} functions to H_m and K_m functions according to (34). It is an entirely different process to the above, effecting the transformation by algebra alone, without any differentiations or integrations. Of this I will give some account in Chapter VII.

The above suggested ambiguity does occur. For if we put $H_m=2I_m$ instead of I_m+I_{-m}, and still use the second of (34), we shall arrive at the same result, equation (39).

Going further, if we use

$$I_m=\rho H_m+\sigma\sin m\pi\, K_m, \tag{40}$$

leaving ρ and σ arbitrary, in place of the first of (34), still using the second, the result is that the right member of (39) is multiplied by 2ρ, so we require $\rho=\frac{1}{2}$ to harmonise the convergent and divergent formula. As for σ, it does not appear in the result at all, so it looks at first as if it were indeterminate, and that

$$H_m=2I_m-2\sigma\sin m\pi\, K_m, \tag{41}$$

with any value of σ. But there is another consideration. The last formula must not contradict the second of (34). Now H_m and K_m are even functions of m, so the last equation makes

$$H_m=2I_{-m}+2\sigma\sin m\pi\,.\,K_m. \tag{42}$$

By addition, we obtain the first relation in (34); and by subtraction the second relation, provided $\sigma=-\frac{1}{2}$, and only then. So the matter is made square.

But I have previously given an investigation which covers the case of integrality of m. I have shown that the operational solution of a certain physical problem, when algebrised in one way leads to the convergent form of the zeroth Bessel function, and in another way leads to the divergent form; thus, $H_0=2I_0$. Now, given a Bessel function of any order, all those differing from it in order by an integer may, as is known, be derived by complete differentiations, as in (18) and (27) above. Therefore $H_m=2I_m$, when m is any integer.

To see what the rigorous mathematicians have to say on this matter, I have referred to the latest treatise (Gray and Mathews). On p. 68, equation (142) is a result given, which, allowing for the difference in notation, harmonises with the second of (34). But the other result given, equation (143), is discordant. It is equivalent to $H_{mx}=2I_{mx}$ in my notation, and is therefore true only when m is an integer, in which case the functions I_m and I_{-m} become identical, as (23) shows. No proof is given in either case.

As regards the algebraical transformation from the divergent to the convergent series, it goes thus. Let

$$B_m(qx,r)=\ldots+\frac{(\frac{1}{2}qx)^{m+2r-2}}{\underline{|m+r-1}\,\underline{|r-1}}+\frac{(\frac{1}{2}qx)^{m+2r}}{\underline{|m+r}\,\underline{|r}} +\frac{(\frac{1}{2}qx)^{m+2r+2}}{\underline{|m+r+1}\,\underline{|r+1}}+\ldots. \tag{43}$$

This B_m function is the generalised Bessel function of the m^{th} order. In it, r is any number positive or negative. If we increase r by 1 it reproduces itself, so it is a periodic function of r. The series is to be continued both ways, unless it stops.

Now in the H, K formulæ, put for ϵ^{qx} and ϵ^{-qx} the following generalised expressions,

$$\epsilon^{qx}=\ldots+\frac{(qx)^{r-1}}{\underline{|r-1}}+\frac{(qx)^r}{\underline{|r}}+\frac{(qx)^{r+1}}{\underline{|r+1}}+\ldots, \tag{44}$$

$$\epsilon^{-qx}\cos r\pi=\ldots-\frac{(qx)^{r-1}}{\underline{|r-1}}+\frac{(qx)^r}{\underline{|r}}-\frac{(qx)^{r+1}}{\underline{|r+1}}+\ldots, \tag{45}$$

where r is as before. In (44) the signs are all +; in (45) they are alternately + and −. On performing the multiplications, the H, K functions are turned into B functions according to the following:—

$$B_m(qx,r)=\tfrac{1}{2}H_m(qx)-\tfrac{1}{2}K_m(qx)\sin\pi(m+2r). \tag{46}$$

Change the sign of m to obtain a second formula. The two formulæ then give H_m and K_m in terms of B_m and B_{-m}.

When r is zero or any integer, B_m reduces to I_m, and we obtain (34) above. In the generalised formulæ (43) to (46), qx should be a real positive quantity, except in special cases.

The identity of I_m and I_{-m} when m is integral, makes the second of (34) assume the 0/0 form. Then take the limit. Thus,

$$K_{mx}=-\frac{1}{\pi}\frac{1}{\cos m\pi}\left(\frac{dI_{mx}}{dm}-\frac{dI_{-mx}}{dm}\right), \tag{47}$$

when m is integral. Or, by (23),

$$-K_{mx}\cos m\pi=\frac{1}{\pi}\left\{2I_{mx}\log\frac{qx}{2}+\frac{(\frac{1}{2}qx)^m f'(m)}{\underline{|0}}+\frac{(\frac{1}{2}qx)^{m+2}f'(m+1)}{\underline{|1}} +\frac{(\frac{1}{2}qx)^{-m}f'(-m)}{\underline{|0}}+\frac{(\frac{1}{2}qx)^{-m+2}f'(-m+1)}{\underline{|1}}+\ldots\right\}, \tag{48}$$

if $f(m)=(\underline{|m})^{-1}$ and $f'(m)$ is its derivative. The convergent formula before given for K_{0x} is a special case of this. The general case presents no difficulty, but requires $f(m)$ to be explained, which belongs to Chapter VII., along with related matters concerning the development of wave formulæ.

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The reader should be cautioned against concluding that equivalence, as of a divergent and a convergent formula, means identity. The fact that they are different shows that they are not alike in *all* respects, and cannot be interchanged under *all* circumstances. I am inclined to think that this is true even when the equivalence exists between two convergent formulæ of different types, in fact, what rigorous mathematicians call an identity. Or there may be equivalence when the argument is real, but not when it is imaginary or even negative. The extent to which equivalence persists is an interesting matter, but is better observed in the practical concrete examples than theorised about upon incomplete data. Experience and experiment must precede theory.

(To be continued.)

THEORY AND CALCULATIONS OF ASYNCHRONOUS ALTERNATE CURRENT MOTORS.

BY A. HEYLAND (BUDAPEST).

(Continued from page 653).

We will explain the connection between A_1, A_2, A_3, da_1, da_2, with the aid of Fig. 13. We have demonstrated, equations (31), (32B), (33A), that

A_1 varies as $\sin x$
da_1 ,, I_1^2, proportional to $(1-\cos x)$
da_2 ,, I_2^2 ,, $(1-\cos x)$; hence also
(da_1+da_2) ,, $(1-\cos x)$.

The relation existing between $\sin x$ and $(1-\cos x)$ can easily be exemplified with the help of rectangular co-ordinates. With

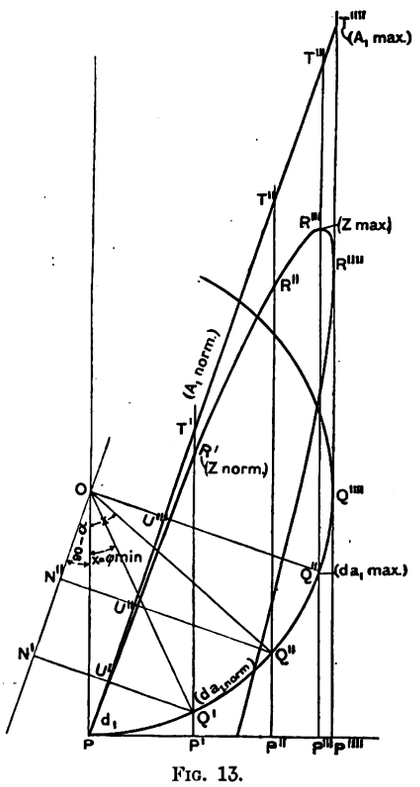

FIG. 13.

radius 1, we describe a circle which passes through the origin, its centre lying on the ordinate, (Fig. 13). If a point moves on this circle, starting from the origin, through the angle x, the abscissa of this point will always be $= \sin x = (PP', PP'' \ldots)$, and the ordinate $= 1-\cos x = (P'Q', P''Q'' \ldots)$. We can now choose the radius of this circle such that the lengths $P'Q', P''Q''$ become equal to the respective da_1 of varying loads. The corresponding A_1 is then proportional to $\sin x$, the abscissa, and can be represented in magnitude by the ordinate of a straight line $P\,T'T''$, which passes through the origin under a certain inclination to the abscissa. We have

$A_1 = P'T', P''T'', \ldots$ proportional to $P'Q', P''Q'' \ldots = \sin x$.

The inclination of this straight line can be found from the conditions of normal load, for which the losses are prescribed. We express these losses at normal power in per cents. of the energy absorbed

$$\frac{da_{1\,\text{norm}}}{A_{1\,\text{norm}}} = \epsilon_1, \qquad \frac{da_{2\,\text{norm}}}{A_{1\,\text{norm}}} = \epsilon_2,$$

$$\therefore \quad \frac{da_{1\,\text{norm}} + da_{2\,\text{norm}}}{A_{1\,\text{norm}}} = \epsilon_1 + \epsilon_2$$

For the normal load x is $\phi_{\min}$. Let this case be marked in Fig. 13 by point Q', so that angle $P\,O\,Q' = \phi_{\min}$. Then $P'Q'$ shall be $da_{1\,\text{norm}}$, and $P'T' = A_{1\,\text{norm}}$, therefore $\frac{P'Q'}{P'T'} = \frac{da_{1\,\text{norm}}}{A_{1\,\text{norm}}} = \epsilon_1$.

We know that $\frac{P'Q'}{PP'} = \frac{1-\cos x}{\sin x}$. If the straight line is inclined at the angle $P'\,P\,T' = a_1$, then $\tan a_1 = \frac{P'T'}{PP'} = \frac{1-\cos x}{\epsilon_1 \sin x} = \frac{1-\cos(\phi_{\min})}{\epsilon_1 \sin(\phi_{\min})} = \frac{\sqrt{1-\cos(\phi_{\min})}}{\epsilon_1\sqrt{1+\cos(\phi_{\min})}}$, and since $\cos(\phi_{\min}) = f$ we find

$$\tan a_1 = \frac{\sqrt{1-f}}{\epsilon_1\sqrt{1+f}}. \quad \ldots\ldots \quad (43)$$

For varying loads, we have

$$A_1 = P'T', P''T'', P'''T''', \ldots.$$

and, in accordance,

$$da_1 = P'Q', P''Q'', P'''Q''', \ldots.$$

$$A_2 = A_1 - da_1 = Q'T', Q''T'', Q'''T''' ; \ldots.$$

or, when we measure off from $T', T'' \ldots, T'R', T''R'' = P'Q', P''Q''$,

$$A_2 = P'R', P''R'', P'''R'''. \ldots$$

A_2 is proportional to the torque Z; the curve $P\,R'\,R''\,R'''$ is, therefore, the torque curve as dependent upon A_1. This curve is, as may easily be shown, an ellipse, and we obtain the important result: *The interdependence between the torque and the work expended is represented by an ellipse.* The torque, we have established, grows with the primary work, but at a slower rate, attains its maximum before A_1 has reached its maximum at R''' in the diagram, and diminishes rapidly.

In order to determine the ratio $\frac{\text{maximum}}{\text{normal}}$ torque $= \frac{Z_{\max}}{Z_{\text{norm}}}$, we draw from $Q'\,Q''\,Q'''$ perpendiculars $Q'U', Q''U'' \ldots$ to $P\,T'$. These projectors measure the variations of the torque, since

$$Q'U' : Q''U'' : Q'''U''' = Q'T' : Q''T'' : Q'''T'''.$$

The maximum is $Q'''U'''$; it corresponds to $Z_{\max}$, and the production of $Q'''T'''$ passes through the centre O. $Q'U'$ denotes normal conditions, corresponding to Z_{norm}.

The ratio $\frac{Z_{\max}}{Z_{\text{norm}}}$ is therefore $= \frac{Q'''U'''}{Q'U'}$.

A parallel to $P'T'$ drawn through O gives us the intersections $N'N'' \ldots$ and we have $\frac{Q'''U'''}{Q'U'} = \frac{Q'''O - OU'''}{Q'N' - N'U'}$.

Further, taking the radius of the circle as unity,

$$\frac{Z_{\max}}{Z_{\text{norm}}} = \frac{Q'''O - OU'''}{Q'N' - N'U'} = \frac{1-\cos a_1}{\cos(a_1 - \phi_{\min}) - \cos a_1}$$

$$= \frac{\sqrt{1+\tan^2 a_1} - 1}{\cos(\phi_{\min}) + \tan a_1 \sin(\phi_{\min}) - 1} \ldots$$

Now, $\tan a_1 = \frac{1}{\epsilon_1}\sqrt{\frac{1-f}{1+f}}$ (43), $\cos(\phi_{\min}) = f$;

hence $$\frac{Z_{\max}}{Z_{\text{norm}}} = \frac{\sqrt{\frac{1-f}{1+f} + \epsilon_1^2} - \epsilon_1}{(1-f)(1-\epsilon_1)}, \quad \ldots \quad (44)$$

or approximately, $$\frac{Z_{\max}}{Z_{\text{norm}}} = \frac{\sqrt{\frac{1-f}{1+f}} - \epsilon_1}{(1-f)(1-\epsilon_1)} \quad \ldots \quad (44A)$$

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The ratio $\frac{\text{maximum}}{\text{normal}}$ power: $\frac{L_{max}}{L_{norm}} = \frac{A_{3\,max}}{A_{3\,norm}}$ can be developed in the same manner, $A_3 = A_1 - (d a_1 + d a_2)$; we substitute $d a_1 + d a$ for $d a_1$, and consequently $\epsilon_1 + \epsilon_2$ for ϵ_1. The inclination of the straight line P T' be now α,

$$\tan \alpha = \frac{\sqrt{\frac{1-f}{1+f}}}{\epsilon_1 + \epsilon_2}. \quad . \quad . \quad . \quad . \quad . \quad (45)$$

Then

$$\frac{L_{max}}{L_{norm}} = \frac{\sqrt{\frac{1-f}{1+f} - (\epsilon_1 + \epsilon_2)^2} - (\epsilon_1 + \epsilon_2)}{(1-f)\{1-(\epsilon_1+\epsilon_2)\}}. \quad . \quad . \quad (46)$$

The dependence of these two ratios $\frac{Z_{norm}}{Z_{max}}$ and $\frac{L_{max}}{L_{norm}}$ upon f is graphically plotted in Fig. 16*; ϵ_1 has been taken equal $\epsilon_2 = 5$ per cent. The curves show that the capacity for taking any excess of load increases with increasing f at a quicker rate than f, but that the internal losses counteract this increase.

If the internal resistances should vanish, the curves $\frac{Z_{max}}{Z_{norm}}$ and $\frac{L_{max}}{L_{norm}}$ would pass into the curve $\frac{A_{1\,max}}{A_{1\,norm}} = \frac{1}{\sqrt{1-f^2}}$, (37).

The capacity for taking higher loads is augmented by diminishing the internal resistance; the limit is given by

$$\lim_{(\epsilon_1=0)} \frac{Z_{max}}{Z_{norm}} = \lim_{\substack{(\epsilon_1=0)\\(\epsilon_2=0)}} \frac{L_{max}}{L_{norm}} = \frac{1}{\sqrt{1-f^2}}. \quad . \quad (47)$$

The maximum slip which corresponds to the maximum torque is determined by the equations:

$$\frac{S_{max}}{S_{norm}} = \frac{d a_{2\,max}}{A_{2\,max}} \cdot \frac{A_{2\,norm}}{d a_{2\,norm}} = \frac{A_{2\,norm} \cdot d a_{2\,max}}{A_{2\,max} \cdot d a_{2\,norm}}$$

$$= \frac{\cos(a_1 - \phi_{min}) - \cos a_1}{1 - \cos a_1} \cdot \frac{1 - \cos a_1}{1 - \cos(\phi_{min})}$$

$$= \cos a_1 \left(\tan a_1 \cdot \frac{\sin(\phi_{min})}{1 - \cos(\phi_{min})} - 1 \right).$$

Substituting $\tan a_1 = \frac{\sqrt{\frac{1-f}{1+f}}}{\epsilon_1}$, (43), and $\cos(\phi_{min}) = f$, we finally arrive at

$$\frac{S_{max}}{S_{norm}} = \frac{1-\epsilon_1}{\sqrt{\frac{1-f}{1+f} + \epsilon_1^2}}. \quad . \quad . \quad . \quad . \quad (48)$$

If we neglect ϵ_1^2 under the root, $\frac{S_{max}}{S_{norm}} = (1-\epsilon_1)\sqrt{\frac{1+f}{1-f}}$. (48a)

The curve resembles the curve of equation (36) $\frac{I_{1\,norm}}{I_{1\,no\,load}} = \sqrt{\frac{1+f}{1-f}}$; the factor $(1-\epsilon_1)$ is absent in the latter case.

V.—*The torque Z, as dependent upon the slip S and the resistance of the short-circuit coils W_2.*

We have established: $Z = A_2$; $S = \frac{d a_2}{A_2} = \frac{d a_2}{Z}$;

$$\therefore \quad Z S = d a_2,$$

and (Fig. 13) $Z = A_2 = \frac{\sqrt{\frac{1-f}{1+f}}}{\epsilon_1} \cdot \sin x - (1 - \cos x)$.

$$Z S = d a_2 = \frac{I_2^2 W_2}{I_1^2 W_1}(1 - \cos x);$$

again, equation (34), $Z S = f \frac{W_2}{W_1}(1 - \cos x)$.

By eliminating x from these two equations, we find

$$Z = \frac{\frac{2(1-f)}{f(1+f)\epsilon_1^2} \cdot \frac{W_1}{W_2} \cdot S.}{1 + \frac{2}{f}\frac{W_1}{W_2} S + \frac{(1+f)\epsilon_1^2 + 1}{f^2} \cdot \frac{W_1^2}{W_2^2} S^2}. \quad . \quad . \quad (49)$$

* For Fig. 16, see p. 652 of our issue of the 13th inst.—ED. *E.*

As we only wish to inquire into the variations of Z, we may divide the expression by the constant $\frac{2(1-f)}{f(1+f)\epsilon_1^2}$, which yields

$$Z = \frac{\frac{W_1}{W_2} S}{1 + \frac{2}{f}\frac{W_1}{W_2} S + \frac{(1+f)\epsilon_1^2 + 1}{f^2} \cdot \frac{W_1^2}{W_2^2} S^2}. \quad . \quad . \quad (50)$$

ϵ_1^2 being exceedingly small, the fraction $\frac{1-f}{(1+f)\epsilon_1^2}$ is so large that we are justified in omitting $+1$, whereupon

$$Z = \frac{\frac{W_1}{W_2} S}{1 + \frac{2}{f}\frac{W_1}{W_2} S + \frac{1-f}{(1+f)f^2\epsilon_1^2} \cdot \frac{W_1^2}{W_2^2} S^2}.^* \quad . \quad (50A)$$

This equation (50A) gives a curve as plotted in Fig. 14. For $S = 0$ the curve vanishes; for S_{norm} it gives Z_{norm}; for that S which we have designated as S_{max}, Z likewise reaches its maximum; for higher S the curve descends again. To which

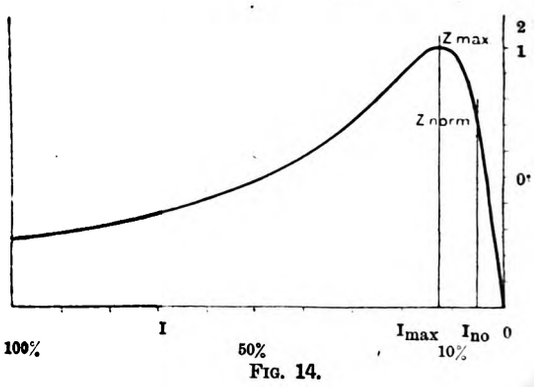

FIG. 14.

value of S the maximum of Z corresponds, can be ascertained by differentiating equation (50), taking S as variable, and setting the differential equal to zero. It will result that

$$Z_{max} \text{ for } S_{max} = f \epsilon_1 \sqrt{\frac{1+f}{1-f}} \frac{W_2}{W_1}, \quad . \quad . \quad (50b)$$

and if we consider that

$$S_{norm} = \frac{d a_{2\,norm}}{A_{2\,norm}} = \frac{d a_{2\,norm}}{A_{1\,norm}} \cdot \frac{A_{1\,norm}}{A_{2\,norm}} = \epsilon_2 \cdot \frac{1}{1-\epsilon_1},$$

we obtain: $\frac{S_{max}}{S_{norm}} = (1-\epsilon_1)\sqrt{\frac{1+f}{1-f}} \cdot f \cdot \frac{W_2}{W_1} \cdot \frac{e_1}{e_2}$.

According to (34)

$$f \frac{W_2}{W_1} = \frac{I_2^2 W_2}{I_1^2 W_1} = \frac{\epsilon_2}{\epsilon_1};$$

therefore: $\frac{S_{max}}{S_{norm}} = (1-\epsilon_1)\sqrt{\frac{1+f}{1-f}}$,

which is the same equation as (48) with ϵ_1^2 neglected as exceedingiy small.

* The relations between torque and slip have recently been very simply deduced by Rothert (*Electrotechnishe Zeitschrift*, Heft. 45, p. 705); in assuming the main field as constant for all loads. By neglecting the decrease of the field with the load in the above equation of the form

$$Z = \frac{aS}{1 + bS + cS^2}$$

the term bS disappears, and we then have

$$Z = \frac{aS}{1 + cS^2}.$$

It is of interest to compare these two equations for the purely theoretical case of no leakage. Then the term with S^2 disappears also, and Rothert's relation

$$Z = \frac{aS}{1 + cS^2} \quad \text{becomes} \quad Z = aS \text{ (straight line)},$$

whilst my relation

$$Z = \frac{aS}{1 + bS + cS^2} \text{ becomes } Z = \frac{aS}{1 + bS}.$$

This is a curve of the same characteristic as Fröhlich's curve of magnetisation.

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If we consider both S and W_2 as variable, denoting the latter by w_2, we may write

$$Z = \frac{W_1 \frac{S}{w_2}}{1 + \frac{2 W_1}{f}\frac{S}{w_2} + \frac{(1-f) W_1^2 S^2}{(1+f) f^2 \epsilon_1^2 w_2}} \quad . \quad . \quad . \quad (51)$$

in which Z appears as function of $\frac{S}{w_2}$.

The curves of equations (50A), (51) have the same characteristics. So far as Z_{norm} and Z_{max} are concerned, we can refer to Fig. 15. Z becomes a maximum when $\frac{dZ}{d\left(\frac{S}{w_2}\right)} = 0$, in which case

$$\frac{S}{w_2} = \frac{f \epsilon_1 \sqrt{1+f}}{W_1 \sqrt{1-f}} \quad . \quad . \quad . \quad . \quad . \quad (51A)$$

It follows, therefore, that any torque may be developed at any slip, provided w_2 be changed in accordance.

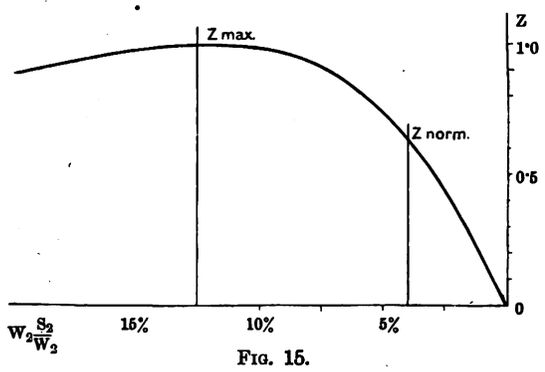

FIG. 15.

If w_2 is changed inversely as S, then the same torque will result for any slip. The normal torque can be obtained for any slip if we add to the armature resistance W_2 an external resistance w_2, such that

$$\frac{w_2 + W_2}{W_2} = \frac{S}{S_{norm}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (52)$$

The maximum torque will then be secured if

$$\frac{w_2 + W_2}{W_2} = \frac{S}{S_{max}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (53)$$

The rule concerning *starting resistance* of the short-circuit armature may hence be stated thus :—

If the motor in starting (slip S = 1) is to develop maximum torque, the starting resistance should be

$$w_2 = W_2 \frac{1 - S_{max}}{S_{max}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (54)$$

If the torque is to be normal,

$$w_2 = W_2 \frac{1 - S_{norm}}{S_{norm}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (55)$$

The starting resistance w_2 should be subdivided at equal intervals.

The motor will, at starting, first develop the normal torque. When we cut out resistance, the torque increases to Z_{max}. When the motor is running the torque will decrease and accommodate itself to the load; the starting resistances can then be cut out successively.

(To be continued.)

THE CLASSIFICATION OF PHYSICAL EXPERIMENTS.

BY E. E. FOURNIER-D'ALBE.

A physical experiment may be defined as the determination of a physical property of a body, or as the investigation of its behaviour under certain well-defined conditions. In accordance with these two definitions two main classes of experiments may be distinguished. Determinations of the dimensions, capacity, weight, density and other normal properties of a body, or the length of a luminous, sonorous or electromagnetic wave, belong to the first class, and would more appropriately be called observations. In every experiment, properly so-called, a body is exposed to a certain test, and its behaviour or reaction is observed and (if possible) measured. Hence we must distinguish three essential elements in every experiment: the body to be experimented upon; the test, action, or circumstance to which it is exposed; and the change or reaction which results. In other words, in our examination of natural phenomena, we must specify the subject, the question and the answer.

Now, a little consideration will show that there are a certain limited number of these elements, viz., bodies, tests, and reactions, and that if these are sorted and arranged in order, it becomes possible to analyse every experiment into its characteristic elements, and to take something like the same step in physics as has already been taken in chemistry, crystallography, and dimensional formulæ by the introduction of symbols. Of these, it will most closely resemble the crystallographic systems of notation, being more qualitative than quantitative, and on that account more comprehensive and less rigorous than chemical formulæ. The object of the present Paper is to specify the characteristic types of experimental elements, and to find a simple and comprehensive classification and notation for the various physical experiments. I believe that this will facilitate the cataloguing of physical researches so far as they have proceeded; the description and survey of the work now being published, by means of symbols capable of international use; and the discovery of gaps in the series of physical investitions which remain yet to be filled up.

1. *Subjects.*—The following are the bodies or things which may form subjects of investigation: Solid, liquid, gas, jet or stream, field ("lines of force"), wave system and ether. Jets or streams may be water jets, flames, liquids or gases flowing through tubes, brush discharges, or such "rays" as are not as yet reduced to wave systems. Fields of force may be gravitational, electric, or magnetic. Wave systems may be gravitational (*e.g.*, water waves), sonorous, or electromagnetic. The last include radiant heat, light and possibly other kinds of radiation recently discovered.

2. *Tests.*—A body may be set in motion or vibration; it may be acted upon by statical force; it may be exposed to a stream, a field, or a wave system; and, finally, energy of various kinds may be imparted to it. The motion may be translational or rotational, or both; the force may be that of compression, tension, shear, or torsion; the vibration may be longitudinal, transverse, or axial: and, finally, the energy may be one of the nine types known—viz., gravitational, elastic, thermal, chemical, luminous, electric, magnetic, acoustic, or kinetic.

3. *Reactions.*—As a result of the experiment, the body may take up any kind of motion, vibration or strain; it may offer resistance, which again may be molar (inertia), molecular (friction), electric or magnetic. It may give rise to a wave system, a stream or a field of force; or it may produce any of the types of energy enumerated. It may transmit, reflect, deviate, absorb or transform a stream, wave system, or supply of energy. It may lead to diffraction, interference, concentration and dissipation or discharge.

Proposed Notation.—It is proposed to use capital and small letters of the Roman alphabet, and some Greek letters, to denote the elements enumerated. These should be chosen so as to agree as much as possible with existing usage, and to give some mnemonic clue to their meaning. Symbols like L length, M mass, T time, F force, H field, R resistance, V potential, and N frequency, are retained, as also *d* difference, *c* constant, *n* number, *p* pressure, *q* quantity, *s* surface, *v* volume, and *t* temperature, while other symbols are immediately suggested by current associations.

The following is a list of the symbols proposed :—

Subjects.

B, body (in general).	J, jet.
S, solid.	H, field.
Q, liquid.	U, undulation (wave system).
G, gas.	X, ether.

Intermediate states of aggregation may be denoted by suitably combining the above symbols, as Q^s for a fused solid, G^Q for a vapour, $(Q+S)^Q$ for a solution, $S = Q$ for a melting solid, $G^Q = Q$ for a condensing vapour, and so forth.

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The shape of a body may be described by indicating its chief dimensions, using l for a body whose only dimension considered at the time is its length, s for a surface, and v for a solid. Thus, a wire or thread will be denoted by S l, a liquid surface or film by Q s, or an enclosed volume of gas by G v. A closed ring or circuit may be represented by S l^c, a hollow (open) tube by S l^o, and we shall then also have such symbols as Q s^c for a bubble, and S s^o for an open vessel.

Tests.

F, force.
- F p, compression.
- F x, tension.
- F y, shear.
- F z, torsion, twist.

K, motion.
- K x, translation.
- K z, rotation.

O, oscillation, vibration.

H, J, U, as before.

E, energy.
- γ, gravitational.
- σ, elastic.
- θ, thermal.
- χ, chemical.
- λ, luminous.
- ϵ, electric.
- μ, magnetic.
- τ, acoustic.
- κ, kinetic.
- ω, rotational.

As in the case of force, O x, U x, L x will denote a longitudinal vibration, wave and dimension respectively, O y, U y a transverse and O z, U z an axial or central (elliptic or circular) vibration and wave, while L y may denote breadth and L z thickness

Reactions.

R, resistance.
- R M, inertia.
- R m, friction (molecular).
- R ϵ, "resistance."
- R μ, "reluctance."

W, strain (elastic).
- W p, compression.
- W x, extension.
- W y, shear.
- W z, twist.

K, O, U, E, J, H, as before.

Reactions upon U, E, or H:
- e, emission.
- o, transmission.
- r, reflection.
- a, deviation, refraction.
- b, absorption.
- f, transformation.
- u, resonance.
- i, interference.
- j, dissipation, discharge.
- k, concentration, convergence

General Symbols.

- L, length.
- M, mass, molar.
- T, time.
- A, angle.
- Z, sense organ.
- N, frequency.
- n, number.
- q, quantity.
- d, difference.
- c, constancy, constant.
- h, intensity.
- m, molecular.
- p, pressure.
- t, temperature.
- w, vacuum.

I here add, for reference, an alphabetical list of the symbols appropriated, which will also show what letters are still available.

A, angle.	a, deflection.	α
B, body.	b, absorption.	β
C, cohesion.	c, constant.	γ gravitational.
D, rupture.	d, difference.	δ
E, energy.	e, emission, generation.	ϵ electric.
F, force.		ζ
G, gas.	f, transformation.	η
H, field.	g, = "g."	θ thermal.
I,	h, intensity.	ι
J, jet, stream.	i, interference.	κ kinetic.
K, motion.	j, discharge.	λ luminous.
L, length.	k, concentration.	μ magnetic.
M, mass.	l, long.	ν
N, frequency.	m, molecular.	ξ
O, vibration.	n, number.	o
P,	o, transmission.	π = "π."
Q, liquid.	p, pressure.	ς
R, resistance.	q, quantity.	σ elastic.
S, solid.	r, reflection.	τ acoustic.
T, time.	s, surface.	υ
U, wave system.	t, temperature.	ϕ
V, potential.	u, resonance.	χ chemical.
W, strain.	v, volume.	ψ
X, ether.	w, vacuum.	ω rotational.
Y,	x, longitudinal.	
Z, sense organ.	y, transverse.	
	z, axial, central.	

Method of Using the Notation.

The body or subject is put down first, then the test, and lastly the reaction. The three are separated by full stops. Thus, in the determination of Young's modulus of elasticity for a wire, the subject is a wire S l, the test a tensile stress F x, and the result an elastic extension W x. The total experiment is represented by the formula S l . F x . W x. If the ductility of the wire is to be measured, the reaction will be a permanent extension, d L c, and if the tenacity of the wire is to be found, the notation will be S l . F x . D.

To take another example. In saccharimetry the body operated upon is a solution $(Q+S)^q$, the test applied is a beam of polarised light U λy, and the reaction is the rotation or twist of the plane of polarisation about the axis, A z. Hence the formula $(Q+S)^q$. U λy . A z. If we wish to denote that the amount of sugar is the final object of the measurement, we may put in M S (mass of the solid) as a secondary result, separated by a comma, thus: $(Q+S)^q$. U λy . A z, MS.

Similarly, a body may be exposed to several simultaneous actions, which may be indicated in the same manner. Thus the pitch of a stretched string which is made to vibrate transversely would be determined by the experiment S l . F x, O y . N.

When simple measurements (observations) are made the result will be a simple number, n, and the test can, as a rule, be expressed by the symbols already in vogue for dimensional formulæ. Thus we have for the measurement of lengths B . L . n, of densities B . M L^{-3} . n, temperatures B . t . n, and barometric pressures G . p . n.

In some experiments the sense organ plays the most important part. In colour experiments we have U λ . d N . d Z λ, and in music U τ . d N . d Z τ or n U τ . $\frac{N_1}{N_2}$, Z τ—*i.e.*, the effect of a change or ratio of pitches upon the eye or ear.

I may now proceed to give a list of the usual laboratory experiments with their symbolic notation.

Simple Measurements.

Length	B . L . n	Thermometry	B . t . n
Diameter	B . L y . n	Barometry	G . p . n
Thickness	B s . L z . n	Capillarity	Q s . C . n
Area	s . L^2 . n	Wave length	U . L . n
Volume	B . L^3 . n	Angle of prism	So . A . n
Capacity	S s^c . L^3 . n	Photometry	U λ . h . n
Density	B . M L^{-3} . n	Field intensity	H . h . n

Mechanical Properties.

Weight	B . H γ . F	Ductility	S . F x . d L c
Moment of inertia	B . K z . R M	Viscosity	Q . F y . R m
Elasticity	S . F x . W x	Compressibility	Q . p . dv
Tenacity	S . F x . D	Boyle's law	G . dp . dv

Heat.

Expansion—		Latent heat—	
Linear	S . dt . d L	Melting	S = Q . E θ . b
Cubical	B . dt . dv	Boiling	Q = G . E θ . b
Conduction	B . E θ . R θ	Dew point	G^q = Q . t . n
Connection	B . E θ . J,	Vapour pressure	G^q . p . n
Specific heat	B . d E θ . dt	Radiation	B . E θ . e
Freezing point	Q = S t . n	Transmission	B . U θ . o
Melting point	S = Q . t . n	Reflection	B . U θ . r
Boiling point	Q = G . t . n	Absorption	B . U θ . b

Sound.

Velocity	Bo . E τ . L T^{-1}	Refraction	B . U τ . a
Pitch	B . O τ . N	Interference	U τ . U τ . i
Reflection	B s . U τ . r	Resonance	B . U τ . O u

Vibration of Strings.

Law of lengths	S $l\sigma$. d L . O y, d N
„ densities	S $l\sigma$. d M L^{-3} . O y, d N
„ diameters	S $l\sigma$. d L y . O y, d N
„ tensions	S $l\sigma$. d F . O y, d N

Light.

Photometry	E λ . h . n	Polarisation—	
Reflection	U λ . s . r	By reflection	U λz . r . U λy
Refraction	U λ . Bo . a	By transmission	U λs . b . U λy
Dispersion	U λ . d L . da	Saccharimetry	Q + Q^s . U ly . As
Spectroscopy	U λ . Bo, a . L		
Interference	U λ . U λ . i		

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Magnetism.

Field intensity ... $H\mu . h . n$	Permeability (Ewing)—
Magnetic moment $S\mu . h$, $L . n$	By magneto-meter ..... $Sl\mu . dH . dh$
Hysteresis..... $S\mu . d\mu . Eb$	By ballistic galv. $Sl^c\mu . dH . dh$

Electrostatics.

Electrification—	Diff. Potential ... $2B . dV\epsilon . n$
By friction ..... $2B . Rm . E\epsilon$	Capacity ..... $2B . dV\epsilon . E\epsilon$
By induction ... $B . H\epsilon . E\epsilon$	Sp. ind. capacity $B . dV\epsilon . E\epsilon$
Attraction ..... $2B . E\epsilon . Fx$	Discharge..... $2B . dV\epsilon . j$
Repulsion..... $2B . E\epsilon . Fp$	

Electromagnetics.

Galvanometer ... $Sl^c . j\epsilon\mu . H\mu$	Current induction ... $Sl^c . dH\mu . E\epsilon\mu$
E.M.F..... $(S+Q)^c . E\chi . dV\epsilon$	Thermo-electricity $2B^c . dt . E\epsilon\mu$
Resistance. $Sl^c . J\epsilon\mu . R$	Self-induction ..... $Sl^c . dj\epsilon\mu . R$
Impedance $Sl^c . O\epsilon\mu . R$	
Electro-dynamics. $2Sl^c . j\epsilon\mu . F$	

A few words may now be added on the present state of physical research and its future development, with reference to some peculiarities which have been brought to light by the application of the above system of notation.

Taking the simple symbols as enumerated, the various combinations of them give a large number of types of experiments, some of which have been performed, while others have only, as yet, been very imperfectly dealt with, or not at all. A rough computation of the total number of possible experiments gives 3,200 as a result, eliminating those which are obviously contradictory or futile. Out of these it may be very roughly estimated that between 2,000 and 2,500 have been performed, and their results published, and that about 1,000 experiments remain to be tried. It must, of course, be remembered that all mixtures of subjects and tests are excluded, and also that other subjects and tests may be discovered besides those enumerated.

With regard to the tendency of modern physical experimentation, it may be pointed out that the conceptions expressed by H, U, and X have only in recent times been strictly formulated, and that such things as a rotating magnetic field $H\mu . Kz$ (Ferraris), a rotating electric field $H\epsilon . Kz$ (Arnò), and longitudinal light, $U\lambda x$, have only been heard of within the last few years. The human mind progresses in the direction of dealing with intangible conceptions as material realities, and it may be expected that "fields" and "wave systems" will more and more take the place of "material" bodies at rest or in motion.

Among experiments yet to be performed, I shall only mention a few by way of illustration, leaving their detailed enumeration to a future occasion.

The transformation of energy from one type to another is being gradually carried through all its 72 variations; but the following are as yet only in a very primitive stage :—

$U\epsilon\mu . f . E\chi$	electromagnetic (waves) into chemical energy.
$E\tau . f . \theta$	heating by sound.
$E\tau . f . \lambda$	sound into light.
$E\tau . f . \chi$	"tonography" (analogue of photography).
$E\tau . f . \kappa$	motion by sound.
$E\epsilon . f . \gamma$	"levitation" by electricity.
$E\lambda . f . \kappa$	motion by light (radiometer).
$E\mu . f . \chi$	magneto chemistry.

There are many simultaneous tests which remain to be applied, such as B. F, $U\lambda . W$ effect of illumination upon elasticity. But of all the known types of energy, sound energy is most neglected. Even the measurement of its intensity $E\tau . h . n$ has hardly been attempted yet.

In the immediate future it may, of course, be expected that the greatest share of novelty in discoveries will fall to electromagnetic waves and vacuum phenomena, but problems concerning transformations of energy will always be of paramount importance to science in its practical application.

THE ECONOMICAL CURRENT DENSITY FOR ELECTRIC LIGHT MAINS.

BY JAMES WHITCHER, A.INST.E.E.

In the practical application of Lord Kelvin's well-known law for the most economical current density for electrical distributing mains, several interesting questions arise, involving points of doubt and difficulty that have considerable influence on the result. It is here proposed to discuss these points, particularly as they affect the design of distributing systems for electric lighting. Broadly stated, the law asserts that the most economically efficient conductor for a given purpose, all working and capital charges duly considered, is one in which the annual waste of energy is equal in value to the annual charges upon that part of its capital cost that is directly proportional to its sectional area. It is easily established mathematically, thus :—

Take c = required current in amperes.
a = sectional area of conductor in square inches.
0·045 = resistance of 1 mile of 1 sq. in. copper conductor, laid.
D = the economical current density in amperes per square inch.
v = value of energy per kilowatt-hour in pence.

For the cost of the conductor it is necessary to obtain some relation expressing how it varies with respect to the sectional area. Practically, the cost of copper is directly proportional to a, and the cost of insulation, protection and laying may generally, with fair approximation, be divided into two parts, one in the same simple proportion to a, the other independent of it. Assuming this correct, we have, if p and q be two constants—

P = $pa+q$ = cost in £ per mile of conductor, laid.
s = sum of rates per cent. per annum of interest, maintenance, and depreciation charges on same.

Though the price P may not conform closely to the simple linear relation over a wide range, it may still be considered to do so within limits, the value of the constants being suitably chosen for each limiting interval, on the same principle by which parts of a curve may be taken as practically coincident with tangents at each part. This point will be treated of more fully later on.

Proceeding to equate for the minimum value for the sum in £ of the annual expenses of the conductor per mile, we have, for a constant current flowing for n hours per annum :—

$$A = 0{\cdot}0000001875\, v c^2 \frac{n}{a} + 0{\cdot}01\, s\,(p\,a+q), \quad . \quad . \quad (1)$$

$$\frac{dA}{da} = 0 = 0{\cdot}01\, s\, p - 0{\cdot}0000001875\, c^2 v \frac{n}{a^2}, \quad . \quad . \quad (2)$$

Whence the first term in the equation for A must equal the second, neglecting q, when the conductor is worked at its most economical load : which is the relation the law indicates ; and

$$D = c/a = 400\,\sqrt{s\,p\,/3\,v\,n}. \quad . \quad . \quad . \quad . \quad (3)$$

This is very simple, but looking deeper, one sees that in actual practice the quantities are more interdependent than they are here supposed to be. For instance, increase of conductor loss means increase of generator plant, and v is a very complex quantity depending considerably on the capital charges of the undertaking. It is evident that the meaning of v in these equations is not the usual average or mean cost per kilowatt hour ; it is instead the cost of adding another kilowatt to the rate of output. It is important to remember this, for in many cases the cost of a small addition to the output may be but a small fraction of the mean generating cost under the particular circumstances. For instance, if it cost 200d. to supply at the rate of 100 kilowatts for one hour, the cost of increasing the rate to 101 kilowatts is more likely to be under ½d. extra than to be as much as the average of 2d. Since the economical density when v = ½d. works out to twice the value it has when v = 2d., the difference is of great significance.

To determine how to estimate correctly the true value to be given to v, we must examine the various components that

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make up the generating cost, and find out which of them enter also into the composition of v, and which are excluded therefrom. The generating cost comprises the following items:—

Interest and other charges on the capital cost of plant.
Labour, supervision and management expenses.
Fuel, water and stores.

The capital cost of an electric light generating station may be very fairly represented in £ by a certain constant sum plus a certain amount per kilowatt capacity of the station. Thus Prof. Robinson has given £(2,500 + 45 X) as a rough approximation to the cost of a station of X kilowatts capacity. This seems sufficient to include a fair allowance for site, buildings and spare plant. Thus, allowing an average of £9 per kilowatt for boilers, pumps and piping, £15 for steam dynamos or alternators, £3 for switchboard, &c., £1 for site, £7. 10s. for buildings, and £2 for stack, settings and flues, the total per kilowatt is £37. 10s., which, with 20 per cent. spares, amounts to £45. Generally, therefore, £45 will represent the complete cost of adding each extra kilowatt to the capacity of the generating plant. The amount of the constant sum, £2,500, or whatever it may be, has clearly no influence upon v, and it may be ignored.

On considering the second item of working cost, it is seen that a large proportion of it is essentially independent both of the output and the dimensions of the station. Three shifts of attendants must be provided, and a great part of the managing expenses must be considered as constant over wide ranges. Further, the increments are of necessity large, and made at wide intervals. Neither plant nor labour can be bought or engaged in small increments or at uniform rates, and the mode of increase or decrease must be essentially discontinuous, with very pronounced steps. Thus the rate of output during a given shift may be augmented by, say, 250 kilowatts before an extra stoker is required; by 500 kilowatts for an extra driver; and by, say, 1,000 kilowatts for an extra switchboard hand. On this liberal basis the annual cost of extra labour for additional output rate of 1,000 kilowatts for one shift per diem will approach £750; allowing £250 for extra managing charges, this becomes equivalent to £1 per kilowatt. If the duration of this same increase extended into two shifts per day, it would be £2. Now there is an element of luck here in the fact that the debt thus incurred to the labour account may not fall due for years ahead; therefore it is worth giving a hostage to fortune, and omitting, say, one-half of this charge from inclusion in v.

The rate for fuel and stores must be taken on the assumption that the stand-by and constant losses have settled down to something like their final proportion of the whole. These only appear in v in virtue of their proportionality to the capacity of the plant, which relation, for simplicity's sake, we will consider a simple one. Apart from them the cost for this item would scarcely ever exceed 0·25d.

Assembling the several items, we may write v thus:—

$$v = 108\, s_1/n + 120/n + k/n + 1/4 \quad \text{pence.}$$

Here s_1 is the percentage rate of capital charges on the generating plant. Taking the interest charge at 3·5 per cent., the sinking fund at 1·1 per cent. (to sink the capital in 42 years), and the maintenance rates to cumulate to 5·4 per cent. of the total £45, s_1 will sum up to 10 per cent. The second term (for labour) is correct only when n is less than 3,000 hours. In the third, k represents the annual cost, per kilowatt capacity of plant, of the stand-bye and constant losses; presuming that when n is 1,000 hours the approximate value of this term will be 0·25d., k will equal 250. Hence,

$$v = 1450/n + 0{\cdot}25.$$

When $n = 1{,}000$, $v = 1{\cdot}7$; when $n = 2{,}000$, $v = 1$ nearly, which illustrates how greatly it varies with n.

To fit practical conditions more accurately, the depreciation charges should not be treated as wholly constant and invariable in respect to n; for it is obvious that they would be much influenced by the number of working hours. A more appropriate convention in estimating maintenance, is to make a constant or "standing" charge, at, say, 1·4 per cent., and a "running" charge of 0·2d. per kilowatt hour per annum, which is equivalent to depreciation at the rate of 2 per cent. per 1,000 working hours. From this point of view, $v = 900/n + 0{\cdot}45$d. Thus, for most practical cases, the value of v will be somewhere between 1d. and 2d., and. 1½d. is a useful general average to take. Opportunity has been taken to discuss it thus fully because the quantity is one that enters into many practical problems besides this.

We may now proceed to examine the quantity p. It is the amount, in £ per mile, of that proportion of the cost of a 1 sq. in. conductor laid complete, which appears simply proportional to the sectional area, assuming the remainder constant. Evidently this also is a very involved quantity. In determining its limits, it may be observed that, firstly, the cost of trenching and making good is practically independent of the size of conductor. Secondly, the cost of protection, meaning the conduit, pipe, or casing enclosing the conductor, is also largely independent of its size. Thirdly, the cost of insulation depends in a great measure upon the section; and fourthly, the cost of copper is entirely dependent thereon.

With copper wire at 7d. per pound, the fourth item is £600. Inspection of makers' price-lists shows that for insulated conductors the extra cost per mile of an additional 0·01 sq. in. of section varies for various classes, makes and sizes of cables somewhat as follows:—

Single, vulcanised rubber,	braided,	5,000 megs.	£18	to £27.
,, ,,	,,	2,000 ,,	£16	to £24.
,, ,,	,,	600 ,,	£14	to £20.
Concentric ,,	,,	high insulation,	£50	to £60.
Single, lead-covered,	fibrous or paper,	low insulation,	£12	to £16.
,, ,,	,,	high ,,	£14	to £20.
Concentric ,,	,,	low ,,	£24	to £28.
,, ,,	,,	high ,,	£30	to £36.

The higher price refers to small size conductors, the lower to large sizes. The limits contain prices of most well-known makes and common sizes; but it is inevitable that there should be many exceptions and eccentricities in such figures. A general mean is about £18, or £1,800 per square inch; and since the copper alone is £600, the insulation accounts for £1,200. That is, that figure is roughly representative of the value of the variable part of the third section of the conductor cost. With the constant parts there is no need to trouble, the complete cost P not being required.

How far the cost of protection varies with the size of conductor depends upon the method employed. Taking the method of armoured mains laid in the ground direct first, we find that the amount to be added to the above figures to represent the cost of armouring varies very irregularly. The commoner values are between 10s. for large cables and £3 for small, but makers' methods of pricing the armouring are too diverse to agree with any general limits or averages. With most conduit, casing and pipe systems the cost varies very little with the size of mains. By working out examples results are found similar to the figures given for armouring —that is, the additional expense incurred on the item for protection when the sectional area is increased is at some rate between £50 to £300 per mile per added square inch of section. We may conclude that the constant p will be about £1,500 for large low-pressure mains, and £2,000 for average high-pressure mains. For heavy bare copper mains in brick culverts, according to Mr. Crompton's figures published some years ago, it would be about £700.

As regards s, the sum of the rates of capital charges on the cost of conductor, the interest and sinking fund rates will be the same as those due on the generating plant, for instance, 3·5 per cent. and 1·1 per cent. For maintenance, one must be careful not to take a fancy rate, for practically this appears to prove very small. Probably 2 to 3 per cent. will not err far from the truth either way; but, of course, as jointing is the weak point, very much depends on the number of joints on a main and the care with which they are made. This makes the average for s about 7 per cent.

In the above the supply is considered to be a constant current, maintained for a definite number of hours per annum. This meets the case of series arc lighting; for the usual parallel systems, the equations must be modified by certain multipliers.

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To determine the losses in a conductor carrying a varying current, the mean square of the current needs to be found. This is the quantity which corresponds to c^2 in the preceding; multiplied by the resistance and hours of supply per annum, it gives the annual conductor loss in watt-hours. To work out this mean from 365 daily load curves is too big a task to contemplate. However, it has been found that its most general values for electric lighting stations fall between the limits 0·04 and 0·16 of the maximum current reached. That is for a continual supply, or 8,760 hours per annum. Call the ratio t. In estimating v in this case, n means the number of hours of maximum load which would result in equivalent conductor loss. That is, $n = 8{,}760\,t$. Likewise, if we take D as the maximum current density, c as the maximum current, and n as above, the deductions already given for constant current supply apply to varying supply also.

When the current differs in various parts of the main, as in distributing mains tapped at many points, the loss depends upon the mean square of the current values at each successive section. Thus, for an evenly distributed load, where the current decreases regularly in arithmetical progression, from a maximum at the feeding point to zero at the far end, the mean square is one-third the maximum square. Therefore, if we here consider D and c to be the initial density and current, the new value of D to fit this instance will be $\sqrt{3}$ times the density appropriate if the initial current be carried the full length of conductor.

Finally, since v closely follows a law expressed by

$$v = S/n + V, \text{ or, } v = S/N\,t + V,$$

for constant currents

$$D = 400\sqrt{sp/3(S + V\,n)};$$

for varying currents,

$$\text{Max. } D = 400\sqrt{s\,p/3(S + V\,N\,t)};$$

each subject to a multiplier to give initial density if the load is distributed.

With the values for capital charges, &c., suggested above, we have practically, for high-pressure constant current mains—

$$D = 40{,}000/\sqrt{2{,}000 + n},$$

or when

$n =$	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000,
D =	800	750	675	630	600	580	525	500.

For high-pressure feeders when $n = 8{,}760$—

$$\text{Max. } D = 900/\sqrt{1 + 4{\cdot}4\,t},$$

or when						
	$t =$	0·01	0·1	0·16	0·22	0·3,
	D =	830	750	690	650	600.

For low-pressure feeders, max. $D = 800/\sqrt{1 + 4{\cdot}4\,t}$, and grades from 750 to 550 for above values of t.

For low-pressure distributors, evenly loaded (maintenance rate raised to 4·4 per cent.), max. initial $D = 1{,}500/\sqrt{1 + 4{\cdot}4\,t}$, grading from 1,400 to 1,000.

For bare copper feeders, max. D = 500 to 400. For bare copper distributors, max. initial D = 900 to 700.

The noteworthy point about these figures is the comparative constancy they show over a wide range of load-factors. Accurate estimate of the latter is of no consequence therefore. They show that the economical density is limited to a much narrower range than that given by calculations based on the arbitrary and erroneous assumption that r is a constant quantity. The feeder and distributor densities given by above methods are the average for all on the system. It may be that one feeder has a load curve, the maximum of which occurs at a different time to that of the others. The density in this feeder should be increased, and that in the others decreased, the average remaining the same. For if we have a main supplying current (from same plant) *only when* the major load is off the station, in determining the density for this main, v ought to be taken at something less $\frac{1}{2}d.$; since none of the fixed capital charges, and probably none of the labour charges, can be properly debited against it. It would be pure waste to design such a main for the same density as those for the normal load

ON TELEPHONIC DISTURBANCES CAUSED BY HIGH-VOLTAGE CURRENTS.*

BY DR. V. WIETLISBACH

(Chief Engineer of the Swiss Telegraph Department).

After a brief summary of the conflict of interests between telephone and power undertakings the author proceeds as follows:—

The injurious disturbances to telephone lines, in so far as they are traceable to the action of the electric current, may be considered under three heads:—

I. The high-voltage current may enter the low-voltage line in consequence of accidental contact with a telephone wire, or in consequence of other accidents, such as the fracture of a pole, support or wire. If the tension of the intrusive current be high, the intensity of the current may become so great as to destroy the telephone apparatus or melt the telephone conductor; or again, the latter may become so overheated as to ignite any wooden parts near it, and thereby set even large telephone stations on fire, such occurrences having already occasioned damage amounting to millions of francs.

II. When the high- or the low-voltage line is either uninsulated, or insufficiently insulated from earth, or when both lines are carried on the same poles or supports, part of the high-tension current may enter the telephone line through earth not only occasionally, *i.e.*, under exceptional circumstances, but permanently. If the high-voltage current be a perfectly constant direct current, such as, *e.g.*, that supplied from a storage battery, no effect is noticeable in the telephone except that the sensitiveness of the apparatus is somewhat impaired when the tension of the high-voltage current exceeds a certain limit. But if the high-voltage current be pulsating, which it always is where continuous current is used for driving car motors; or, again, if the high-voltage current be a single or polyphase alternating current, a humming noise is set up in the telephone apparatus, the humming being less violent in the case of a pulsating direct current, but very violent in the case of an alternating current, so that in either case telephonic communication may be rendered difficult or altogether impossible.

III. The high-voltage current affects low-voltage lines in the neighbourhood by induction, *i.e.*, to every rise and fall of the high-voltage current there is a corresponding electric wave in the telephone line, the intensity of that wave being proportional to the oscillation in the high-voltage line; in other terms, a succession of waves in one conductor is reproduced by a similar succession of waves in the other. There is an essential difference in the effect of electromagnetic and electrostatic induction. In both cases the electromotive force is proportional to the magnitude of the change in the primary, *i.e.*, the inducing current, and is governed by the reciprocal position of the lines and by the distance over which the two lines run parallel to each other.† In the case of electromagnetic induction, the intensity of the induced current set up is inversely proportional to the resistance, *i.e.*, it decreases as the length increases. On the other hand, in the case of electrostatic induction, the intensity of that current is proportional to the capacity of the affected line, and, therefore, also proportional to the length of the latter. Hence electromagnetic induction predominates, generally speaking, in short lines, and electrostatic induction in long lines, independently of the distance over which the two sets of conductors run parallel to each other.

The disturbances considered under I. may be counteracted by lead fuses inserted in the telephone line at the point where the latter enters the building, and which melt when the intrusive high-voltage current exceeds one ampere. By that means the line is interrupted, and damage to the telephone apparatus is rendered impossible. There is no difficulty in constructing safety fuses which are far more sensitive than those mentioned; but they offer no practical advantage, because they melt much too easily even in the case of very light thunderstorms, and hence only produce innumerable interruptions which greatly interfere with the regular working of the telephone service.

When the tension in the high-voltage line exceeds 500 volts, the arc which forms at the safety fuse is not immediately extinguished, and may, therefore, become even more dangerous than the high-tension current itself. In such cases special devices are necessary in order to prevent the formation of an arc or to ensure its immediate extinction when formed. To this end, the wire fuse is enclosed in long glass tubes or imbedded in sand, and no combustible materials must be kept in the immediate neighbourhood. With a view to prevent the bursting of the glass tubes or render the

* Translated by Dr. C. S. du Riche Preller. This Paper is a Report just published at Berne (*Blätter für Electrotechnik*), and was kindly communicated by Dr. Wietlisbach to the translator. The translator is of opinion that it strikingly confirms the facts and conclusions recently set forth by him in *The Electrician* (January 10, 1896, "Electric Tramways and Telephonic Disturbances"). The author uses the term "high-voltage currents" (500 volts and above) as contrasted with low-voltage telephone currents.

† [The phraseology of what follows is not so clear as could be wished, but it is a faithful rendering of the original.—ED. *E.*]

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bursting harmless, they are encased in fibrous material. When an intrusive current of sufficient amount arrives at the wire-fuse, the latter is explosively vapourized and the vapour is expelled from the glass tube. The explosion at the same time extinguishes the arc if such be formed. There are various other means of counteracting the overheating of telephone wires and apparatus; but the higher the tension the more complicated and inconvenient are the safety contrivances.

The disturbances considered under II.—*i.e.*, the humming produced in telephone apparatus by intrusive undulating or alternating currents, may be avoided by insulating the telephone line as carefully as possible from earth, as well as from any parts which may be connected with the high-voltage line. But when the tension in the latter exceeds 500 volts, that precaution is not always sufficient, the less so because, in practice, it is impossible to maintain either high- or low-voltage lines at all points and permanently in a state of perfect insulation. The practical application of both classes of currents frequently involves the necessity of installing the conductors in damp, or otherwise unfavourably situated places, business premises, &c.; and having regard to the high tension of the one class of installation and the extreme sensitiveness of the apparatus of the other, an almost infinitesimal leakage, amounting to only one millionth of the total current, suffices to produce a very marked telephonic disturbance. It is on this account that the juxtaposition of the two can be rendered bearable only by carefully insulating *both* systems from earth. It is, moreover, but fair to require that the conditions which are imposed upon one class of installation should also be made obligatory upon the other, if it be for the general and public advantage.

The telephonic disturbances most difficult to deal with are those considered under III.—*i.e.*, those due to induction. The most effectual means of combating this class of disturbance consists in doubling the telephone conductor, the two wires being placed as closely as possible to each other, and the telephone apparatus at each terminal being inserted between them.

A high-voltage line in proximity to the double telephone line will produce in each of the two wires a disturbing current which will flow to the same terminal, where both currents compensate each other; no disturbance will, therefore, be noticeable in the telephone apparatus. When the disturbing cause is not of excessive magnitude, this remedy will give satisfactory results. But when, on the other hand, the value of the disturbing current is several hundred or several thousand times greater than that of the normal telephone current, the remedy must of necessity fail. In that case corresponding precautions are required also in respect of the high-voltage line—*i.e.*, the latter must, like the telephone line, be provided with a metallic return, the two wires being placed in close proximity to each other, and requiring, moreover, a very high degree of insulation. Currents of approximately equal amount will then flow in both the high-voltage wires in opposite directions, and the same will apply to currents which are thereby induced in the telephone line, and which will, therefore, virtually neutralise each other.

Thus, in respect of the difference of induction, a twofold effect is obtained: one between the high-voltage, and another between the low-voltage wires; and it only remains to place the two lines at such a distance apart from each other as will ensure the noise being sufficiently deadened. This distance is obviously governed by the parallel length of the two lines and by the nature of the inducing high-tension current. In order to get rid of the noise altogether the two pairs of wires should, moreover, be placed in a properly-defined reciprocal position. Suppose the wires 1 and 2 to form the high-voltage circuit, and the wires 3 and 4 the low-voltage circuit, and suppose r_{13}, r_{23}, r_{14}, r_{24} to be the distances between them, the equation for reducing the inductive effect to 0 is—

$$r_{13} \times r_{24} = r_{23} \times r_{14}.$$

In practice, however, this result can only be obtained approximately. The complete metallic circuit gives satisfactory results only when the insulation is perfect at all points, and the two component parts are electrically and in every respect perfectly symmetrical. This desideratum is attainable in short telephonic lines, but to permanently maintain this perfect condition in telephone lines extending over hundreds and thousands of kilometres, is a practical and technical impossibility.

This is obvious from the following considerations: When at the terminal of a telephone line of say 500 kilometres (312 miles) in total length, a high-voltage current line runs parallel to the telephone line for a few hundred metres, a single point of defective insulation, *e.g.*, the contact with the branch of a tree at the other terminal, suffices to immediately produce along the whole telephone line a noise so marked as to render telephonic communication absolutely impossible. Nor is this all. When the noise is sufficiently violent it spreads to all the other telephone lines which use the same poles as the disturbed line for part of the total length of the latter.

When, for example, a slight defect occurs in the telephone line from Zurich to Geneva, the noise produced by a high-voltage installation, *e.g.*, the electric tramway in Zurich, spreads not only from Zurich to Geneva, but makes itself more or less felt in all lines which, for part of the distance, use the same poles. Hence the noise is perceptible also at Lausanne, Berne, Fribourg, Neuchatel, Bienne, Chaux-de-Fonds, Basle, and generally throughout the telephonic system of Western Switzerland. Under unfavourable circumstances, *i.e.*, when the noise is particularly violent, it may even, by secondary or tertiary translation, spread from the Zurich and Geneva line to the Berne and Basle line, thence to the Basle and Bienne line, and thence to the Bienne and Chaux-de-Fonds line at the points where Basle-Bienne runs parallel, not to Zurich-Geneva, but only to Berne-Basle, and again, where Bienne-Chaux-de-Fonds runs parallel only to Bienne-Basle.

This phenomenon is one of the most difficult to deal with, and is, as a rule, not sufficiently taken into account. The telephone system of Switzerland now comprises a total wire length of about 60,000 kilometres (37,500 miles),* and it is therefore obvious that the task of maintaining so large an aggregation of lines at all points in faultless condition is by no means an easy one. In many cases the only way to obtain a fairly satisfactory result is to bury the specially exposed or affected sections of a telephone line underground; but it is not worth while to incur the trouble and expense which that operation involves, unless a large number of telephone wires can be buried at the same point and at the same time.

A further remedy consists in translators, which correspond to the transformers of high-tension installations, and which connect two sections of a telephone line electrically by electromagnetic induction, but at the same time prevent the injurious effect of a fault in the line, *e.g.*, leakage to earth, abnormal resistance, &c., being transferred from one section to the other. The effective capacity is, by this means, also lessened. When, *e.g.*, the telephone sections Zurich-Berne and Berne-Geneva are connected by a translator at Berne, any leakage which may take place in Geneva does not affect the Berne-Zurich section. The efficiency of translators does not, however, exceed 90 per cent., and though they furnish a means of restricting the effect of a telephonic disturbance to a given section of the entire line, they involve, on the other hand, a loss of energy.

Other remedies, such as a differential arrangement of wires, Muller's method of running the wires, &c., can only be regarded as of minor importance; for though they may render valuable service in special cases, they are not suitable for general application.

The noise produced in the telephone by a disturbance varies, of course, greatly in degree, and depends essentially on the amount of the high-voltage current and on the parallel length of the high and low-voltage lines. Where the high-voltage line is well insulated from earth, and the wires constituting the high-voltage circuit run parallel to each other, it is, in the majority of cases, and in conjunction with the metallic return, also of the telephone line, practicable to place the two lines in juxtaposition for short distances not exceeding a few hundred metres, even in the same street. But when the parallel length extends over one kilometre or more, the noise may be distinctly observed, even though the two lines be as much as 100 metres or more apart. It would seem that the configuration of the ground, too, may exert a certain influence. When the high-voltage line, *e.g.*, that of an alternating current installation, is insufficiently insulated, or, what is worse, is connected to earth, a single crossing of the telephone line, even though it be at right angles, suffices to produce in the telephone a humming disturbance of a very marked character.

Conspicuous among high-voltage installations connected to earth are the majority of electric tramways. As a rule, these tramways are worked with continuous current, which is, however, by the motion of the motor cars converted into a pulsating one. And since the current is conveyed only by one wire, and the compensating effect of the metallic return is wanting, the telephonic disturbance is much greater in proportion. In Switzerland there is only one electric tramway which, instead of using earth, *i.e.*, the rails as return, has a complete metallic circuit constituted by two overhead wires, to wit, the Vevey Montreux-Chillon tramway. The effect of the working of this tramway upon the telephone line running along the same road is noticeable where that telephone line is only single with earth return, but the slight noise disappears almost entirely where the same telephone line has two wires.

All the other electric tramways so far constructed in Switzerland use only one conductor, which is suspended above the rails, and from which the continuous current is conveyed either by trolley wheel or by slide contact to the motors of the cars, whence it passes through the car frame and wheels to the rails, and through the latter is intended to flow back to the generator. The rails are generally imbedded in the roadway, and more especially in wet weather insulation is either defective or is wanting altogether, the insulating resistance being only 15 to 20 ohms per kilometre. Hence, a more or less large proportion of the current spreads

* This is equal to 20 kilometres (12.5 miles) per 1,000 inhabitants.—TRANSLATOR.

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through earth or straggles back to the generator by water and gas pipes, or by telephone wires, the telephone lines connected to earth being thereby subjected to the intrusion of the high-voltage tramway current. In order to obviate this, the rails should be insulated from earth as well as possible, and that might be accomplished by imbedding them in cement or asphaltum. Experience tends apparently to show that where the permanent way is imbedded in wood pavement, the loss of current is greatly mitigated.

A further means of counteracting the spreading of the high-voltage current through earth consists in insulated cables laid underground from the generator to the points of greatest load of the tramway system, and at these points connected with the rails. By this means, high differences of potential between the different sections of the tramway system are avoided. Of course, the rail joints must be such as to ensure adequate conductivity; this can be enhanced by bare copper wire. With the aid of these various expedients, it is possible to keep down the leakage of current from the rails within certain limits, while, in specially difficult or serious cases, there always remains the remedy of replacing the earth return of the telephone lines by a complete metallic circuit.

Far more difficult is it to deal with the effects of induction which latter, as already stated, is due to the continuous current, supplied from the generator becoming an undulating one owing to the motion of the cars. Two causes suggest themselves as operating to bring about this effect. One is the motor itself, during rotation of which successive pairs of commutator segments, connected to corresponding armature coils, are alternately short-circuited under the brushes. The effect produced thereby may be somewhat mitigated by increasing the number of commutator-segments which will also result in raising the noise to a higher pitch. The other cause will be found on the line itself, *i.e.*, at the point of contact of the conductor with the collector, in this case the trolley wheel. This latter is fixed to an elastic rod which, upon the car being started, assumes a vibratory motion. Moreover, the contact wire, which in this respect behaves like a drawn cord, also experiences considerable vibrations as the trolley wheel runs along its surface. Consequently, and as in the similar case of a microphone, the resistance at the point of contact undergoes a change, and the result is an undulating current. In fact, the inductive noises separately produced by the two causes referred to, *i.e.*, the motor and the trolley wheel, can be distinguished side by side in the telephone apparatus.

It is curious to note that the noises produced by different electric tramways of similar construction vary considerably in degree, and, further, that these noises are, as a rule, comparatively slight when the tramway has just been opened for traffic, and that only in the space of a few weeks do they attain an intensity which renders telephonic communication difficult. It is not clear how this gradual change takes place, if at all, in the motors; on the other hand, it may conceivably be due to the contact wire, which gradually becomes loosened at the insulators, while the supports, too, attain greater play and move more freely in consequence of the constant vibrations to which they are subjected.

That the mode of contact is also a factor in the phenomenon referred to appears probable from the further fact that the increasing intensity of the noise is observed chiefly on tramways where the current is collected from the contact wire by trolley wheels, whereas tramways using slide contact-bars or shoes experience that phenomenon in a far less degree. An important difference between the two systems consists in the circumstance that where the trolley wheel is used, the contact wire must be suspended as exactly as possible over the axis of the tramway, in order to prevent the trolley wheel jumping off the wire, whereas in the case of the slide-bar or shoe, so high a degree of accuracy is unnecessary, and the contact wire therefore requires fewer points of suspension, nor need it be drawn so tight. In the former case the elastic vibrations of the contact wire are of high frequency, and correspond to the acoustic waves perceived by the ear. In the latter case, on the other hand, the vibrations are of so low a frequency—*i.e.*, so slow—that they fall outside the range of perceptibility of the ear. The aerial crossings and bifurcations of trolley tramways involve much greater difficulty of construction than those of tramways with slide contact, and when the electrical connection or the insulation at those points is defective, such defects will likewise aid in aggravating the phenomenon referred to.

In some quarters great weight is further attached to the lubrication of the contact surface. Be that as it may, the fact is attested and confirmed that some electric tramways produce in telephone lines only slight or moderate disturbances which can easily be obviated or neutralised, whilst other electric tramways cause telephonic disturbances of so marked or violent a character that even mere crossings of telephone lines having metallic return and possessing a somewhat high capacity suffice to render telephonic communication extremely difficult.

In such cases, the only remedy is to bury the telephone lines which are in proximity to the tramway underground. Having regard to the considerable expenditure which the laying of such cables involves, it would certainly be worth while to further investigate the causes of those telephonic disturbances which may presumably be obviated by very simple means. As regards cost of construction, electric tramways which do not cause telephonic disturbances are in no way more complicated or more costly than tramways which do produce the noises referred to. It is even reasonable to presume that the wear and the cost of maintenance are less in the former than in the latter case.

Electric tramways having underground conductors will, presumably, not give rise to telephonic disturbances. On the other hand, it will not be out of place to mention one electric tramway which is now in course of construction, and which it is proposed to work with three-phase current, two of the conductors being constituted by two overhead wires, and the third conductor by the rails. In this case, it is no longer a question of an undulating current whose oscillations might possibly be mitigated by electro-mechanical means, but of a high-tension alternating current, which to the telephone lines simply means unconditional surrender. It is obvious that here the low-voltage *i.e.*, the telephone, lines will have to give up their earth return over a wide range. But the high-tension system referred to claims to be paramount even in the aërial space. Double telephone wires of low capacity are practicable only for parallel lengths of a few hundred metres; for as soon as the capacity increases, the amount of the intrusive high-tension current exceeds that of the telephone working current. Under these circumstances, the only means of rendering the regular working of the telephone service possible is to bury all the aërial telephone wires underground; only this is no longer a case of equable compromise, but of being overcome by brute force.

In dealing with telephonic disturbances, it must be borne in mind that the radius of telephonic communication from a given centre increases, in accordance with the demand of the public, from year to year. Originally it extended to a few hundred metres, then to several kilometres, whilst the radius is at present several hundred, and will soon be several thousand kilometres. With this rapid growth the strain on telephone apparatus and installations increases also as a whole, and it is no easy task to maintain them always in the required degree of efficiency. If, therefore, the working of the telephone is not to be in a great measure restricted and its efficiency impaired by the disturbances caused by high-voltage currents, these disturbances cannot be permitted to make themselves felt in telephones more than other accidental sounds or noises governed by meteorological and other conditions.

A high-voltage installation may produce a noise which *per se* has no disturbing effect on telephones, but the same telephone line may, in a length of several hundred kilometres, come in collision with 20 or more high-voltage installations, and the sum of all the disturbances produced by those installations collectively will suffice to give a death-blow to the telephone.

There is, therefore, a wide and fundamental difference between a short telephone line which only serves to connect two local points (*e.g.*, an electric generating and a motor or other service station), and a telephone installation for interurban and long-distance service. The difference between the two cases may be likened to that between a horse tramcar jogging along through a town at the rate of 8 kilometres per hour, and an international express train covering a distance of thousands of kilometres at the rate of 100 kilometres per hour.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, March 27th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read: (1) "The Electromagnetic Effect of Moving Charges," by G. W. Morton; (2) "Quantitative Measurements of the Edison Effect in Glow Lamps," by Dr. J. A. Fleming, F.R.S.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at St. James's Hall Restaurant.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "New Researches on Liquid Air," by Prof. Dewar, F.R.S.

SATURDAY, March 28th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture (VI.): "Light," by the Right Hon. Lord Rayleigh, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

3:30 p.m Students' Visit to the Metropolitan Electric Supply Company's Station. Meet at Amberley-road Station.

INSTITUTION OF JUNIOR ENGINEERS.

7:30 p.m. Conversazione at the Westminster Palace Hotel.

TUESDAY, March 31st.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read and discussed: "The Tampico Harbour Works," by Dr. E. L. Corthell.

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GOOD-FRIDAY WEEK.

"THE ELECTRICIAN" will be published on THURSDAY in Good-Friday week instead of on Friday. Communications intended for this issue must reach us not later than Wednesday morning's post.

Alterations to existing Advertisements and copy for new Advertisements should reach the Publisher on Tuesday, but in any case not later than Wednesday morning.

COMPETITION IN ELECTRIC SUPPLY.

There is nothing to equal a long bout of commercial prosperity for engendering healthy notions with regard to competition. When our competitors are being beaten out of the field it is the easiest possible thing to subscribe to the doctrine that "to be protected against competition is to be protected in idleness, in mental dulness," and to believe in the double blessedness of price-cutting. But no sooner does the tide turn than the vague but expressive phrases such as "unfair competition," "demoralising competition," become fashionable. Only yesterday it was distinctly heterodox to so much as question the unbounded beneficence of unlimited competition; to-day the pass-word is either "regulated," "potential" or "limited" competition.

Possibly it was the trend of public opinion in this direction that induced the Metropolitan Electric Supply Company just recently to fee the lawyers and fight the Charing Cross and Strand Electricity Supply Corporation. More probably the Company was actuated by the idea that to quietly condone an invasion of its huge territory would be to encourage raiders generally, and its advisers, no doubt, thought that there was a greater probability of winning a victory in Committee than of rendering the Company's position absolutely impregnable from the electro-technical point of view. It is notoriously difficult to prove a negative, and still more difficult to prove to demonstration that all a competing company is likely to do has already been done by the company in actual possession. Mr. BALFOUR BROWNE certainly did his best for his clients. His picture of the evils of competition would have been positively alarming—had it been drawn by anyone else. If all Mr. BROWNE says be true there is evidently a bad time in store for some one. "Where competition was allowed between two companies in one district it invariably resulted in the bankruptcy of one of the companies. Com-

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petition between such companies inevitably led to combination, and combination was nothing but a conspiracy against the public. If this Bill passed the result would probably be that either the Metropolitan or the Charing Cross Company would become bankrupt, and the surviving company would have to buy it up, and then charge higher prices to recoup itself." Prave ords! But as they are only the eloquent vaticinations of counsel, we will not stop to inquire too minutely how the bankruptcy which is, according to the first sentence, the invariable result of competition becomes in the second "a conspiracy against the public," and in the third a mere amalgamation. Be all this as it may, these dismal and contradictory forebodings need have no terrors for the consumer, however they may impress the timorous investor. Are not all these contingencies carefully provided for in the Provisional Order by a paternal Board of Trade?

Competition, like everything else, has its defects; but that it is bound to have one or other of the undesirable sequels prophesied by Mr. BALFOUR BROWNE we unhesitatingly deny; even in the case of competition in the business of electric supply, where the advantages of trade rivalry, at any rate under the conditions now obtaining in London, are by no means so obvious and overwhelming as they are in most instances. It is by no means a fair inference, as one witness argued it was, that any new company coming in must get its customers from the existing concern. If the supply of the company in possession be unreliable and dear, no doubt the major portion of the intruder's *clientèle* will be composed of ex-customers of the old concern; but they will not compose its entire *clientèle* even at first, and certainly not later on. And when, as in this particular instance, there is no allegation of an inferior supply at a superior price, experience has shown over and over again that the competitor gains his living at the expense of an entirely new set of customers and not necessarily at the expense of the pioneer undertaking. If London were apparently electrically saturated, the argument would have some weight, but things being as they are it savours somewhat of the doctrine of the old mercantile school of economists, who held that wealth was absolutely limited in quantity; so that one man's gain was of necessity another man's loss. Nevertheless, granting that competition in electric supply need not of necessity lead straight to bankruptcy, price-pooling, amalgamation or even to permanent loss to an existing undertaking, the arguments against the duplication of electrical undertakings all over the metropolis except in the quarters occupied by the much-favoured municipal enterprises, have considerable cogency. Except in the case of the upper ten thousand, who will under no circumstances take gas when they can obtain electricity, the competition of gas must be quite enough to keep down prices and stimulate economy. With nearly 1¼ million lamps connected to the London mains, it is tolerably evident that central stations already have to do with customers who *do* think of cost, and who would go back to gas for a sufficient consideration. That being so, it looks like blind fetish worship to harry electric light undertakings with still more competition, increasing at the same time the number of mains beneath our thoroughfares and adding to the frequency of surface upheavals. But then a Parliamentary Committee, especially if it be of the Lower House, is just the very body to be hopelessly opaque to any X-principle, although it will transmit to the end of time any principle which has been embodied in an Act of Parliament. To all such committees the last sentence of Section 1 of the Electric Lighting (Amendment) Act of 1888 is a sole and a sufficient warrant. "The grant of authority to any undertakers to supply electricity within any area, whether granted by licence or by means of a Provisional Order, shall not in any way hinder or restrict the granting of a licence or Provisional Order to the Local Authority or to any other company or person within the same area." Circumstances may alter cases. But nothing under heaven can alter the principles that guide (?) a Parliamentary Committee to its decisions, unless it be some dry document which has received Royal Assent one hot August day.

REVIEWS.

Elements of Electricity and Magnetism. By Prof. J. J. THOMSON. (Cambridge University Press.)

The study of the theories of electricity and magnetism, according to the method usually adopted by text-books, consists for the most part of statements of the results of research, both experimental and mathematical, with explanatory notes comparing the two. In books of this kind there are, it is true, portions of analysis to be found, but careful investigation reveals important gaps or assumptions in the chain of argument in places where the author has considered the complete mathematical treatment to be too complicated and above the heads of his readers. From a practical point of view this method has many advantages, affording to the reader a means of acquiring an acquaintance with the present state of our knowledge of the subject without requiring of him the power of checking for himself the accuracy of the knowledge obtained. In fact, it may be argued with some plausibility that it is no more necessary to follow carefully through the mathematical structure of some particular theory than it is to repeat the experimental work upon which it is based, and the shortness of life necessitates a certain amount of faith in the reliability of other workers.

Nevertheless, for the true student of science there is always a satisfaction in identifying for himself as far as possible the security of his foundations, and in tracing out the chain of reasoning upon which the various formulæ and theorems rest, while at the same time his power of using them under different conditions is vastly augmented. By such students Prof. Thomson's book on "The Elements of the Mathematical Theory of Electricity and Magnetism" will be much appreciated, as affording them access to ground which has been hitherto, in many cases, beyond the limits of their power or available leisure. In a book of moderate size the author has given the lines of reasoning by means of which the main structure of electrical and magnetic theory has been built up. He begins with the fundamental facts of electrostatics, and finally arrives at the theory of electromagnetic wave propagation, including on the way short discussions on side issues, such as electrolysis, thermo-electricity and alternating-current problems.

In a book originating from the Cavendish laboratory the treatment of the subject naturally follows Maxwell's system, but the reasoning is much simplified from the methods employed in that writer's famous treatise, and with the exception of a few paragraphs a knowledge of the elements of the differential and integral calculus is sufficient for the complete understanding of the text. It is indeed recognised now that avoidance of the calculus by the use of cumbrous algebraic proofs or verbal explanations renders a book not one whit more intelligible to beginners, and certainly makes it uselessly verbose and involved for everyone. Prof. Thomson has, however, introduced many simplifications in the mathematical treatment of electromagnetic theory, avoiding the complete investigation when it is only a particular case that is required. Though the book is not and does not pretend to be suitable for the casual reader, the comprehension of the methods employed should not prove more difficult than the appreciation of the results attained, and this is really the lowest needful limit of simplification.

A distinctive feature of the book is the frequent comparison of the physical aspect of a theorem with its mathematical treatment. Faraday's tubes of force and the action of the medium form the guiding principle throughout, and lead up

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to the development of electromagnetic waves and Maxwell's theory. It is essentially a treatise on physical electricity, in which mathematical analysis is called in only in so far as it is needful, and in their clear physical interpretation of analytical results these parts of the book will be found highly suggestive and interesting to mathematical readers.

The chapters on electrostatics deal with the usual theorems, Gauss's theorem being taken as the fundamental, and many of the proofs depend immediately on this. The principle of minimum potential energy is largely employed, and the energy residing in the medium is frequently examined, thus bringing the physical idea strongly to the front. In the electromagnetic theory intimate connection is kept up with the earlier parts of the book, and the identity of many of the expressions is preserved as often as possible, thereby reducing the demands upon the patience of the reader in purely mathematical portions, and correlating similar properties in electrostatics and magnetism. In the same way the distribution of electric currents falls under the same laws as those of the force in the electrostatic problem.

The chapter on dimensions and the foundations of systems of units is exceptionally clear while it is thoroughly sound. The relation of the C.G.S. system, and the derived electromagnetic and electrostatic systems, the essential and the conventional parts of each and the variations which are possible in the latter, are treated in a masterly manner. It appears that Heaviside's system has not yet been admitted as a serious rival to the present method of measurement, since there is only the slightest notice of it in this book. It must be allowed, however, that from the point of view of the orthodox mathematical treatment his improvements do not lead to any great gain in simplicity.

It may be regretted that the space occupied by ordinary text book information on batteries, electrolysis, magnetisation of iron, and a few other points, has not been more usefully employed. The modern theories built upon these phenomena have been excluded, and the main principle of the book is not aided by this information; moreover, all readers of the book would already possess this knowledge to a much more complete extent than is given by the author; while we cannot help grudging the pages devoted to these extraneous points, and wishing that they had been devoted to a fuller treatment of Hertz's work and its extensions in the last few years. A succinct and efficient account of this branch with its connection to the other parts of magnetic theory is much needed by students, and the style of the rest of the book makes us regret the loss of the opportunity.

One point only in the book calls for some question. In the otherwise very valuable chapter on alternating currents, the usual expressions for the currents in a transformer are given, with the assumptions of sinoidal curves and iron cores without hysteresis. It is well known to every one who has ever plotted the current curves of a transformer on open circuit that these expressions are not in the least like the actual curves. While such readers will not be deceived by the formulæ, it is surely desirable in a book for students to point out the serious limitations to any mathematical treatment dependent on the assumption of the constancy of μ in iron. It is especially needful in this chapter, since there is a flavour of practical application about it and frequent reference to numerical constants which suggest that the expressions are working formulæ. It may be that a closer interpretation of the facts is not at present possible, but that only places a writer under additional obligations to indicate the conventionality of the assumptions that are made.

The book is singularly free from misprints, and the diagrams are clear and useful, those of lines of force in electromagnetic and electrostatic fields of various kinds being especially worthy of note. In the lettering of quantities in analysis there are, it must be confessed, a few unnecessary ambiguities and divergences from the usual symbols employed, but there are always clear statements of the meanings of symbols (a boon to the reader which is not always conferred by some modern writers), and frequent references to earlier sections.

When the labours of Prof. Thomson, both in the field of advanced theory and of experimental work are remembered, we cannot but be grateful to him for spending his time in making a little easier to humbler workers the thorny path to the mathematical theory of electricity and magnetism.

F. G. B.

Current from the Main. By W. S. Hedley, M.D. (London: H. K. Lewis. 1896.)

The vagueness in the title of this little book throws considerable doubt, at first, upon its purpose; but when we have examined more fully its title page and contents we find that it professes to be a treatise on "the medical employment of electric lighting currents." It is as though the purchaser of a work on "Town Water Supply" should discover to his dismay that it treated only of the use of town water in making up homœopathic prescriptions. Dr. Hedley is the medical officer in charge of the electro-therapeutic department of the London Hospital; and by his official position he is in possession of valuable special information, in regard to this growing branch of medical and surgical practice. It is not generally known, even among medical practitioners, that it is a very different matter to take current from the mains, for medical or surgical work, than to use the current given by a small battery. In the former case precautions have to be observed that do not enter into consideration in the latter instance. Dr. Hedley's little work, of some 31 pages, the greater number of which have appeared in the *Lancet*, should be read by every medical practitioner who is interested in electro-therapeutics.

HIGH VOLTAGE LAMPS AND THEIR INFLUENCE ON CENTRAL STATION PRACTICE.

DISCUSSION.

The following is an abstract of the discussion which followed the reading of Mr. Addenbrooke's Paper before the Institution of of Electrical Engineers. Speakers who have returned their remarks revised have an asterisk placed against their names:—

Thursday, March 12th.

Mr. J. W. SWAN said Mr. Addenbrooke's Paper raised the question whether the time had not come when electrical engineers might arrange their plans for general electric supply on the assumption that incandescent lamps adapted to a voltage double that now in vogue would be forthcoming on demand, and whether there was good reason to believe that lamps of that kind would be as cheap and as good as the lamps for lower voltage. It was, without doubt, a question of the greatest moment whether incandescent lamps of low candle-power, and requiring a voltage of something like 200 or 220 volts, could be made to compete in point of efficiency and cost with lamps for the lower voltage now in common use. The demand for such lamps was comparatively a new demand, and as yet it was not a large one, but it was increasing, and the pressure was already sufficiently strong to compel the most strenuous efforts to meet the demand in the way it was required to be met—viz., by the supply, at a moderate cost, of a lamp for double the voltage hitherto employed, and that should have a fairly long life at a moderate efficiency. He thought that was very nearly the way in which Mr. Addenbrooke stated the question. Mr. Addenbrooke had told them that it was already possible to buy fairly good lamps of 8 and 16 c.p. to take from 200 to 250 volts. The lamps shown appeared to bear out that statement. From his own experiments he knew that it was possible not only to fulfil the very moderate requirements stated by Mr. Addenbrooke, but to go considerably beyond them, and as time went on, the difficulties which attended a new departure of that kind would undoubtedly decrease, and the result would be both increased efficiency and diminished cost. But in the meantime it must be remembered that the 220-volt 8 c.p. lamp was a more fragile thing than the 110-volt lamp of the same candle-power as at present made, and rather more costly to manufacture. Looking at the question from the point of view of the electrical engineer, instead of that of the lamp manufacturer, it was fairly clear that these drawbacks had a sufficient, and perhaps more than sufficient, compensation in the additional facilities they gave for a wider and more economical distribution of current from supply stations, a most important advantage, and one well worth making some considerable sacrifice to gain. But he hoped the ardour for progress in that direction might not lead to the adoption of lamps requiring double the voltage of the lamps now in use in connection with already existing installations, except after the most thorough over-hauling of all portions of the installation, including the wiring of the houses. To go from the question of high voltage to that of high efficiency, the real difficulty connected with the employment of lamps at a higher efficiency in watts per candle was not so much in the lamps themselves as in the conditions under which they were generally used, both in connection with the private and public supply of current. The fluctuations of pressure to which lamps were subjected were commonly too great to give a high efficiency lamp a fair chance of life. At 2½ watts per candle the filament was, of course, heated to a very high temperature, and any rise in voltage above that which produced the 2½-watt efficiency was very trying to the life of the lamp; in fact, they all knew that even the best lamps of that character

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would not bear for long any extra pressure producing a super-high efficiency and a super-high temperature. The published charts made by the recording voltmeter showed that in the case of nearly all the public electric supply companies, the normal voltage was often exceeded by more than 5 per cent., sometimes by even 10 per cent. When such pressure was brought to bear on lamps at the high efficiency of 2½ watts per candle, the result was disastrous. But given a voltage that never rose more than 1 or 2 per cent. above the normal point, there was then no difficulty in realising that degree of economy of current which Mr. Addenbrooke had described as obtainable by the use of 2½ watt lamps. Things would doubtless greatly improve in this respect, and he therefore hoped that in the near future it might be practicable to make a much more general use of lamps of high efficiency than under existing circumstances would be either convenient or economical.

*Mr. C. H. STEARN said that all interested in the extension of electric lighting could not but feel a deep debt of gratitude to Mr. Baynes for the courageous experiment he had tried at Bradford under such very difficult circumstances, and had carried through to so triumphant a conclusion. Mr. Addenbrooke, also, by his pen had rendered great service to the new movement by bringing clearly before the minds of many who had not previously given much attention to the matter, the great importance of the economical results that would follow from the general adoption of the system of higher pressure in central station practice. With Mr. Addenbrooke's view that

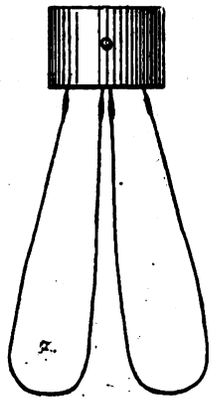

FIG. 1.—First type of High-voltage Double-filament Lamp, 16-c.p., 200 volts. ⅔ actual size.

economy in lighting could be more easily reached by high pressure and low temperature than by high temperature and low pressure, he fully agreed, inasmuch as they had not the same difficulty which the decrease in light of high temperature lamps presented, while at the same time they had, or were likely to have, a more equably maintained pressure on the lamps themselves. As to duration, he must differ from Mr. Addenbrooke in the view that increased pressure necessitated any diminished duration either in 16 c.p. or in 8 c.p. lamps. Careful experiment had shown that the duration at equal temperatures (at least at temperatures corresponding to 3·5 to 4 watts per candle) was, if the filament were homogeneous, independent of the sectional area of the filament, that is, within the limits of 1,200 to 1,400 hours. Dealing with the same efficiency in the comparative trials to which

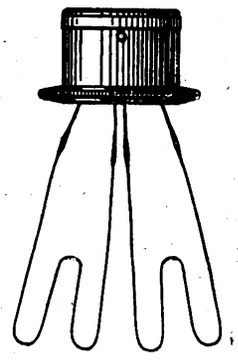

FIG. 2.—Second type of High-voltage Double-filament Lamp, 8-c.p., 220 volts. ⅔ actual size.

he referred, the lamps of 8, 16 and 6 candles at 200 volts gave similar results, that is to say the majority were not destroyed after 1,100 hours. If in commercial lamps this result was not always confirmed in the thinner filaments, that evidently arose from preventable causes. The defects in some earlier forms of double filament lamps (Fig. 1) were that they were unsuited for using out of the vertical position, as installers, though they do not expect the laws of gravity to be suspended in their favour when dealing with gas, had decided that the lampmaker must be able to so completely triumph over gravity that his lamps could be used in any position. The form (Fig. 2) shown on the board, through the greater stiffness of the filament obtained by the M form, would bear being used out of the vertical without falling and touching the glass. Some of these had run in a horizontal position for over 800 hours without any perceptible drop of the carbon. Though the double-filament lamp was, on the whole, the best as a transitional form, yet no doubt the single filament, if it could be made sufficiently rigid and self-supporting, would ultimately become the typical form. The long life, which was obtained at efficiencies of 3·8 to 4 watts, showed clearly that they could move with advantage in the direction of higher efficiency with perfect safety. But at the outset it was well to first establish public confidence in the durability at the lower temperature, and then gradually to pass on to the higher efficiency. With the construction of carbon filament suggested by Mr. Topham, shewn in the lowest row of lamps on the board (Fig. 3) low resistance carbon with its increased length could be more easily dealt with, and in that way a higher efficiency could be obtained without any increase in the rate of fall in candle-power. The movement had now gained such strength that there was little fear of its opponents being able to resist its progress. The same objections now raised as to the diminished life of lamps at doubled

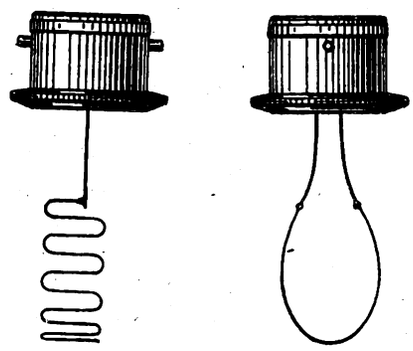

FIG. 3.—New type of High-voltage Single-filament Lamp, with Sinuous Carbon, 16-c.p., 202 volts. ⅔ actual size.

voltage were raised at the outset in 1881, when they passed from 50 to 100 volts. But for all that the 100-volt system had displaced the 50-volt, as it in its turn would be displaced by its double. The 8 c.p. and the 6 c.p. lamps of 230 volts, he ventured to prophesy, would be firmly established in popular favour this time next year, and they would all wonder why they had made so much difficulty over so simple a matter.

*Mr. T. A. ROSE said he would simply give his experience of high voltage lamps, and that was that he found very little trouble in the manufacture of them. Of course a little more care was required. Still, he had been very successful, and had supplied the lamps to several places, such as Wolverhampton, Manchester, Bradford, &c., from which places he had received very flattering reports and increased orders.

*Mr. J. F. C. SNELL said at the King's-road station, St. Pancras, the lamps were running entirely at a pressure of 220 volts. At the present moment there were about 4,000 lamps fixed, the greater number of them having been running for five months. They had had very little trouble indeed with them, and he did not think the consumers really knew the difference between the 220 and 110-volt supply. His experience caused him to think that manufacturers ought to make some difference in the cutouts and holders; it was in the holders that they got the chief difficulties. There was either short-circuiting between the contacts or between the contacts and the brass case. With reference to the life of the lamps, he had had some running at his house for over 1,300 hours. With regard to the steadiness of pressure, the Board of Trade now permitted them to vary to the extent of 3 per cent. above or below the standard pressure. On a 440-volt supply, that was a three-wire system, with 220 volts on each side of the balancing wire, the percentage variation would obviously be less than on a 220 volt three wire system, and this should conduce to the longer life of the higher voltage lamps.

*Mr. C. J. ROBERTSON said the troubles his firm had found with high-voltage lamps up to the present were practically nil, except in the case of people who had to handle the lamps in the course of manufacture. They had to use low specific resistance filaments, which were, he imagined, the only practical filaments to be used. Beyond that he pretty well agreed with what Mr. Swan and Mr. Stearn had already said. The Incandescent Electric Lamp Company, (Limited), had had very small experience, but they were perfectly capable of converting all their manufacture instantly to 200 or even 300 volts if required.

*Mr. W. GEIPEL said before he read Mr. Addenbrooke's Paper he was under the impression that, granted the 200-volt lamp was successful, it was all up with transformer systems; but if all Mr. Addenbrooke said was true, then he thought those of them who had devoted years to the perfecting of these systems might feel that there was a vast field of use still before the results of their labours. He thought they were many of them indebted to Mr. Addenbrooke, in the first place, for the care he had taken in showing them that even with the three-wire and 200-volt lamps and the station planted in the centre of the town, the low-pressure direct supply system for distributing apparatus alone cost £60 per kilowatt. He was quite sure that on the alternating-transformer system, with 100-volt lamps, this figure would cover the cost of the whole works, including buildings, generating plant, and distribution. It required no words of his to emphasise the singular importance which the first cost had upon the cost per unit. He might remind the members that they would find a curve showing this relation in his contribution to the discussion on Mr. Crompton's Paper "On the Cost of Electrical Energy" (May, 1894), in which they would see that taking a given sum for works costs the total cost per unit varied from about 3½d., when the first cost of plant was 2s. 9d. per unit sold, to 1½d. when the first cost was 6d. He thought, therefore, that if Mr. Addenbrooke's estimate was

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correct the transformer system would give a cheaper supply with a 100-volt lamp than the direct system would with a 200-volt lamp. In addition to that he saw that Mr. Addenbrooke calculated his £60 per kilowatt for distributing from the centre of a town radially in all directions, so that excepting in unusual cases, there was the increased expense of working as compared with the high tension station, which might, of course, be situated more favourably. It was a matter of fact that at least one of the important direct supply stations in London had decided to remove from the centre of the district to a spot entirely outside, so that at any rate in that case they appreciated those expenses and difficulties, while Mr. Addenbrooke's calculations as to first cost presumably would in such case be increased. He did not believe, however, that the 200-volt lamp was the correct lamp to use—in fact, he quite agreed with Mr. Addenbrooke that it was in the tentative stage, and he feared it would remain there for many years to come. They all knew that, apart from all questions as to economy in watts per candle and as to the necessity of small candle-power, lamps could be made and used successfully very much higher than 200 volts, but then people could not all afford to use Sunbeam lamps in their little dark corners, especially in those places which required artificial light all day. The question to his mind resolved itself upon the 8 c.p. lamp; people ought to have the advantage of using such lamps without wasting half the energy by burning another lamp in series with it as had been suggested, for they might just as well use the 16 c.p. lamp at once. Could lamp makers produce a good 200-volt lamp of 8 c.p. which would last 600 or 700 hours with a strain of three watts per candle? His experience was that they could not do it, and he knew one of the leading makers who candidly admitted it. He doubted if it could be done at less than six watts per candle. Indeed, it was difficult enough to obtain efficient 100-volt 8 c.p. lamps which would stand, satisfactorily, the ordinary varying pressure of an electricity supply works. A great deal was made of the improvements which had taken place and which might be expected in lamps. He would be a bold man who stated that advance were an impossibility, but had that wonderful improvement actually taken place? Ten years ago good 100-volt 16 c.p. lamps could be obtained using four watts per candle and lasting 1,000 hours. It might be that the watts had been reduced to 3½ watts per candle for a similar life, but he thought that was about the extent of the improvement. Of course the price had been so much reduced that it paid to use lamps at a higher efficiency, but the improvement in the quality did not appear to be so wonderful. For his part, he thought the 200-volt lamp policy a mere subterfuge, which should be strongly opposed. Why were people adopting the Welsbach gas burner? Simply because they got a good light for half the consumption of gas. If, then, they wished to compete with the Welsbach—and it was a serious competition—they must give the consumer a lamp which took less watts; in fact, the tendency, if anything, should be to reduce the 100-volt supply rather than to increase it to 200 volts, for he thought no one would deny that with the lower voltage more efficient 8 c.p. lamps could be made. It was his opinion that the popularity of the electric light would be distinctly and unfavourably affected if they forced upon the consumer a 200-volt supply.

Mr. L. EPSTEIN said the figures as regards accumulators contained in the Paper were borne out by his experience, and he really had no fault to find with them.

*Mr. A. A. C. SWINTON said Mr. Geipel had touched on the question of efficiency, which, of course, was a very important one, but he thought it ought to be carried a step further. They were told that the efficiency was so many watts per candle. Now what did a candle mean? There were two candles: there was a foreign candle, a German candle he believed, and an English candle, and he must say that in many cases he had been much puzzled to know to what particular candle-power the makers referred.

*Mr. W. H. PATCHELL said he had not had time to read this Paper, although it had been sent out a week before, but on looking over it it had struck him as a Paper of extreme moment. There were several things in it which touched central-station practice very pertinently. He had tried for some time to introduce 200-volt lamps, but he had first tried to get the lamps at the same price as those of 100-volt. This was of manifest importance to every central-station engineer, for if he doubled his pressure the capital value of his mains was increased, but when the consumer came to pay the bill not only for current but for lamp renewals, he thought the Company would have to subsidise the consumer to some extent or find him the lamps at a loss. Whether that would pay the Company was a moot question. He thought as they had so many lamp makers present he ought to impress upon them the importance of having the price the same as for low-voltage lamps. They had heard that night of difficulties with 100-volt 8 c.p. lamps, but he had had no trouble with them when run at a steady pressure. Those who had had difficulties could not have run them on a steady pressure.

*Mr. H. W. HANDCOCK said a client of his firm had for a long time been complaining about his lamps going, and the matter was a mystery to them. At last they told him the best thing to do was to see the engineer at the central station. The result was he was advised to use 110-volt lamps instead of 105-volt. This was a little bit suggestive, as the circuit was only a 105-volt circuit. They had heard a great deal about the satisfactory life of 200-volt lamps, and the advantages of these lamps had been demonstrated to them very obviously, from the central station point of view; but they had not heard very much from the consumer's side. They should have before them relative figures. That was to say, taking a lamp of the same life if they liked, they wanted to know what was its efficiency at 200 volts, what was the efficiency of a similar lamp at 100 volts, and also what was its efficiency at 50 volts; also what was the candle-power of that lamp at each voltage at the end of 1,000 hours. In their experience they felt that with the 100 volts the limit had been about reached. Occasionally they had very good lamps, but when they went far above 100 volts they had so much trouble and such continuous complaints about filaments going that it was evident the life was very uncertain. If the voltage were steady it was quite a different thing, and he thought the inventor of the incandescent lamp had struck the right nail on the head when he spoke of the great fluctuation of pressure they were subject to at the present moment. As things were 90 per cent. of the difficulties were due to faulty lamps, and the trouble was got over in New York by the Company including in their rate the lamps themselves. Every lamp went through their laboratory and was carefully tested with the photometer; anything not coming up to their standard was rejected and returned to the makers. If they had some similar system here the gain would be very considerable. Going back to efficiency, he should like to ask this question now they had so many central station engineers present: If they doubled their voltage were they going to supply the consumer with current at such a rate that if he got the same amount of light out of his lamps his account would be the same instead of 33 per cent. more than it was now? Taking the case of three watts on the existing circuits, where an account amounted to £100, with four watts that account would come out at £130. Were the customers to expect a substantial reduction which would also cover the expense due to the higher price of the 200-volt lamps?

*Mr. W. R. RAWLINGS said if they were going to compete against gas, it was necessary to carefully consider the question of cost. He was very often called in by people who wanted to know the reason of their enormous electric accounts, and he very often found that in out of the way places 16 c.p. lamps were kept burning simply because those lamps had a long life. If they reduced those lamps to 3 c.p., such as some of the 100-volt lamp makers were giving them, and put in 8 c.p. lamps where more light was required, they would then reduce the electric account to something reasonable.

*Mr. SYDNEY BAYNES sent some remarks, which were read by Mr. J. F. C. Snell. As he believed he had had the privilege of being the first to employ lamps of high voltage in electrical distribution, a short summary of his experience might not be without interest. In early days it remained an open question whether central stations would ultimately become a source of revenue to municipalities or not. The expenditure was consequently limited and meagre in comparison with the handsome sums now freely voted by municipal bodies. Shortly after the opening of the Bradford installation in 1889, it became evident that the mains were likely to become loaded in a much shorter time than had been anticipated. It thus became a pressing question with him in what manner he could increase their carrying capacity with the smallest possible capital outlay. After carefully going into the matter, the most promising solution of the difficulty seemed to be theoretically in the adoption of a three-wire system with lamps at 230 volts. The three-wire system was already in the market, not so the 230-volt lamp. Feeling confident, however, that the lamp was but a question of time, he made ready for its adoption by giving personal attention to every detail in the wiring of premises, and prohibiting the use of double-pole cutouts, so that when the day came for the fulfilment of his expectations, there should be no cause for anxiety in connection with the consumers' premises. He could only touch briefly on the initial difficulties in procuring lamps. After persistent inquiries and interviews, he managed to procure small consignments from several makers. Only one design of lamp, however, survived the test satisfactorily at that date. After further considerable delay another firm entered the field, and supplied a good lamp; but it became apparent that to achieve any degree of success it would be necessary to encourage the manufacture of such lamps on a commercial scale, and, as he was then satisfied that two makers could be relied on, he resolved to give effect to the scheme which he had so long hoped to put into practical use. Accordingly, he issued notices intimating that all future consumers would be supplied at 230 volts. There remained the terms of the Provisional Order to consider. The most diplomatic method of dealing with the difficulties therein presented appeared to be—first, to prove the practical utility of the double pressure, and then leave the matter for the consideration of the Board of Trade. He therefore used only the outer conductors as a pair, and thus maintained the spirit of the order. He had to acknowledge his indebtedness to the Board of Trade in allowing him a certain latitude wherein he had time to demonstrate the practicability of the innovation. At an early stage in the working of the scheme he had numerous inquiries from America as to lamps and the measure of success achieved. He now learned that in the comparatively short time which had elapsed there were over 15 central stations in the United States working with 200-volt lamps. They were not yet in a position to report such progress on this side of the Atlantic—a striking instance of British caution contrasted with Yankee go-aheadness. In regard to the question of current density, he would suggest that Mr. Addenbrooke was too liberal with his allowance of copper. He preferred to allow for a 2 per cent. variation, with distributors extending 880 yards from the feeding centres, and working at a current density of about 700 amperes per square inch. The pressure should be gradually increased to 2 per cent. above the normal at the feeding point as the load approached maximum, while the pressure on the distributor at the far end would fall 2 per cent. below the normal; thus by a judicious compromise they were able to limit the variation at the lamp terminals to 2 per cent. In that way the number of feeding centres would be reduced to a minimum, and might be spaced at intervals of a mile. The generating station would feed direct into the network up to a half-mile radius; and the distance in any direction to 2½ miles would be readily dealt with by throwing out two feeders into the distance to be supplied. The near feeder would obviously be worked at double the current density, so that both the near and the far feeders would be coupled to one common 'bus bar. It would be advisable on the score of economy to serve the home position of the network from a separate bus 'bar, as the voltage would only be required to exceed the normal by 2 per cent. at maximum load. It being usual to place feeding centres where roads intersect, there would be 8 distributors, each extending 880 yards, or a total frontage of 7,040 yards. Allowing for branch streets, you might readily count on a lamp density of three lamps per yard. This would represent about 3,200 amperes at 440

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volts to be delivered to each feeding point. It would be preferable to divide this current amongst four seperate conductors constituting the feeder. This method of grouping the conductors simplifies the regulation, and allows for the adjustment of varying pressures by switching off portions of the feeder should any irregularity occur between the feeding centres. The facility in regulating thus afforded would be considerably augmented by a judicious selection of the sectional areas of the cables combining to make up the feeder. Very shortly the King's-road works would be supplying current with the distributing network extending a total distance of nearly 2¾ miles to the furthest lamp. He might here remark that providing the centre wire of the distributing system be brought back to the generating station, and reasonable care taken to balance the distribution of lamps, there appeared to be no necessity for a centre feeder. In regard to the possibility of using lamps of high efficiency and low voltage, since the regulation at the increased pressure would approach much nearer the ideal than had hitherto been obtainable, those lamps could be adopted two in series, with a success and certainty which was quite impracticable on a system run at 110 volts. The tendency in shop lighting was to group several lamps on a switch. so that it would make little difference whether they were burning in series, parallel or otherwise. If a really reliable high efficiency lamp could be obtained any waste of current inevitable from the necessity of burning two in series would be a mere trifle compared with the economy effected by their use. As to lamps of high voltage, those makers who had devoted both time and money to perfecting their methods had been remarkably successful in producing lamps of comparatively high efficiency, averaging from 3·3 to 4 watts per candle, whilst the average life already greatly exceeded that assumed in the Paper. He considered the profession was under an obligation to several of those manufacturers for their persevering efforts to keep pace with the requirements of the electrical industry, and in their courteous endeavour to deal with and remedy any defects that had occurred during the development of the lamp; but for their able assistance they would not be assembled that evening to discuss that very interesting Paper. As to the question of fire risks, where the wiring had been well done there was certainly less risk than with the lower voltage, first because the fuses were lighter, and, second, because should an arc occur across the casing, the current would more readily exceed the carrying capacity of the fuse. In the St. Pancras installation they limited the current through any pair of mains to 25 or 30 amperes, and as each circuit was protected by the Vestry's standard fuses, kept under seal, it was immaterial whether or not any fuses existed on the branch circuits. The rule that no conductor should be smaller than a No. 18 S.W.G. rendered a 220-volt supply absolutely safe, though not a single branch cut-out existed on the whole system, because they might short-circuit and blow the main 30-ampere fuse through a No. 18 S.W.G. insulated conductor without damaging it in the least. Cut-outs in ceiling roses were useless; the branch cut-outs—one on each pole—with 1in., or certainly not less than ⅜in. of clear break, should be relied on. Double-pole cut-outs should not be permitted, as they were liable to short-circuit. Main cut-outs at entrance of buildings should have by preference 1¼in. to 1½in. of clear break. No trouble whatever had been experienced with any switches or other fittings. It was regrettable that the insurance companies still acknowledged the use of casing with the conductors kept at about an arcing distance apart. Practically that was wrong; the conductors should be kept in close proximity, then on the failure of the insulation, instead of an arc springing up and continuing (as he had known it to do on 115-volt circuits) a "short" would occur, at once blowing the fuses. He was unable wholly to concur with Mr. Addenbrooke's remarks as to the effect on alternating-current practice. As the most modern systems now employed a distributing network, the introduction of a higher voltage lamp would be a distinct advance for either system.

*The PRESIDENT (Dr. John Hopkinson) said as Manchester had been referred to by one or two speakers he should like to add a few words to the discussion. At Manchester, of course, they had for two or three years had experience of the high voltage; in particular, in the Town Hall they were working at 400 volts, for they took in all five wires there. According to circumstances they burned from two to four lamps in series, and they had large groups in series for the lighting of public rooms. They had had no trouble whatever in connection with the wiring. Of course they had special fuses arranged for the purpose. The question of leakage had been referred to in connection with Manchester. It was true that from the negative terminal there was a substantial leakage; and that existed, and always existed, because they were bound to put the middle wire to earth. That, of course, really arose from the fact that bare copper was used to a considerable extent. It was now used to a greater extent on account of the great facility it afforded for making connections and avoiding vulcanising of the joints. But leakage caused them no inconvenience at all; still, there was, of course, a certain admitted loss of power from that leakage. Mr. Addenbrooke had referred to the use of accumulators, and particularly to the use of accumulators at out stations, and he had pointed out that if you required to increase the capacity of a main you could do so by putting an accumulator at the end of that main and charging it. The fact really amounted to this, that comparing the out-station accumulator with the corresponding power at the station, you should compare its cost with the cost of the boiler, the engine, the dynamo, and the feeder. There was an additional advantage in the use of out-station accumulators in the fact that such great facility for regulation was obtained; they could regulate the pressure at the end of that feeder to the extent of one cell.

*Mr. G. L. ADDENBROOKE, in his reply, said that he mentioned in the paper a certain proportion of 8 c.p. lamps to 16 c.p., and, following out earlier experiences, he was under the impression that the number of 8 c.p. lamps was very considerable, but when in conversation with Mr. Swan recently that gentleman said that the sales of the 8 c.p. Ediswan lamps did not amount to much more than a quarter of the 16 c.p. lamps. That was, he thought, a very important point, because if after so many years the Edison-Swan Company, which had enjoyed almost a monopoly, had found comparatively so few 8 c.p. lamps were used, it was clear that this must indicate the proportion of 8 c.p. lamps in use, which was so small that the argument against the 200 volts on the ground of the difficulty of procuring good 8 c.p. lamps was greatly lessened in force. Was it not a pity that central-station engineers calculated all their results in 8 c.p. lamps when there was a much more reliable basis in 16 c.p.? There was one very curious thing about this higher voltage question, and that was this: Why had they not had an intermediate voltage? It was very curious that there were no 150-volt lamps in the market, for they would be very useful for lighting factories and many other purposes. He believed lamps of these voltages were much more largely used on the Continent. But apparently in this country we were going to make a big plunge right away. At Edinburgh Prof. Kennedy was changing the whole system to 230 volts, and he believed the Westminster Company were offering their customers to change their customers' lamps to 200 volts for 1s. 3d. each and to give them a certain guarantee if they would go over. He spoke without actual official data, but he fancied the Brush Provincial Company had determined to use 200 volt lamps at the Wandsworth station, and that voltage was going to be in use at many other places. Mr. Shoolbred had told him that he was carrying out the Birkenhead installation on this system, and found his calculations come very near those in this Paper. There was one thing this debate had brought out: they had actually seen the lampmakers and heard them speak. He did not think they had ever heard very much from the lampmakers since Mr. Swan first brought out the lamp, and there was no doubt a great many electrical engineers had been feeling their way in the dark to a great extent with regard to this lamp question. Mr. Swan had spoken about the fluctations of voltage: this had been a sort of pet subject of his (the speaker's) for a long time. It was very much greater in extent than central station companies liked to acknowledge, and it was one reason why up to last year he had been in favour of alternating currents, for if they were forced to use 100 volts they would get better regulation than on a continuous-current system, at any rate, if the area were at all considerable. That was a good deal altered by having 200-volt lamps. In the experience he had had of 200-volt lamps he felt sure they were a good deal less affected by slight changes of voltage than 100-volt lamps. He had recently tested some oil engines on dynamos which were not very steady, and with which they were not always able to keep the voltage down; once or twice they ran away, and caused the voltage to rise to 300 volts. The lamps were horizontal, and although some filaments were bent over, and seemed half fused, they did not give way. In one or two cases the filament touched the under side of the lamp, but in other cases it did not, but for some time afterwards burnt in the bent form. He was sure Mr. Stearn's remarks would be very much appreciated. He had made the subject a speciality, and certainly the form of lamp he had shown was exceedingly pretty, at the same time that it was a thoroughly practical form, one, indeed, which would be very nice, even at 100 volts; they got the light more concentrated. Mr. Geipel spoke of the £60 a kilowatt in his (the speaker's) estimate as the cost of distributing mains; but he had pointed out that that estimate was for a station carrying feeders 2¼ miles long, and it assumed that the density of population was the same over the whole area. As regards alternating central stations, he was told the cost per kilowatt in the case of the Islington station amounted to £21?.

Mr. GEIPEL: That includes some provision for extension.

*Mr. ADDENBROOKE said that might be. Practically he was willing to admit that that was an outside figure; but there it was. Mr. Baynes had given them some actual figures. He himself had taken a very small drop, a lower one, indeed, than Mr. Baynes considered desirable. If they wanted even pressure, which all lampmakers would tell them was necessary, they must have more copper. The amount of copper at 250 amperes per square inch came out at a very moderate figure. Mr. Baynes allowed a rather greater fall and worked at a greater current density, and, no doubt, if they worked out the central station that way, the cost of mains per kilowatt would come down very much indeed, even on the £60 which he had taken as a rough basis. Referring to a Paper read before the North-East Coast Institute of Engineers fifteen months ago by Mr. Alexander Siemens, Mr. Addenbrooke said the real object which Mr. Siemens had in writing the Paper was lost sight of. The Paper was written to show the running of the central station. It was true the central station was established at Messrs. Siemens' works, but it was a very large one. To all intents and purposes it was a central station of about 1,000 or 1,200 H.P., and that was working at something less than a nine-hours' load, the load factor being 0·28. Well, Messrs. Siemens said the result of a six months' run of that station under ordinary working conditions, the cost of their coal being 17s. 10d. a ton, and adding the cost of labour, depreciation and other matters, was that the cost per kilowatt hour came out a little over ·58d. It was true the cost of labour might not be quite so large an item as in another station, because they had skilled engineers who could attend to it; still with a load factor of 0·28 and coal at 17s. 10d. a ton, the cost per kilowatt hour was about ·58d. What Messrs. Siemens could do others could do; if they had a nine-hours' load they could generate their current for something in the neighbourhood of ½d. It appeared to him if they could introduce accumulators, which the present price admitted of, they could supply current, except for the question of distribution, and except for one or two other questions, at a very much reduced figure on its cost at present. If they could get these 200 or 220-volt lamps and cut down the cost of their mains in such a proportion, and if they could get accumulators and keep their voltage even, they might generate the energy quite as economical as Messrs. Siemens. He might say in reply to some of the speakers that in view of the great gain to companies of 220 volts, they could very well afford, where customers used them, to make a slight reduction in the cost of current, and he had shown

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that a reduction of ¼d. would really cover anything the consumer was likely to suffer from. Mr. Addenbrooke concluded by saying that he would give his reply more fully in the pages of the *Journal* of the Institution.

The meeting then adjourned until March 26th.

THE BOOSTER IN RAILWAY WORK.*

BY J. B. SCOTT.

The limitations of the 500 volt direct system of feeding are very soon felt when any very large amount of travel has to be provided for at a considerable distance from the power house. Here it becomes absolutely necessary to adopt some means of cutting down the enormous amount of copper needed, if the road is to be practicable from a financial standpoint. To take an actual case: In laying out the feeder system of the City and Suburban Railway, of Baltimore, the following conditions had to be met. The general plan of the system shows six main branches radiating from approximately the centre of the City, on the south water front. It was determined to locate one main power house at this point, for besides being the centre of the system, it had exceptional facilities for receiving coal both by water and rail, and gave an unlimited supply of water for condensing. Several of the lines extend from five to seven miles from this point, and have a very large summer excursion travel to the parks located at the ends. To handle this occasional load satisfactorily by the direct feeder system at such distances would have required an enormous outlay of copper. The extremely heavy load is only felt on Sundays and holidays and warm nights during about four months in the year. At these times there are as many as 20 cars on each suburban division, while for the remainder of the year but two or three cars are required.

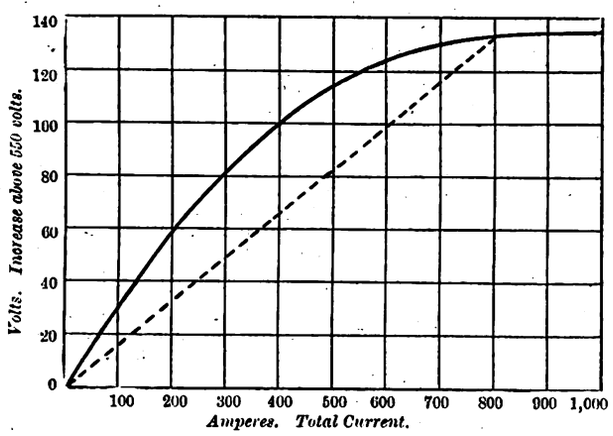

FIG. 1.

Under these conditions the booster seemed especially suitable, and was accordingly installed, with sufficient copper in the line for the ordinary travel up to six or seven cars, with a drop of 50 volts by the direct feed. The ordinary shunt-wound booster used in lighting work was not considered suitable for this purpose, as it would have required constant attention to regulate the voltage by hand on the variable loads experienced in railway work. To accomplish this automatically the fields were wound with series coils only. This gives a regulation which, while not theoretically perfect, is entirely satisfactory for railway work. The curve in Fig. 1 is plotted from readings taken from the machine in actual service, and shows the variation from the theoretically perfect regulation indicated by the dotted line. The greatest variation from this is at 400 amperes, where it amounts to 35 volts, this being only a trifle over 5½ per cent. of 615 volts, the normal for that current in this case. This is negligible in railway work.

The machine used in this case was a standard General Electric Company's six-pole lighting generator, with a capacity of 800 amperes and 125 volts. The field coils were rewound for series connection, and the machine was belted to an auxiliary engine already installed for running a 200-kilowatt standard railway generator. This generator is used for lighting the cars and barns, and also for shifting cars after the road is shut down at 1:30 a.m. As the two machines are thus used alternately, no additional engine plant was required. The remainder of the plant at present consists of four 500-kilowatt standard railway generators.

The switchboard connections, in simplified form, are shown in Fig. 2; but for convenience the circuit is run through a special panel, similar to the usual generator panel, but with only an ammeter, voltmeter and circuit-breaker on it. A quick break switch is placed in front of the machine to cut it entirely clear of the circuit when necessary, but the double-throw switches on the feeder panels are generally used for throwing the machine in circuit. From the main 'bus bar the circuit is through the circuit-breaker and ammeter to one side of the machine, through the armature and field and switch to an auxiliary 'bus bar on the long distance feeder panels. By throwing any switch up, the feeder is connected directly to the main 'bus bar at 550 volts. By throwing the switch down, the circuit is completed through the booster. If the heavy loads on the different feeders do not occur at the same time, one machine can be made to serve for a number of feeders, but if the heavy loads occur simultaneously, it is preferable to have a separate machine for each feeder, though in an emergency two or three feeders can be thrown on one machine, up to its full current capacity, but without the advantage of automatic regulation of voltage.

The accompanying table shows what may be done with this particular machine on various distances. With higher voltages, longer distances may be economically fed, though, of course, the operating expenses and first cost of the machine would be somewhat greater. The results in the table, however, only show what has been actually accomplished with a machine in regular service. The first column shows the distance required to be fed, for simplicity a trunk line, without distribution. Columns 2 and 3 show the amount of copper required for the various distances when the drop is respectively 175 volts and 50 volts, with a load of 675 amperes. Column 4 shows the actual amount of copper saved by allowing the additional 125 volts drop in the line. Column 5 shows this saving expressed in dollars, the copper being taken as worth $550 per mile erected, not including pole line. Column 6 shows the cost of the booster, including foundation, belt and switchboard panel, this cost being constant for any distance in this particular case. Column 7 shows the saving in first cost between the booster

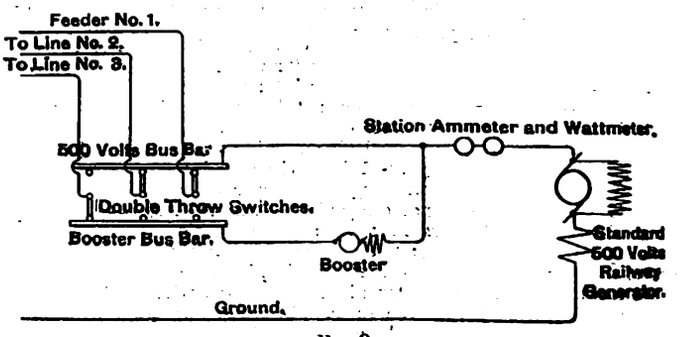

FIG. 2.

Comparison of One Case of Direct and Booster Feed.

1. To feed 675 amp.	2. Copper required at 175 volts drop.	3. Copper required at 50 volts drop.	4. Copper saved.	5. At $550 per mile.	6. Cost of Booster.	7. Net saving in first cost.	A. Capitalised cost of power 1 yr. at 10 hrs. per day.	B. Capitalised cost of power 4 mos. at 10 hrs. per day.	C. Capitalised cost of power 4 mos. 1 day a week.
1 mile.	1 mile 0000†	3·5 miles 0000	2·5 miles 0000	$1,375	$2,500	- $1,125	$61,320	$20,440	$2,920
2 ,,	4 ,, ,,	14·0 ,, ,,	10·0 ,, ,,	5,500	2,500	+ 3,000	61,320	20,440	2,920
3 ,,	9 ,, ,,	31·5 ,, ,,	22·5 ,, ,,	12,375	2,500	9,875	61,320	20,440	2,920
4 ,,	16 ,, ,,	56·0 ,, ,,	40·0 ,, ,,	22,000	2,500	19,500	61,320	20,440	2,920
5 ,,	25 ,, ,,	87·5 ,, ,,	62·5 ,, ,,	34,375	2,500	31,875	61,320	20,440	2,920
6 ,,	36 ,, ,,	126·5 ,, ,,	90·5 ,, ,,	49,500	2,500	47,000	61,320	20,440	2,920
7 ,,	49 ,, ,,	171·0 ,, ,,	122·0 ,, ,,	67,375	2,500	64,875	61,320	20,440	2,920

* Abstract from the *Street Railway Review* of Chicago.

† [This is a wire approximately 0·46in. in diameter, or about 19/12.—ED. *E.*].

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for 175 volts drop and the additional copper required for the direct feed at 50 volts drop. This saving in first cost is itself sufficient to recommend the system to a large class of railway managers who, from necessity or otherwise, consider a dollar saved in the equipment worth two in the operating expenses.

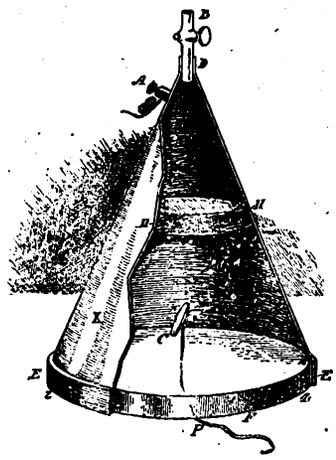
But the next three columns show the real value of the booster in railway work. Column A, when operating 10 hours continuously during the year, shows a loss between the saving in first cost and the capitalised cost of operating expenses for a shorter distance than 7 miles. Column B, when operating 10 hours a day for four months in the year, shows a gain from a little over 4 miles and upwards. Column C, representing Sunday travel during the summer and early fall months, shows a decided gain at 2 miles, while at 5 miles the saving in first cost is over 10 times the capitalised cost of power.

In making the above comparisons the cost of power is taken at 1 cent per kilowatt-hour, including fuel, water, labour, interest and depreciation of plant, and is a fair figure for an ordinary plant. At 675 amperes and 125 volts this amounts to $8.40 per day, which capitalised at 5 per cent. per annum for the number of days in operation, gives the amounts in the columns.

It is only necessary to add that the machine is in every way satisfactory to the management of the road, having been in operation since July, 1895.

A NEW FORM OF RAY LAMP.*

We illustrate herewith a new form of ray lamp devised by Prof. Woodward, of Harvard University, by means of which excellent radiographs have been obtained. As the sides of the lamp permit cathode rays to pass through them, the fact that with it radiographs may be obtained contradicts the theory that a glass envelope plays an essential part in the generation of Röntgen rays.



From the diagram it will be seen that this new form of ray lamp is that of a cone, and its characteristic difference from the ordinary Crookes tube is that the sides or walls of the lamp, H H, are made of sheet aluminum, $\frac{1}{10}$th of an inch in thickness; the base of the lamp 1, 2, 3, 4, is of solid glass, practically a plug fitted into the base of the aluminum cone with plaster of paris, and made air tight. A metallic ring passes around the base of the cone at E E, and holds the sides of the cone firmly to the glass bottom. Through a point, F, a little to the side of the centre of the glass base, passes the cathode pole into the lamp, and at the end of this is fastened a platinum disc, at such an angle as to be parallel with the side of the lamp at the point X. At the top of the lamp, and directly connected to the metallic side, is the anode pole A, and at the top of the cone is a glass tube with a stop-cock, so that the air may be exhausted. This glass tube is also fastened in with plaster of paris and bound by a metallic ring. A circular wooden disc is fastened on the inside of the metallic cone at H H, to prevent any collapse of the sides on exhaustion. By this construction it has been found that the difficulty from the absorptive power of the rays by the glass of the Crookes tube has been eliminated in a most marked degree.

Fluorescent Salts.—An American firm of chemical manufacturers has announced that, owing to the extraordinarily large demand for barium platino-cyanide, "they have been obliged to increase their laboratory force."

* From the *Electrical World* of February 29, 1896.

PARLIAMENTARY INTELLIGENCE.

THE STRAND DISTRICT ELECTRIC LIGHTING ORDER.

On Friday last, at the House of Commons, Sir J. Kitson's Committee on the Electric Lighting Provisional Orders (No. 4) Bill resumed the consideration of the Strand District Electric Lighting Bill, which had been sent down by the House of Lords' Committee. Mr. Pember, Q.C., Mr. S. Wills, Q.C., and Mr. Claude Bagally appeared for the promoters. The Metropolitan Electric Supply Company (Limited) petitioned against the Bill, and were represented by Mr. Balfour Browne, Q.C., and Mr. Fitzgerald, Q.C. The promoters' case was reported in our issue of the 20th inst.

Sir James Kitson, the Chairman of the Committee, was unable to be present, and his place was taken by Mr. C. J. Murray, the senior member.

Mr. BALFOUR BROWNE, in opening for the petitioners, said one of the most important principles that had been submitted to a committee of Parliament was now before the committee; that was whether there was to be complication in electric lighting. He was going to ask them to come to the conclusion that competition in electric lighting was not in the interests of the public, and if the Committee agreed with him he trusted they would reject the Provisional Order. Why should the Order be confirmed? He would show the Committee absolutely that the alternating-current was as good as the direct for the purposes of power. The promoters suggested that competition would bring down prices. It was, of course, to the interest of the public to have electricity supplied as cheaply as possible, but the question was, would competition bring down prices more than regulation. He absolutely denied it. The prices of the Metropolitan Company were fixed by an agreement between the Company and the Strand District Board of Works entered into seven years ago. According to that agreement a revision was to take place every seven years, so that this year the revision would take place, and the interests of the public would be fully protected. The highest price the Company could charge was 7½d., while the highest price which the Charing Cross Company sought to be able to charge was 8d. The promoters said that the real advantage of competition was the reduction of price, but that reduction could be secured without competition. The only parts of London where competition could be tried were the only parts where it ought not to be allowed. The Strand was the very part of London where the breaking up of the streets caused the greatest inconvenience, and because it was a rich part companies like the Charing Cross Company wished to come into it. It was certain that by one means or the other the public would have to pay more for the two installations than for one. That had been established again and again. Although competition in gas was possible yet it was not encouraged by Parliament, because it was found to be bad for the public. If there were two mains in one street where one would do the consumer had to pay more for his gas, and in the case of repairs the streets had to be taken up twice instead of once, and thus the public was inconvenienced. Where competition was allowed between two companies in one district it almost invariably resulted in the bankruptcy of one of the companies. Competition between such companies inevitably led to combination, and combination was nothing but a conspiracy against the public. If this bill passed the result would probably be that either the Metropolitan or the Charing Cross Company would become bankrupt, and the surviving company would have to buy it up and then charge higher prices to recoup themselves. If the local authority in course of time desired to buy up the existing rights, they would have to buy up two companies instead of one. It was therefore no wonder that the District Board, by 17 to 8, desired to rescind the consent they had already given. It had been suggested that the Board had been influenced in some way, but no evidence of this had been given.

Mr. GEORGE LIVESEY, examined by Mr. Fitzgerald, said he was a member of the Institution of Civil Engineers and Chairman of the South Metropolitan Gas Company. Witness deposed that in the case of gas companies experience had shown that in the great majority of instances, where competition was allowed, there was first an arrangement as to price, and then amalgamation between the companies.

Cross-examined by Mr. S. Wills, WITNESS said he was aware that the local authority had the power to revise prices every seven years whether there was combination between companies or not. In electric lighting, if Callender cases were used, there was very little occasion for breaking up the streets. He did not think that electric lighting companies needed any competition to keep down the price other than that supplied by the gas companies with their cheap gas and their improved burners. In the public interest it was certainly desirable that more companies should not be allowed to occupy the streets than was absolutely necessary.

Prof. SILVANUS THOMPSON, examined by Mr. Fitzgerald, said there was no difficulty in using the alternating current for even the largest motors, and as a matter of fact the largest motors were used with those currents. Motors of several hundred horse-power could be run with them as well as small motors. The advantages of alternating-current motors were several. He thought it was a fair inference that any new company coming in must get its customers from the existing company. He was positive on the point that there was no difficulty in using alternating currents for any of the ordinary purposes of arc lighting.

Cross-examined by Mr. Wills, Prof. THOMPSON said he did not think that the continuous current was better for small motors. For supplying power to a large factory it was probable that three-phase alternate motors would be used. For smaller requirements in the Strand the Metropolitan Company used one-phase motors. Some few years ago there was a difficulty experienced in starting the motors, but modern improvements had removed that.

Mr. FRANK BAILEY, examined by Mr. Fitzgerald, said he was chief engineer to the Metropolitan Electric Supply Company, and engineer to

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the City of London Electric Light Company. There was no doubt whatever that all the fair requirements of the Strand district had been met by his Company, for they were able to supply electricity to any person who wanted it. If any of their customers wished for continuous current the company were ready to give it. Last year some gentlemen living in the district gave evidence before the House of Lords Committee, when they stated they were desirous of getting a continuous current. Witness stated at the time that his company were prepared to supply it, but not one of them had applied for it. It was believed that it was the intention of the Charing Cross Company to establish their new works at some distance from the area of supply. It would be impossible, if the works were so situated, to give an adequate supply of electricity throughout the Strand District by the continuous-current system. Communications had been received by the Metropolitan Company from customers of the Charing Cross Company complaining of the character of the light supply to them.

Cross-examined by Mr. S. Wills, WITNESS said he had cursorily looked through the books and he had seen the names of half a dozen of their customers who had motors which were driven by the alternating-current.

Mr. ARTHUR VENTRIS, engineer to the Strand Board of Works, was the next witness called. Mr. Wills raised the objection that the Strand Board had given their consent to the Provisional Order, and were not appearing against the Bill.

Mr. BALFOUR BROWNE said Mr. Ventris would be examined in his individual capacity. He appeared on the Speaker's Order.

The WITNESS said that on January 30, 1895, he made a report to his Board on the state of things which would exist in the district if the Provisional Order were confirmed. In it he referred to the fact that the streets and pavements would be cut up and permanently disfigured, and expressed the view that in some streets it would be almost impossible to find room for new mains.

Cross-examined by Mr. Wills, WITNESS said he had not obtained permission from the Strand Board to attend and give evidence, nor was the Board aware that he was coming. He was not aware that after the receipt of his report the Strand Board approved the Provisional Order.

A report prepared by Mr. Crompton, an electrical engineer who was consulted by the Strand Board, was put in and read by Mr. Fitzgerald. The report condemned the proposal of the Charing Cross Company.

Mr. DE FERRANTI said there was no difficulty in supplying motors with the alternating current. On the question of competition he was able to speak with some experience. Competition between electric companies was bad for the companies themselves, and did not lead to economy so far as the consumers were concerned.

This closed the petitioners' case.

The room was then cleared while the Committee consulted in private.

On the public being readmitted, the CHAIRMAN intimated that the decision of the Committee was that the Order, as amended, should be confirmed.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March 13th, 1896.*

The Westinghouse-General Electric Combination.—It is officially reported that the General Electric and Westinghouse Companies have finally come to an arrangement in regard to the common use of patents. The basis of the agreement is that the General Electric Company's patents shall be valued at 62½ per cent., and those of the Westinghouse Electric and Manufacturing Company at 37½ per cent. of the value of the combined patents, and each company is licensed to use the patents of the other company, a royalty being paid for any use of the combined patents in excess of the value of its contribution. A Board of Control is to be in charge of all matters relating to patents, and will consist of five members, two appointed by each company, and a fifth selected by these four. These negotiations have been under way at intervals for more than a year, but heretofore no agreement could be reached, the high value placed upon the polyphase patents having been, it is thought, the cause. In passing it may be noted that the negotiations from the beginning have been a considerable source of profit to insiders through manipulation of the stock market. Each time the negotiations were resumed there was an advance in stock, advantage of which was taken. In the present instance, the General Electric stock, which a few weeks ago was quoted at 30, advanced to 40.

Contributory Infringement.—A recent Federal Court decision, based upon the lately-sustained Van Depoele trolley patent, holds that a manufacturer infringed that patent who sold trolley stands, one of its elements. The Court implied that parts, such as the trolley wheel pole, or others having a short life, can be supplied by others than the patentee, but the stand is such an essential part of the overhead running trolley that the owners of the patent alone could supply it, even for repair purposes.

Rapid Transit for New York.—The construction of the municipal underground rapid transit road in New York city seems now to be assured. This week the Commissioners appointed by the State Supreme Court, which Court possessed a veto power over the measure, reported in favour of the project after having heard most voluminous testimony both for and against it. During the sitting of the Commission no other motive power than electricity was referred to by the various experts examined. Mr. Frank J. Sprague, and Mr. David L. Barnes of the Westinghouse-Baldwin combination, both advanced systems of electric traction for adoption. That of the former consists in each car having its own motors, either one or two, all to be controlled from a single point in the train. The plan of Mr. Barnes proposed the use of electric locomotives.

CORRESPONDENCE.

RÖNTGEN RAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is accepted as a fact that "the X-rays discharge negative electricity from all bodies with great rapidity, and positive more slowly, leaving every body finally with a positive charge."

I have just discovered that this law is not true, and that the correct statement is as follows:—

> The X-rays charge some bodies positively and some negatively, and whatever charge a body may receive by other means the X-rays change it, both in magnitude and in sign, to the charge which they independently give to the body.

Thus, while gold, silver, copper, platinum, iron, &c., are all charged *positively* by the X-radiation, I find that sodium and magnesium are charged *negatively* and with much greater effect than any of the above metals. Of course, we find also that if a positive charge is given to magnesium the X-rays instantly discharge it and replace it by a negative one, and that they merely diminish or increase a negative charge given to the metal. Antimony is almost neutral; but, apparently, it belongs to the positive group. Doubtless we shall now find a number of bodies behaving like magnesium.

It seems, then, that this observation disposes of the theory (which I held and worked on until yesterday) that the X-radiation is a stream of electricity (or electrified particles) shot off the Crookes tube. These positive and negative effects seem to bring the rays under the category of waves, the result being just the same as that which ordinary light gives with various kinds of photoelectric cells.

The result is greater with a bright surface than with an oxidised one.

I shall give a full description of the experiment later. Meanwhile observe that inductive effects from the coil and Crookes tube on the electrometer must be carefully screened off.—Yours, &c.

Cooper's Hill, March 24, 1896. GEORGE M. MINCHIN.

[ADDENDUM] Many metals are charged negatively by the rays. The following is a list of metals arranged in approximate descending order of their susceptibility to positive and to negative electrification:—

Positive.	*Negative.*
Iron.	Sodium.
Platinum.	Magnesium.
Copper.	Tin (greatly depending on surface).
Steel.	
Aluminium.	Lead.
Gold.	Zinc.
Bismuth.	
Silver.	
Antimony.	

Antimony is very feeble. The behaviour of tin is just the same as that with ordinary light. Sodium is very strong, and must be charged with negative electricity to a high degree before the rays begin to diminish the charge.

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THE CLARK CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to your correspondent "X" in your last issue. In the first place, owing to the article in question having been hurriedly written and proof not corrected, there are several mistakes and omissions; for instance in the phrase cited, it should have read that the Board of Trade adopted "the Clark cell as a *commercial* standard for the comparison of E.M.F.," the writer being quite aware of the definition of the true standard. As to the advisability of the Board's so doing, whether they should or should not, is of course, a matter of opinion; but there are few *practical* men who hold the negative view, and unless the writer is mistaken their ranks are not likely to be thinned by the article in question, which article "X" must have skimmed over very lightly, or "it" would have noticed that the writer mentioned that cells *had* been made according to the Board of Trade specification; in fact, one such cell takes a prominent place amongst the experiments given.

With reference to "manipulative skill and general laboratory experience," the writer addressed Dr. Muirhead upon these very points, and was assured that they had absolutely nothing to do with the construction of a reliable cell, and as a proof stated that he had set a man from his workshop, who had never seen a cell made, to make up several dozen from the raw materials. This he did with perfect success, the cells in no way differing from those made by the usual assistant.

In conclusion, the writer would only add that he is not so optimistic as not to look forward with pleasure to the prospects of a definite one-volt standard cell.—Yours, &c.,

WM. C. FISHER.

Crompton Laboratory, Thriplands, Kensington Court, London, W., March 24th.

THE AUDIT OF ELECTRIC LIGHTING ACCOUNTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As one interested in electric lighting undertaking I should like to make a few remarks upon the article in your columns of March 13th, "The Audit of Electric Light Companies' Accounts." I consider the object of the Board of Trade audit is to see that nothing is put to capital that can in any way be charged to annual income. The Memorandum of Association of most of the electric lighting companies naturally give them extremely wide powers, such as to manufacture engines, the purchase of lands, &c., and companies could under the memorandum embark in business of a very speculative nature, but the Board of Trade will not permit this. They naturally wish that at the end of 42 years the local public should have the opportunity of acquiring these industries on the lowest possible terms, and the less the capital expenditure so much the better for the public, as no one is likely to value the industry at more than the capital expenditure (except under very exceptional circumstances). As a consequence the Board of Trade are very stringent in making electric light companies write down items which the companies' auditors hold are fair charges against capital. For instance, I heard of a case the other day in which directors' fees paid during the construction of buildings and works were not allowed by the Board of Trade as a capital charge, although the directors had during the period of construction more onerous duties, and the charge is quite as just a capital one as architect's and engineer's commission.

It appears to be maintained by your article under reference that the Board of Trade desire lighting companies to have as good an annual income as possible, having in view the reduction of the rate per unit at the septennial average, but this I hold to be quite an erroneous idea. The companies have in many instances voluntarily reduced the rate nominally 8d. to an average of 5½d., and largely increased their profits thereby, so that it is evidently also the companies' interest to work at as low a rate per unit as possible, and this is quite a secondary consideration to the reduction of capital charges.

The Board of Trade auditor is, I consider, a most unsuitable person to audit the accounts of an electric lighting undertaking for the shareholders. However unprejudiced he may desire to be, he has a natural bias for his employers the public, and the economy of fifty guineas or so is, in my opinion money ill saved. As I have shown, it may result in many thousands of pounds, fair capital charges, being charged against revenue to the shareholders' loss and the public gain.—Yours, &c.,

March 21, 1896. OBSERVER.

LEGAL INTELLIGENCE.

Wake v. H. Calhaem and Wake v. E. E. Calhaem.

These actions were recently heard at the Lord Mayor's Court, London, and were brought by the plaintiffs, Messrs. Sanders, Wake and Co., the well-known mica merchants and shipbrokers, who sought to recover damages from the defendants, formerly clerks in the plaintiffs' service. Plaintiffs' counsel stated that the defendants were brothers, and had been in the service of the plaintiffs for some years. This action was brought to recover damages for breach of duty in improperly disclosing the names and addresses of the plaintiffs' customers, to recover any notes or memoranda now in their possession belonging to the plaintiffs, and also for an injunction restraining them from using information obtained from the notes and memoranda. Whilst in the plaintiffs' service the defendants gained experience in the mica business, which was only carried on by six firms in London. While in the plaintiffs' employ they disclosed to another firm in the same business the names and addresses of the plaintiffs' customers, and other valuable information. The consequence was that the plaintiffs' had lost some valuable contracts, and a mass of evidence in support of this part of the case was given. Two cases were especially referred to as glaring instances of the unscrupulous conduct of the defendants, and of the singlar methods by which certain persons in the mica trade obtain business.

Mr. B. B. WAKE, the senior member of the firm, stated that his firm had received an apology from the defendants, and he estimated the damages at £250. The defendants denied that they interfered with the plaintiffs' customers in any way.

The learned RECORDER observed that one of the defendants had pleaded infancy, but he should tell the jury that was not a valid defence if they did what they were charged with doing. Ultimately a private consultation took place between the learned Recorder and counsel, and defendants' counsel consented, on behalf of his clients, to a verdict for the plaintiffs for £10, an injunction and costs, which terms were accepted. The plaintiffs, taking into consideration the position of the defendants, and the fact that they were young men just starting in life, decided to forego costs. The learned Recorder said he thought defendants' counsel had adopted a very wise course, having regard to the practical confession of the two youths. There was no doubt that an impudent attempt was made to undercut the plaintiffs in their business, and he was not sure that the plaintiffs might not have taken a much more serious course, as there was such a crime known as conspiracy. He thought Mr. Wake was a kind-hearted and generous man in not pressing for costs, as, if he chose, he could make either one of the defendants bankrupt. He had been not only just, but kind and generous.

Reduction of Capital.

On Monday last the Manchester Edison-Swan Company (Limited and Reduced) applied to the Vice-Chancellor of the Lancashire County Court for the sanction of the Court for a further reduction of capital. Mr. Tweedale, who appeared for the petitioners, said that in 1887 the capital of the Company was reduced from £600,000 to £550,000, and a resolution had now been passed for a further reduction to £300,000. This was to be effected by extinguishing the liability in respect of uncalled capital to the extent of £4 per share. His Honour sanctioned the proposed reduction, and continued the use of the words "and reduced" in the title of the Company for one month longer.

Poole and White (Limited) v. South.

In the City of London Court, on Friday last, Mr. T. Ellis, the receiver and manager of Poole and White (Limited), sued Mr. Harry South, for the recovery of £37. 7s. 10d. for electrical fittings supplied. The action was remitted from the High Court. The claim was for electrical switches and holders supplied from July, 1894. The defendant had filed a counter claim for electrical appliances and fittings supplied for an allowance for returns, and for a special allowance on 620 lamp holders. The defendant also claimed 2½ per cent. on the sum of £115. 13s. 11d., the value of goods supplied to the plaintiffs. The defendant admitted the plaintiffs' claim less £5. 12s. charged for a switch which he alleged had been returned. The plaintiff also admitted the counter claim, except as to £25. 4s. 4d. In the end the Assistant Registrar found for the plaintiffs for £17. 10s. 10d.

BOOK RECEIVED.

"Synopsis of Current Electrical Literature," 1895. By Max Osterberg. (London: Messrs. Kegan Paul, Trench, Trübner and Co. Price 5s.)

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TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations.

TENDERS INVITED.—The Directors of the Lancashire and Yorkshire Railway require tenders for the supply of various stores for the twelve months ending April 30, 1897, of which some particulars are given in our advertisement columns, and further particulars and forms of tender can be had at the Stores Department, Osborne-street, Manchester, where samples are also to be seen. Tenders addressed to the Directors of the Company must be lodged with Mr. C. W. Bailey, Secretary, not later than 10 a.m. on Monday, April 6th.

——— The Electric Lighting Committee of the Derby Corporation require tenders for the supply and laying of low-tension cables and junction boxes in the borough. Plans may be seen after Monday next on application to Mr. J. E. Stewart, engineer at the Electric Lighting Station, Derby, and specifications obtained. Tenders have to be sent in to Mr. H. F. Gadsby, Town Clerk, at the Town Hall, not later than 12 (noon) of Monday, April 13th. Some further information is afforded in our advertisement columns.

——— The Urban District Council of Wallasey require tenders for (*a*) steam alternators, switchboard and accessories, (*b*) high and low tension concentric cables, and (*c*) transformers. Copies of specification can be had of the engineer, Mr. J. H. Crowther, Gas and Water Works, Great Float, near Birkenhead. Tenders must be sent in to Mr. W. Danger, clerk to the Council, Public Offices, Egremont, Cheshire, by 4 p.m. of Monday, the 6th April. Our advertisement columns contain further particulars.

——— The Edinburgh Corporation invite tenders for the wiring of the police cells. Specifications, &c., can be obtained at the offices of the resident electrical engineer, Mr. E. W. Monkhouse, 5, Dewar-place, and tenders must be sent in not later than 10 a.m. on April 11th, to the Town Clerk, Mr. Thomas Hunter, W.S., Town Hall, Edinburgh. Further particulars appear in our advertisement columns.

——— Our advertisement columns contain particulars of a concession for 50 years for the electric lighting of a town in the south of Spain, regarding which information can be obtained of the British Consul at Puerto de Mazarron, Murcia, Spain.

——— The proprietors of the Prince of Wales Hotel, Harrogate, York, invite tenders for the electric light installation (about 400 lights), including generating plant; also for telephone and bell work. Some further particulars will be found in our advertisement columns, and specifications may be obtained of Mr. Walter Leake, 30, Victoria-buildings, Manchester, to whom tenders under seal are to be sent by April 7th.

——— The Shoreditch (London) Vestry require tenders for engines, dynamos, switchboards, instruments, street lamps, pumps, steam and water mains, water tank, cast-iron work, motor transformers, starting switches, a battery of accumulators and stands. Tenders to Dr. H. Mansfield Robinson, Vestry Clerk, by 4 p.m. on Tuesday, April 14th.

——— The Electric Light Committee of the Bedford Corporation invite tenders for the supply and erection of one 240 B.H.P. double-acting compound enclosed engine, and one 150-unit alternator with stationary armature. Tenders to Mr. T. S. Porter by April 4th.

——— The Bradford Corporation invite tenders for the erection of the building work for their new electricity station. Tenders to the Town Clerk (Mr. W. T. McGowen), Town Hall, Bradford, by April 8th.

——— The Elberfeld Direction of the Prussian State Railways requires tenders for the supply and erection of the plant (including four steam engines, four dynamos, 174 arc lamps, &c.) required for the electric lighting of the railway stations of Elberfeld and Barmen. Tenders to the Königliche Eisenbahn Direction, Elberfeld, by April 20th.

——— The Municipal Council of Lima (Peru) invite tenders for the establishment and working of an electric lighting installation in the squares and streets of the city, with power to work the private service, under a contract for twenty years. Particulars may be obtained at 13, Comeragh-road, West Kensington, W.

TENDERS INVITED.—Tenders are invited for the supply of the necessary plant for the electric lighting of the County of Antrim Lunatic Asylum. Tenders to the Secretary of the Board of Control of Lunatic Asylums, Custom House, Dublin, by May 1st.

TENDERS ACCEPTED.—The Hammersmith Vestry have decided to accept the tender of Messrs. S. Z. de Ferranti (Limited) for the supply of necessary plant for their proposed electric supply station at £12,302. 1s. The original tenders were submitted to the consulting engineer (Mr. A. H. Preece), and he recommended the Vestry to adopt the alternating current transformer system. Mr. Preece also reported that, although Messrs. Siemens Bros. and Co.'s tender was the lowest, it would be more economical to adopt Messrs. Ferranti's system, and recommended that both firms should be invited to submit revised tenders for complete station plant, leaving the mains to be dealt with later. These revised tenders have now been sent in, and Mr. Preece recommends the acceptance of Messrs. Ferranti's tender.

——— The Brighton Town Council have accepted the tender of Messrs. Willans and Robinson for supplying and erecting a 750 I.H.P. steam engine coupled to a Crompton dynamo at the Corporation electricity station for the sum of £4,655.

——— The Hampstead Vestry has accepted the tender of Messrs. Sir W. A. Rose and Co. for the supply of dynamo oil, &c., for their electric lighting station for one year.

——— The tender of the Colombo Gas Company has been accepted for lighting the Galle Face Hotel, Colombo (Ceylon), electrically. Tenders were also received from Messrs. Johnson and Phillips, Boustead Bros. (Colombo), B. Verity and Sons and the Brush Company. It is also intended to supply current for lighting the bungalows in the neighbourhood of the Hotel.

TENDERS RECEIVED.—The Town Council of Durban, Natal, received eight tenders for the supply of the machinery and plant for their proposed electric supply station, viz.:—

Electric Construction Company (*accepted*, subject to modification)	£15,007	0	0
Goddard, Massey and Warner (Nottingham)	23,926	0	0
British Thomson-Houston	20,057	3	0
J. G. Statter and Co.	17,904	0	0
Wigston Electrical and Engineering Company	17,360	0	0
Brush Company	16,365	0	0
Siemens Bros. and Co.	16,350	0	0
Crompton and Co.	15,001	16	0

Only two firms—the Telegraph Manufacturing Company, of Helsby, near Warrington (£6,114), and the India Rubber Company (£5,442. 14s.)—tendered for the supply of the cables. In our issue of the 13th inst. we gave the names of the successful tenderers for the supply of the arc lamp columns and cast-iron conduits.

APPOINTMENTS VACANT.—The Bolton Corporation invite applications for the appointment of borough electrical engineer. Salary £300 per annum. Applications must be sent in to Mr. R. G. Hinnell, town clerk, Town Hall, Bolton, by April 6th next. Further particulars appear in our advertisement columns.

——— The Council of the County Borough of West Ham invite applications for the post of electrical engineer, with a commencing salary of £300 per annum. Our advertisement columns furnish some further particulars in regard to the experience, &c., required, and applications must be sent to Mr. Fred. E. Hillery, Town Clerk, Town Hall, West Ham, by 5 p.m. of Wednesday, April 8th.

——— The Staffordshire County Council require a Science Master capable of conducting classes in physics and chemistry at the Technical Schools, Stafford. Salary £200 per annum. Applications to the Director of Technical Instruction (Mr. T. Turner), Stafford, by April 25th.

STEAM PLANT FOR SALE.—Particulars will be found in our advertisement columns of a quantity of steam plant, in good condition, for disposal, on application to Mr. Dunn, Bank Lodge, Scarborough, Yorks.

PATENTS SPECIFICATIONS.—Those interested will find in our advertisement columns particulars of an application to amend Patent No. 2,329 of 1892, granted to Alfred Imray for "Improvements in processes and apparatus for bleaching by Electrolysis." Objections must be lodged within one calendar month from March 11th current.

DISSOLUTION OF PARTNERSHIP.—The partnership of Charles Richardson and Edward Geisler Herbert, electrical engineers, of Cornbrook Park-road, Manchester, has been dissolved. Debts by Mr. E. G. Herbert, who continues the business in his own name.

REMOVAL.—Messrs. Bergtheil and Young give notice of removal from 13, Walbrook, to 12, Camomile-street, Bishopsgate-street, London, E.C.

NEW FIRM.—Messrs. Ashton, Frost and Co. (Limited), engineers, of Blackburn, have added a dynamo and motor department to their

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business. Mr. F. J. A. Matthews, formerly of Rosing and Matthews, Bradford, has been engaged to take charge of this department. The firm will make for the trade only.

AGENCY.—Messrs. Fleming, Birkby and Goodall (Limited), of Halifax, have appointed Mr. J. E. Lawler, of 36, Lime-street, E.C., London representative.

BANKRUPTCIES.—The following are some of the principal creditors under the deed of arrangement by Walter Emmott lately trading as an electrical engineer under the style of Walter Emmott and Co., at 16A, Thomas-street, Halifax :—

Northern Electric Wire Company	£53	0	0
B. Verity and Sons	24	0	0
Manchester Edison-Swan Company	18	0	0
Beecroft and Wightman	11	0	0

The liabilities amount to £1,197. 14s. 10d., assets £225. Mr. W. D. Taylor, Town Hall-buildings, Halifax, is trustee.

——— The Shropshire County Court has approved a proposal to pay a composition of 7s. 6d. in the £ in the bankruptcy of G. J. Reakes, electrical engineer, lately trading as G. Reakes and Co. at Shrewsbury.

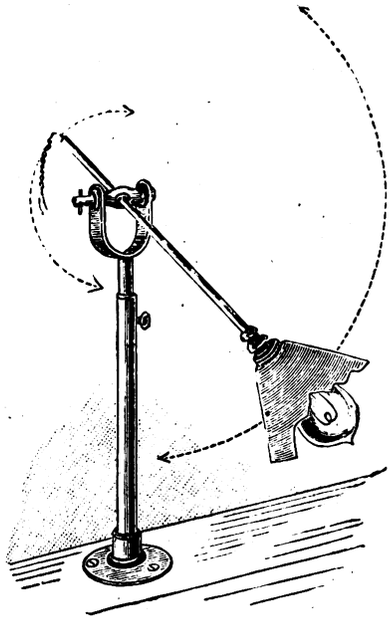
——— Notice is given of the release of the trustee (Mr. G. Wreford, Bankruptcy Court) in the bankruptcy of Walter Andreae, electrical engineer, lately trading as Walter Andreae and Co.

——— The examination of Wm. Gray, electrical engineer, lately trading as the Scottish Electrical Engineering Company, and Gray and Son, takes place at the Court House, Edinburgh, on the 31st inst., and a meeting of creditors at Messrs. Romanes and Munro's, 46, Hanover-street, Edinburgh, on April 8th.

LIQUIDATIONS.—It has been decided to wind up the Weybridge Electric Supply Company (Limited) voluntarily, and Mr. J. S. Lobb, 11, Queen Victoria-street, E.C., has been appointed liquidator.

——— At a meeting on the 16th inst. it was resolved to wind up the Coventry Electrical Engineering Company (Limited), and Mr. S. T. Peirson, 17, Hertford-street, Coventry, was appointed liquidator. On the 10th inst. Mr. Peirson was appointed by Mr. Justice North to act as receiver and manager for the debenture-holders.

ELECTRIC LIGHT STANDARD.—Mr. G. Stegmann has just brought out a useful invention for the workshop, in the form of a telescopic standard, having at its upper end an adjustable socket for the reception of a tube carrying the wires and an incandescent lamp. The socket is so arranged that the light may be brought down close to the work, as shown in the illustration, or can be turned round



in any direction. If desired, the tube carrying the wires and lamp may be withdrawn from the socket, and the light used under the bench. These standards should prove servicable to students using the microscope, and to those requiring an adjustable light.

STANDARD MEASURING INSTRUMENTS.—Messrs. Nalder Bros. and Co., of 16, Red Lion-street, Clerkenwell, London, forward an advance copy of their new ammeter catalogue, in which will be found illustrated and described the firm's latest (1896) type of ammeter. This is a brass-cased instrument, and takes the place of the "Ironclad" ammeter, being supplied at the same price. The new instrument has been designed to meet the large demand for a low-priced instrument to match ordinary switchboard work ; it is therefore felt to be unnecessary to continue the manufacture of the well-known "Ironclad" type. The list also contains useful particulars of the Preece-Trotter portable photometer (for measuring illumination and candle-power in streets, public buildings, &c.), the Trotter bar photometer (for measuring candle-power of glow lamps), and also of Crawley's patent automatic accumulator switch, the prices of which have been reduced somewhat. We are asked to point out that the letters "N. C. S." upon instruments of Messrs. Nalder Bros. and Co.'s make represent the words "Nalder, Crawley and Soames," the members of the firm, and not the "Nalder Construction Syndicate," as the letters have, we are informed, been erroneously interpreted.

PHOTOGRAPHY.—Many of our readers are interested in matters photographic, and they may like to know that a handy and useful catalogue of photographic materials has just been issued by Messrs. Ross and Co., of 111, New Bond-street, London, W.

SMOKING CONCERT.—Members are reminded that the last smoking concert of the season of the Electro-Harmonic Society takes place this (Friday) evening at the St. James's Hall Restaurant, Regent-street, W., at eight o'clock.

CONCERT.—The members of the Electrical Trades Union hold a concert, under the auspices of the London Central Branch, at the Clerkenwell New Town Hall, to-morrow (Saturday), at 7.30.

ASYLUM LIGHTING.—The work of installing the electric light at the Purdysburn Asylum, Belfast, has just been completed. The generating plant consists of two continuous-current E.C.C. machines, coupled direct to two Bumsted and Chandler single-crank engines. A battery of E.P.S. K17 cells has also been installed, the switchboard being supplied by Messrs. Crompton and Co. For lighting the various parts of the building 10 32 c.p., 90 16 c.p. and 150 8 c.p. Ediswan incandescents are employed. The work has been carried out by Mr. W. H. Drennan to the specification of Mr. V. A. H. McCowen, the Belfast borough electrical engineer.

BELFAST.—A meeting was held last week at Belfast to consider the desirability of constructing an electric tramway between Belmont, a suburb of Belfast, and Holywood. A resolution in favour of the scheme was unanimously passed, and a subscription list was opened to meet preliminary expenses, &c. A further meeting will be held this (Friday) evening.——The Borough Electrical Engineer, Mr. V. A. H. McCowen, is preparing a report on the proposed extensions of the electric light works, to be presented at the next meeting of the City Council.

COMPANIES' ACTS AMENDMENT BILL.—The *Statist* is a journal which has consistently advocated certain amendments to the Acts relating to the formation of joint-stock enterprises, and in its last issue deals with the Bill which has recently been introduced into the House of Lords. The journal points out that the vexatious 38th section of the Act of 1867 is to be repealed, so that the objectionable waiver clause which figures so conspicuously in some of the more unblushing samples of the promoter's handiwork, will be missed should the Bill become law, as every contract and fact which is material in influencing the judgment of a prudent investor must be clearly set out in detail, or the prospectus will be void. A director will, under the Act, be liable to a penalty of £5 a day if he acts without having qualified himself within the specified period of one month at most. A minimum subscription is to be set out in the prospectus, and unless this amount is reached no allotment is to be made, and no waiving compliancy with this section of the Act will be allowed to be mentioned in the prospectus. A somewhat drastic clause is that which insists upon a return of the number and amount of shares allotted, and the names and addresses of the allottees to be sent to the Registrar within seven days after allotment, or in default every director to be liable to pay £50 a day. The prospectus of a new company must be filed with the Registrar on or before publication, and must be signed by every Director and official. The statutory meeting is to be held within one month from the date of filing the declaration required for commencing business, and seven days before the meeting a report must be sent to every shareholder, giving particulars of the allotment and the cash received in respect of shares, and other information. On examination of the clauses of the Bill we find that it provides for the filing of all information concerning the creation of debentures and similar priority stock. This is, perhaps, the most important feature of the Bill. It is reasonable to look forward to a heavy flotation of joint-stock companies prior to the Bill (should it be passed) coming into effect.

CARDIFF.—The Electric Lighting Committee is again in trouble. Last week it was the question of the four fitters at the supply station ; now it is the acceptance of a tender for lamp pillars from a "non-unionist" firm. The Committee recently decided to let this tender to Mr. D. Evans, Eagle Foundry, Llandaff, but the Moulders' Trade Society protested against this, and the matter was in due course debated in the Council Chamber. The Committee

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were compelled to reconsider the matter, and the contract has been transferred to Mr. Franklin Jackson, of Cardiff.

CHELSEA (LONDON).—The Vestry have decided not to oppose the application of the Chelsea Electricity Supply Company for a Provisional Order for lighting the western portion of the parish.

CONFERENCE ON LONDON GOVERNMENT.—At the recent conference between the London local authorities and the County Council the clerk of the Shoreditch Vestry (Dr. H. Mansfield Robinson) raised the question of giving the vestries power to construct tramways. He drew a vivid picture of what his own vestry would be prepared to do in running electric tramcars within its own parish, but the proposal did not meet with support.

ELECTRIC TRANSMISSION OF POWER IN MINES.—Under this title Messrs. Siemens and Halske of Berlin have just issued a brochure giving some information with regard to the application of electricity in mines, and also a record of plants manufactured by them and at present in actual operation. In the introductory part a short review is given of the different systems employed for transmission of power, and the various advantages which electricity offers over steam, compressed air, and hydraulic pressure for this particular kind of work are set forth. The efficiency of electric transmission of power, it is stated, can always be kept within reasonable limits, on an average from 75 to 80 per cent. Of the different systems prominence is given to continuous current and three-phase alternating current, and nearly all mining machines described and illustrated can be adapted to either current. Three types of three-phase motors are manufactured by Messrs. Siemens and Halske, viz., machines with three collecting rings for use with starting apparatus, machines with closed armature winding, and without collectors, and machines with a special winding and a starting mechanism. With regard to the application of three-phase current for traction work Messrs. Siemens and Halske assert that continuous current is best suited, as the former requires three overhead wires, "the use of the rails as a conductor being excluded, iron conductors not being permissible for alternating currents." This assertion does not appear to correspond with actual practice, as at Lugano a tramway is worked by three-phase currents, two trolley wires being employed and the rails making the third conductor. Various illustrations of electric mining pumps, hoists, winding machines, rock drills, and locomotives at present at work in different mines in Germany, Japan and South Africa furnish many useful hints for those interested in mining work.

——— The *Financial News* of the 24th inst., dealing with the subject of mining at Barbertown, in the Transvaal, stated that at Moodie's Fortuna Mine it was proposed to substitute steam power for the electric power now being used for the battery. According to the report of the Directors of that Company, it has been found that electric power has not proved suitable; but no figures are given in support of this view. Commenting upon this article, Mr. W. B. Esson writes to our contemporary, pointing out that its remarks might be taken by the uninitiated to amount to a condemnation of the use of electric power in gold mining. Mr. Esson contends, however, that power transmitted electrically can be made as reliable as power obtained by any other means, steam included, and he points to the success of the electric installation at the Sheba Mine as convincing proof of this. Applied to the exigencies of gold mining it has, of course, been found that certain details require to be modified as the work proceeds, but respecting the final results, so far as the Sheba Mine is concerned there has been no question. Mr. Esson concludes:—"Electric power is transmitted through cables five miles long, and the mill works night and day, never stopping save for an occasional examination of the machinery at the generating or receiving end of the lines. For the four months ended February 29th the mill worked night and day, with stoppages aggregating in that time only one day and a half in all. This amount of stoppage was made up of a quarter of an hour here and twenty minutes there to take up a belt, adjust a rope, examine a bearing, or to give to the plant any of the little attentions always required from time to time by running machinery. The record as it stands, forms an undeniable tribute to the success of power transmission by electricity, and it will be obvious that what has been done at Sheba can be done elsewhere, if the problem be tackled in the right manner."

ESTON (YORKS).—At the last meeting of the District Council the surveyor (Mr. T. W. Stainthorpe) stated that since the last meeting he had prepared and sent out to electrical engineers plans and particulars of the present system of street lighting, and several firms had expressed their intention of sending in estimates, &c., for lighting the streets electrically.

FAREHAM.—Matters are smoothing down here, and now that the Local Government Board has sanctioned the loan of £6,681 for electric lighting purposes the Local Council seem disposed to promote good feeling and to turn their serious attention to electric lighting matters. It has been decided to retain the services of the existing staff and to purchase or hire such additional plant and machinery as may be required.

FOLKESTONE.—After a long discussion the Town Council, on Tuesday last, decided to transfer its Provisional Order, when obtained, to a company to be formed.

HAMMERSMITH (LONDON).—The Law and Parliamentary Committee of the Vestry recommend that sanction be given to the United Tramways Company's Provisional Order.

HULL.—The Borough Electrical Engineer (Mr. A. S. Barnard) has prepared a report on the proposed extension of the electric lighting works. He recommends that 14,670 additional yards of mains should be laid in various streets; that it might also be desirable to lay mains in certain streets in the eastern part of the town. The Committee considered this report at their meeting last evening.

HUYTON.—Major P. Cardew, R.E., held a Board of Trade inquiry on Wednesday last into the application of the British Insulated Wire Company for a Provisional Order for the districts of Huyton-with-Roby, Whiston, Rainhill and Eccleston. The District Councils of Huyton and Whiston oppose the application, and the inquiry was held for the purpose of taking evidence. Mr. Sydney Morse, who appeared for the applicants, stated that they already possessed powers, and were actually supplying current for public and private lighting in Prescot, and also for lighting Knowsley Hall. They were prepared to spend £10,000 at once, without risk or cost to the ratepayers. Opposition was taken on the grounds that the present application did not differ in any way from the one previously refused by the Board.

INTERNATIONAL HORSELESS CARRIAGE EXHIBITION.—We are asked to state that there will be no charge made for space at the Motor Car Exhibition to be held at the Crystal Palace from May to July, and, except for attendants, who are to be provided by the exhibitors, there will be absolutely no charge. There is a road distance of eight miles in the grounds of the Palace for trials of horseless carriages exhibited. The whole of the central nave and eastern and western corridors and courts are to be appropriated to coaches, carriages, and accessories. A uniform charge of £5 is to be made for each carriage or vehicle coming under the heading of trade exhibits, and accessories will be charged for at a small sum per square foot, according to position. The Lord Mayor will open the exhibition on Saturday, May 2nd, in State. Historical exhibits from the Coachmakers and Coach-Harness Makers Companies and the Institute of British Carriage Manufacturers will form a feature of the exhibition, which will be divided into 12 sections, section 11 being devoted to the historical and modern exhibits of steam, electric, petroleum and other traction plant. Under section 12 will be included all kinds of self-propelled passenger vehicles. Competitions have been arranged for the vehicles in this section in speed and general efficiency in actual work, and facilities are to be afforded exhibitors to show their motors in actual operation in boats and launches upon the lakes and basins in the grounds of the Palace.

LARNE.—A scheme has been formulated for the construction of an electric tramway between this town and Cushendall. The promoters hope to eventually carry the line to Portrush, so as to connect it with the Bushmills and Giants' Causeway electric tramway.

LECTURE.—Mr. J. C. Howell gave a lecture to the members of the Llanelly Intermediate and Technical College at his works at New Dock, Llanelly, last week. Prof. Viriamu Jones, who was present, remarked, in proposing a vote of thanks to Mr. Howell, that there was not another establishment in Wales where such a series of interesting electrical experiments could have been performed. The lecture was illustrated by lantern slides.

MEVAGISSEY.—This quaint little Cornish town can now claim to be quite up-to-date in the matter of public illumination, for on Wednesday last it celebrated the formal inauguration of the electric light. The Mevagissey Electric Light Company placed the contract for the work with Messrs. Veale and Co., of St. Austell, who completed the job in six weeks. The contractors have also undertaken the management of the station for three years under a guarantee. The supply station is situated near the new quay, and current is obtained from a Crompton dynamo driven by a Davy-Paxman steam engine. A battery of 60 Epstein cells with a 300 ampere-hour capacity has also been put down. The street lighting (at £48 per annum) is effected by means of 32 16 c.p. and two 32 c.p., and the harbour is to be lighted by means of one 100 c.p. and 11 16 c.p. incandescents. Current to private consumers is to be supplied at 6d. per unit.

MOSS SIDE.—The Board of Trade have revoked the Collier-Marr Telephone and Electrical Manufacturing Company's Provisional Order for this district.

OFFICE LIGHTING.—The new offices of the Jewish Board of Guardians in Widegate-street, Bishopsgate-street, which were formally opened on Sunday last, are lighted throughout electrically.

OLDHAM AND HYDE ELECTRIC TRAMWAY.—Major Marindin held a Board of Trade inquiry at Audenshaw on Friday last concerning

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the proposal to construct an electric tramway between Oldham and Hyde. Messrs. Sydney Morse and S. Sellon represented the British Electric Traction (Pioneer) Company, and the Town Councils of Ashton and Hyde, and the District Councils of Denton and Audenshaw, were also represented. Mr. Morse stated that the total length of the proposed tramway was seven miles six furlongs, and nearly all the local authorities through whose districts the proposed tramway would pass had already approved the scheme. The Audenshaw Council, who had received a proposal from the Manchester Carriage Company, opposed the construction of the tramway.

PAISLEY.—The Town Council have decided to establish municipal electric supply works at a cost of £25,000. A portion of the old prison buildings will be utilised as a site for the station.

PORTSMOUTH.—At the last meeting of the Town Council the Electric Lighting Committee recommended that a special committee be appointed to open negotiations with the local tramway company for the purchase of their undertaking. The Chairman of the Committee (Alderman Ellis) made a lengthy speech in support of the recommendation. He stated that the tramway company had applied to Parliament for power to introduce the overhead system of electric traction on their lines, and he had no doubt that, subject to the approval of the Corporation, their application would be granted. His proposal was that the Corporation should purchase the plant and equip the lines electrically, and then lease them to the present Company at a rental of ½ per cent. over and above the amount the Corporation would have to pay as interest to the sinking fund. They had sufficient power at the electricity station to run all the cars in the town, and at present their engines were working during the day with no profit. He was sure that if the Corporation adopted the scheme they would be able to hand over between £4,000 and £5,000 a year to the borough funds, and, in addition, they would be able to materially reduce the working expenses. After a short discussion the report was approved.

SOUTH AFRICAN EXPORTS.—Under the classification "Electrical," goods to the value of £2,897 were exported to South Africa for the week ended 14th inst., made up as follows:—Cape Town £1,117, Algoa Bay £153, East London £1,346, Natal £281.

SOUTHAMPTON.—At the meeting of the Town Council on Wednesday last it was decided to form a special Electric Lighting Committee to deal with all matters relating to the purchase of the Southampton Electric Light and Power Company's undertaking, and the electric lighting of the Borough.

STRAND (LONDON).—A House of Commons Select Committee on Friday last passed the Bill confirming the Provisional Order granted to the Charing Cross and Strand Electricity Supply Corporation authorising the supply of electric current in the area of the Strand Board of Works. The Bill was opposed by the Metropolitan Electric Supply Company, who already possess an Order for and supply current in the district. The Bill has now received the sanction of both Houses.

SUNDERLAND.—Mr. H. Tulloch, M.I.C.E., held a Local Government Board inquiry at Sunderland on Friday last into the application of the Town Council to borrow a further sum of £16,000 for electric lighting extension purposes. Evidence in support of the application was given by the Town Clerk, who stated that £25,000 had already been borrowed in connection with the Council's electric lighting scheme.

TELEGRAPHIC FACILITIES.—The Postmaster-General was present on Wednesday at the annual meeting of the Association of Chambers of Commerce of the United Kingdom, and was able to take part in a discussion upon a resolution asking for increased telegraphic facilities, and that the Posts and Telegraphs of the country should be considered as one undertaking in order to avoid the invidious comparison now made as to the remunerative or unremunerative working of the two departments. The Duke of Norfolk stated that, as regarded telegraphic facilities at railway stations, the Department were perpetually urging this matter upon the railway companies, with the result that considerably extended facilities had already been given. As regarded the period of three minutes allowed for trunk line telephonic communication, this length of time had been fixed after very careful and prolonged investigation and calculation, and had been adopted by the International Telephone Union. He could not therefore hold out any hopes of its being modified. So far as combining the Post and Telegraph Departments in one whole, he considered it would be a mistake, as it was, in his view, essential that the country should know the departments of the State that were profit-earning or otherwise.

TELEPHONIC COMMUNICATION FOR FARMERS.—A Paper was read last week at the meeting of the Fife Farmers' Club, in which a Mr. Longmuir recommended the extension of the telephone to rural districts, claiming that farmers and growers generally would by this means have more direct access to the markets of the country, and so, with increased light railway facilities, become in touch with those able to dispose of their products at higher rates than at present prevailed.

TORQUAY.—Last week, at the annual meeting of the Torquay Gas Company, the Chairman (Mr. Kitson, J.P.), in referring to the action of the Town Council on the electric lighting question, said "their old friend, the electric light, had been a long time trying to get a footing in Torquay, and if it was now shortly to succeed it would seem rather on the principle of 'now or never' than on its own intrinsic merits, or on the strength of the convictions of those who were championing its cause." Mr. Kitson, unlike most chairmen of gas companies, seems to have taken a rather liberal view of the effect of the introduction of the electric light on the prospects of his Company. He pointed out to his shareholders several towns where the only effect of the competition of the electric light had been to increase the consumption of gas.

TRAIN LIGHTING.—The Great North of Scotland Railway Company are making some experiments in train lighting, and one of their trains has just been fitted up for the electric light. Each carriage is provided with a generator and an accumulator, power being obtained from the revolving axle of the carriage.

WORCESTER.—The Market Hall was lighted electrically for the first time on Tuesday evening last by means of ten 2,000-c.p. arcs suspended from the roof. The installation has been carried out by a local wiring contractor, Mr. J. F. Santonna.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

March 9, 1896.

5,253. S. O. COWPER-COLES. London. Improvements in or connected with the electro-deposition of metals.

5,574. A. S. SMITH, T. A SMITH, R. J. SMITH, S. SMITH and T. DEAKIN. Birmingham. Improved apparatus for the electro-deposition of metals.

5,295. J. A. SEAVERNS. London. Improvements in arc lamps.*

5,298. A. J. BOULT. London. Improvements in electric flash-light apparatus. (W. Bruns, United States.)*

March 10, 1896.

5,315. E. H. SEDDON. Manchester. Improvements in the method of and means for electrically dispatching parcels from one station to another.

5,320. J. H. PARSONS. Leicester. An improved method of attaching the terminal wires to the zinc rods or cylinders of electric batteries.

5,345. R. HOLIDAY and J. FREEMAN. Barnsley. Improvements in gramme ring armatures.

5,389. H. F. JACKSON. London. An improved system of call suitable for use with autographic telegraph apparatus. (H. Etheridge, United States.)

5,408. W. S. SMITH and W. P. GRANVILLE. London. Improvements in telegraphic relays.

March 11, 1896.

5,467. E. H. HACKETT. Halifax. Improvements in appliances connected with electric tramcars and tramways.

5,479. A. S. FRAZER. London. Improvements in alternating current electric motors for operating commuting devices for converting alternating into continuous currents and other purposes.

5,480. W. V. HUNT. London. An improved method of and means for locating leakages on systems of electric conductors.

5,491. SIEMENS BROS. AND CO. (LIMITED). London. Means for varying the speed of asynchronous alternate current motors. (Siemens and Halske, Germany.)

5,506. P. F. RIBBE. Liverpool. Improvements in electric accumulators.*

5,511. W. J. DAVY. London. Improvements in arc lamps.

March 12, 1896.

5,537. G. HYVERT. Brussels. Automatic telegraph apparatus.

5,584. A. COEHN. London. Improvements relating to the use and treatment of carbon in electro-chemical or electrolytic processes, and to apparatus therefor.

5,616. A. E. PEYRUSSON. London. Improved electrolytic processes and apparatus.

March 13, 1896.

5,673. A. S. ELMORE. London. Improvements in apparatus for refining metals by electrolysis. (J. O. S. Elmore, India.)

5,703. A. J. BOULT. London. Improvements in arc lamps. (W. B. Joiles and E. H. A. H. R. von Nollendorf, Austria.)*

March 14, 1896.

5,752. J. PERRY. London. Electric apparatus for use either as an electro-motor or as an electricity meter.

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SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1894.

22,729. HORSBRUGH and LEE. Mariners' compasses.

1895.

3,841. NISBEIT. Ventilating manholes, electric light boxes, &c.

5,815. SIEDENMANN. Typewriters, telegraphs, &c.

7,315. BARBER-STARKEY. Electric storage batteries.

7,990. HIGGINS. Telegraphy.

8,072. WÜRL and NOVOTNY. Phonographs.

8,810. SIEMENS BROS. AND CO. (Siemens and Halske). Indicating value of electric resistances.

14,262. KARN and PAYNE. Electric signalling apparatus.

24,172. IWANOWSKI. Galvanic batteries.

1896.

207. THOMPSON (Electric Arc Light Company). Arc lamps.

1,427. MARCUSE. Telephonic apparatus.

COMPANIES' MEETINGS AND REPORTS.

Direct Spanish Telegraph Company (Limited).

The forty-fourth ordinary general meeting of this Company was held at the offices, Winchester House, Old Broad-street, on Tuesday, under the presidency of Mr. Edmund Etlinger.

The MANAGER (Mr. Charles Gerhardi) read the notice calling the meeting and the minutes of the last meeting.

The CHAIRMAN: Gentlemen, before commencing the actual business of the meeting I wish to express my great regret—in which I am sure you will all join—that our Chairman, Sir John Pender, has been and is still seriously ill. He is quite unable to attend to business. We can only hope that it may please God to restore him to health soon, so that we may see him again among us. You will probably take the report as read, as usual. In the first paragraph you will see that the year 1895, with which we are now dealing, has been on the whole not an unfavourable one. I might almost say it has been a prosperous one. We have earned sufficient money after deducting not only the ordinary expenses of working the traffic, but some rather heavy extraordinary expenses, to enable us to recommend a dividend of 10 per cent. for the whole year on the Preference shares and a dividend of 4 per cent. for the whole year on the Ordinary shares. You will remember that in each case half of this dividend was paid to you last October as an interim distribution in respect of the six months ending June 30th; and a resolution will presently be submitted to you declaring a similar dividend for the second half of the year. As regards the receipts, you will find in the second paragraph of the report that they have exceeded by £4,571 those of the year 1894, but it is only right to say that this comparison is not quite a fair one. 1894 was not only a poor year for us as far as the traffic was concerned, but I may say it was an exceptionally poor year, and therefore I have worked out what the result would be taking the average receipts for the last four years—the years 1891, 1892, 1893, and 1894. Our receipts for the year 1895, I find, only exceeded that average by £1,400 odd, and I think I am justified in saying that that excess of £1,400 is not entirely owing—perhaps only owing to a very small extent—to ordinary trade. You are all aware that there has been throughout this period a serious insurrection in Cuba, which, of course, has brought a large amount of traffic over our wires. I do not wish by any means to make you believe that we have not been as prosperous as we ought to have been, but I wish to guard you against supposing that this increase of £4,571 in the traffic receipts represents an enormous activity in trade between here and Spain, because that is not the case. Then I come to the third paragraph, in which we state that the ordinary working expenses are £238 in excess of those of 1894. This also wants a little qualification. The ordinary expenses include what we may call the working of the traffic from one place to the other, and the fixed expenses connected therewith. They have increased by this small amount of £238, and that is almost natural owing to the great increase we have had in our traffic, which means extra stationery, &c., besides some overtime done by the clerks. On looking at the accounts you will find that in addition to the excess of £238 in the ordinary expenses of working the traffic, an amount of £1,953 for extraordinary expenses has been charged. Those extraordinary expenses are composed of several small items to which I need hardly refer—an increase of income tax, an item owing to the opening of stations at Liverpool and Manchester, and a charge of £96 for expenses in consequence of the change in the representation of the Company in Spain. You are aware that our esteemed representative in Spain died, and we had to replace him. There is also an item of £151 for the removal of the offices at Barcelona and an extension of underground line. That outlay arises from the fact that we are bound by our concession to follow the Spanish Government Office. The Spanish Government built a new office or took a new house, and we had to move into it, which necessitated the laying of half a mile of underground line. These are all small items. The heavy item is the damage to the Bilbao cable in 1894, which cost £1,660. Those who were present at our meeting last year are aware that in 1894 a steamer fouled our cable outside of Bilbao, the cable being, in fact, hacked to pieces. We brought an action against the owner of the ship and it went against us. We then appealed, and the Court of Appeal sustained the judgment of the Court below. That was a misfortune for us, for we lost £1,660 by it. Still, one good thing has been done by this action for our future, and for the future of all submarine companies who may possibly get into the same trouble. At the trial it came out that the owner of the ship against which we brought our action got its anchor, in dragging, entangled with two cables. One was ours, and the other was probably an abandoned cable of the Spanish Government. Both cables were dragged up to the surface, but the lighter of the two got disengaged from the anchor and disappeared, while as regards the other cable, which we say was ours, they could not get rid of it, so they cut it and severed it. The sea was very rough at the time. We could not prove to the satisfaction of the Court which cable was ours; but the important part of the judgment is in a passage which I will quote. It says, "In the course of some time one or other of these cables goes—about that there is no question—and the remaining cable is undoubtedly cut. Now, if we were satisfied that the cable belonging to the plaintiffs (that is, our Company) had been cut, we should be of opinion that the captain had done that which he was not entitled to do, and that the defendants were responsible for the injury so caused; but I am not satisfied upon the evidence that the cable of the plaintiffs was cut." That is the whole point, I take it, on which we lost our case. I suppose it will be possible for hundreds of ships to anchor and never drag up two cables at the same time again, and I take it that in the future, if a ship, fouls a cable, and those in charge of the vessel deliberately sever it the owner of the ship is liable, the duty of the captain, according to the Law, being to slip his anchor and gear and charge the cable company with the cost. That seems to be what is established by this decision. We have a curious example of it already. A small ship—a fishing smack—fouled our cable outside Falmouth. When he found that he had fouled the cable he let go everything. He slipped all his gear and ran to Falmouth. He asked us to pay the damages, which we did, as that was the right course for him to follow. The next paragraph in the report deals with the fact that the Company's cables and landlines in connection with them have continued in good working order throughout the year. I have nothing to say on that except to congratulate ourselves on the fact. The next paragraph deals with the unfortunate loss which the Company has sustained by the death of Señor Don Jose Aparicio, who was our representative in Spain from the first inception of the Company 24 years ago. We have all known him personally to some extent, and I think that the whole of the Board and the manager agree with me that we have every cause to be grateful for the services which that gentleman rendered to us. In his place we have appointed Señor Don Vicente Coromina, who, as far as we can judge, is a gentleman very much of the same calibre. He is thoroughly acquainted with Spanish matters generally, and is a complete master of all business connected with telegraphy. We feel sure that he will do as well for us as the late Mr. Aparicio. The next point alluded to in the report is the election of Directors, which will come on presently. I have now only to refer to one further matter in connection with the balance sheet. You will remember that two years ago we informed you that the harbour authorities at Bilbao had occasion to build a new pier, which necessitated our taking up our cable, removing it beyond where they built the pier, landing it at the new place, and connecting that place by an underground line to the old place. We held that the Harbour Board, or whoever was responsible for those works, had to refund us what we spent in consequence. Last year I told you we were going on with the matter in Spain, and that I hoped it would soon come to a conclusion. If, however, law is slow in this country, it is vastly slower in Spain. We are where we were in this matter, and we can only await the result. If the case goes against us, we have the satisfaction—if it is a satisfaction—of knowing that we have long since paid for this work, so that it cannot make our position worse, while if it is in our favour it will make a difference in the accounts, as the amount in question will be transferred from one side to the other in the balance sheet. I now move—

"*That the report and accounts now presented be and are hereby received and adopted.*"

Mr. JOHN DENISON PENDER seconded the motion.

Mr. E. S. PEARSON observed that a good many balance sheets came before him, but none were presented in a more admirable form than that which was submitted to the shareholders of this Company. There were two very satisfactory features in the accounts, namely, the increase of £4,500 in the revenue, and the addition of £5,000 to the reserve fund, which now stood at the substantial amount of £28,000. The investments of the reserve fund were also very satisfactory. He presumed that the debenture redemption account of £19,000—he referred to the last item but one on the debit side of the balance-sheet—was not really a liability, but, he hoped, was more in the nature of reserve fund.

Mr. M. B. COCHRAN inquired where the case alluded to by the Chairman was tried—the action for the breakage of the Bilbao cable.

The CHAIRMAN: In the Court of Admiralty in this country.

Mr. COCHRAN said he understood that the breakage occurred near Spain.

The CHAIRMAN: The vessel was an English ship, and the case had to be tried here.

Mr. COCHRAN thought the legal expenses, £9, very moderate, and he therefore wished to know whether the expenses connected with the trial were included.

The CHAIRMAN: That expenditure is included in the sum of £1,660. We are gratified that Mr. Pearson is satisfied with the balance sheet which we have taken every pains to make clear for our shareholders. With regard to the item of £19,069 for debentures redeemed, the entry states—"being amount taken from reserve fund towards the redemption of £62,000 6 per cent. debentures in May, 1894." What took place was this. We were indebted to the amount of £62,000 in debentures at 6 per cent. We thought we could do better than that,

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and we issued new debentures at 4½ per cent. At the same time we did not see any good in renewing this £62,000, as we did not want the money. We therefore took a certain amount from the reserve fund and a certain amount we got from the call of £1 a share; but what we took from the reserve fund was £19,000. You can easily put it on the other side of the account by taking it off the value of our cables, but there is no reason for that, so it stands on the debit side as a liability, but it is a liability to you, that is, if the Company were wound up to-morrow, and you got £141,847 for your cables, &c., you would not only get 20s. in the pound for your shares, but this bonus in addition of £19,000. It is a liability, but, as I have said, it is a liability to yourselves. It is not represented by cash. I am very glad you made your remarks, because I made a omission in my opening observations. I ought to have said that we were able to pay these dividends after transferring £5,000 to the reserve fund, and, of course, after providing for the debentures.

Mr. COCHRAN desired to know how the traffic returns were being maintained, as he believed the information would be interesting in view of the present position of Cuba. That island had been in a state of chronic insurrection for the last 30 years, but the present was certainly the most serious outbreak the Spanish authorities had had to deal with. From private sources he heard that a very large portion of the crop would this year be valueless. He was told that not one-third of the tobacco crop would be obtained, and the information as to the sugar crop was very indefinite. He thought that this would materially affect the Company's operations.

The CHAIRMAN: The returns this year have been extremely favourable. What you say is perfectly correct. No doubt if there is an insurrection in the country trade must be affected. There is, however, a very large trade between Cuba and the American States, and commerce in that direction will probably suffer more than in the direction of England.

The CHAIRMAN then put the motion, which was carried unanimously. Continuing, he proposed the payment of the dividends recommended.

Mr. PENDER seconded the resolution, which was carried unanimously.

On the motion of Mr. JOHN GLOVER, seconded by Mr. E. S. PEARSON Mr. Etlinger and Mr. Pender, the retiring Directors, were re-elected.

The auditors, Messrs. Deloitte, Dever, Griffiths and Co., were afterwards re-elected.

An extraordinary general meeting was held subsequently to consider a resolution altering clauses 90 and 91 of the articles of association.

The CHAIRMAN, in moving the resolution, stated that there were only three Directors, and at present two went out of office every year. This had been found perfectly unnecessary, and, he might almost say, irksome. He believed the Company could be carried on perfectly well if they followed the course usually adopted by companies by which the directors retired in the proportion of one out of three.

Mr. COCHRAN seconded the motion, which was carried unanimously. Mr. Cochran afterwards proposed a vote of thanks to the Chairman and Directors. He expressed sincere regret at the absence of Sir John Pender, and an earnest hope that that gentleman would speedily recover.

Mr. STIMPSON seconded the motion, which was carried unanimously.

The CHAIRMAN briefly acknowledged the vote, and the proceedings then terminated.

Altrincham Electric Supply Company (Limited).

The second annual general meeting of the shareholders of this Company was held at the offices, Manchester, on Monday last.

The CHAIRMAN (Mr. F. B. Ross) moved the adoption of the following report:—

The result of the first year of the Company's working shows most satisfactory results, orders having already been secured for the equivalent of upwards of 10,000 8-c.p. lamps. The loss on the first year's working has been much smaller than is usually the case in similar new undertakings, in spite of the fact that the Directors have given a continuous day and night service to meet the views of many of their consumers. This has, of course, entailed considerable extra expense, but has resulted in a considerable increase in the number of consumers. He said their plant was fully employed; in fact for several months they had been compelled to have the whole of the machinery running at the same time during the hours of heavy load, and, in spite of the severe test to which the generating station had been put, they had been able to keep up a continuous and satisfactory supply of current. The Directors had considered it desirable to order a new and larger unit of plant capable of supplying current to over 4,000 8-c.p. lamps, thus doubling the capacity of the station. It was expected that this plant would be ready for use by the beginning of August. The number of consumers continued to increase satisfactorily. At present they had 118 consumers (an equivalent of 9,532 8-c.p. lamps) actually connected to the mains, and they had 21 additional consumers (an equivalent of 1,268 8-c.p. lamps) waiting to be connected, making a total of 139 consumers, with an equivalent of 10,800 8-c.p. lamps. In order to extend the area of the Company's operations, the Directors have applied for a Provisional Order for the district of Ashton-on-Mersey and that portion of the rural district of Bucklow which included Timperley. As this Order would probably be granted in July, they would be in a position to supply current to the residents in September. The Company's system of mains was divided into three portions, and they had actually laid 12⅜ miles of mains. The first year's working had resulted in a small loss, but when it was remembered that at the commencement of the year they started operations with practically no consumers connected, and that they had come on by degrees throughout the year, the number of lamps even at the end of the financial year being not nearly so great as at present, it would be seen that this result was very satisfactory. At the present time the income more than paid the expenses, so that the Directors confidently anticipate that at the end of this year's working not only would this loss be wiped off, but a profit would have been made.

Mr. W. P. J. FAWCUS seconded the adoption of the report, which was carried.

Sheffield Electric Light and Power Company (Limited).

The annual meeting of the shareholders of this Company was held on Monday at the Cutlers' Hall, Sheffield, Alderman G. Franklin presiding.

The CHAIRMAN, in moving the adoption of the report and accounts, said the net profit of the past year was £3,391. 9s. 4½d., compared with £1,943. 3s. 10½d. in 1894, and £562. 15s. 5½d. in 1893. In 1892 there were 7,734 lamps connected; in 1893, 8,419; in 1894, 15,672; and in 1895, 25,552. Last year they sold 302,965 units against 192,220 in 1894. During the year the number of customers had increased from 170 to 249, while the new customers were increasing in a satisfactory manner, and no customer who had adopted the light had abandoned it. In 1893 the cost of production and distribution was 5·14d. per unit; in 1894 it was 3·80d., and last year it was 3·55d. During the year the capital expenditure amounted to £16,426, and the total expenditure on capital account £68,614. There was a constant outlay in extensions of mains in order to meet the requirements of customers, and at the present time they had laid about twenty-five miles of pipes. After paying debenture interest and transferring certain sums to the depreciation funds, &c., a balance was available for dividend, out of which the Directors recommended the payment of a dividend of 5 per cent. Considering that the Company only got its Provisional Order three years ago, he thought this record would be considered satisfactory. The gross revenue in 1893 was £3,955; in 1894, £4,894. 9s. 4d.; and in 1895, £6,935. The Directors had deemed it advisable to make a further issue of shares, and they had offered 3,375 shares to the existing shareholders at a premium of 10s. per share. The shareholders were also invited to apply for any surplus shares; but he did not anticipate there would be many unapplied for on April 2nd, as their shares were already quoted at a premium. The Directors have purchased from the gas company a piece of land in Commercial-street for the purpose of erecting buildings for offices, &c. The Chairman next referred to some remarks made by Sir F. Mappin at the meeting of the gas company. Sir Frederick said "they should bear in mind that they had the electric light with them, that it was going to stay, and going to increase as gas had done." That was a very sensible view to take of the question, and it was what they had been telling the public for some years, and they were glad to find the gas company had at last realised the fact. Sir F. Mappin had also told them that "electricity had been with them for some years, and was quite unable to stop the increasing demand for gas." He would like to add that although gas had been with them for 80 years it was quite unable to stop the increasing demand for electric light. If he were a holder of gas stock he should not be in the least alarmed, for the gas company had plenty of scope in the two-light meters and in supplying gas to gas engines, grilling stoves, &c. The object was to supply not only the best and the brightest, but the cheapest of all illuminants; and he believed that if they could increase their day load they would be able to supply electric current at a lower price than that charged at present. Despite the fact that the bright and clear weather experienced this winter, and the absence of fogs, had given their engines very little to do in the day time, there had been an increase of 33 per cent. over the corresponding period of last year. Although the dividend they proposed to pay was not a large one, yet, considering the enormous difficulties they had had to contend with, he thought the shareholders would find the result satisfactory. The report was then unanimously adopted, and a dividend at the rate of 5 per cent. declared.

Scarborough Electric Supply Company (Limited).

The fourth ordinary general meeting of the shareholders of this Company was held last week at the Grand Hotel, Scarborough, Mr. J. Woodall, J.P., presiding. In moving the adoption of the report and accounts, the CHAIRMAN said that the statement of affairs gave them a full and concise account of the working of the Company, but he would remind them that it represented the first whole year's working, because during 1894 they had hardly settled down to work. The policy pursued by the Board had been, and would be in the future, to give as good a supply as possible to the consumers consistent with such economy as would eventually conduce to the proper working of the concern. Owing to the expense incurred by the great amount of current that was required at a late period of the autumn their receipts per lamp did not show a very large average, but the cost of production per unit would compare very favourably indeed with that of other companies which were far better situated to meet a continual demand. The result of the working for the year would allow a dividend to be paid at the rate of 2½ per cent. on the paid-up capital, after writing off sundry expenses connected with the formation of the Company. After bringing forward £418. 12s. 3d. from the revenue account of the previous year, there was a sum of £1,356. 1s. 11½d. available for distribution. They proposed that £304 should be written off from the preliminary expenses. The item of £525 for the Provisional Order would also have to be reduced regularly, and would have to be provided for in the reserve fund. In conclusion, Mr. Woodall moved the adoption of the report and accounts, and that a dividend of 2½ per cent. be declared.

Mr. A. A. CAMPBELL SWINTON (the Managing Director) seconded the motion, and gave figures showing the position of the Company, and the progress that had been made. After some discussion the motion was carried unanimously.

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Anglo-Portuguese Telephone Company (Limited).

The ninth ordinary general meeting of this Company was held yesterday at the offices, 53, New Broad-street, Sir Alexander Armstrong, K.C.B., F.R.S. (Chairman), presiding.

The SECRETARY (Mr. R Rodgers) read the notice calling the meeting.

The CHAIRMAN: Gentlemen, you will see from the report that this Company continues to make very good progress in Portugal. There has been an increase in the subscribers both in Oporto and Lisbon during the year under review. The amount to the credit of profit and loss at December 31st last, after making all deductions, and including the balance brought from last year, was £8,529, from which the Directors propose to pay a dividend of 2½ per cent., and to place £3,000 to reserve, leaving £4,279 to be carried forward. We confidently hope that in the future we shall be able to augment this dividend. The report shows the income and expenditure for the year and the total number and value of our subscribers. Since the commencement of the current year the subscribers have increased, giving in Lisbon an increased income of £59 and in Oporto £136, a total increase for the first two months of this year of £136. The exceptional expenditure in Oporto during 1895 was mainly for the erection of a central exchange cupola, rendered necessary by the increasing number of wires coming into the exchange. The continuance of the high rate of exchange between the two countries is a serious matter, and but for it we should be able to pay a better dividend. Bright days, however, appear to be before the Company. I am happy to be able to add that our relations with the Portuguese Government and the municipal authorities continue to be of a very friendly character. I beg to move the adoption of the report and accounts.

This was seconded and duly carried, as was a resolution declaring the dividend of 2½ per cent.

Mr. Henry Grewing, of the London Board, and Senhor Jorge O'Neill O'Neill, of the Lisbon Board, were re-elected. Messrs. Deloitte, Dever, Griffiths and Co. were reappointed auditors, and a vote of thanks to the Chairman terminated the proceedings.

The Directors' report states that the amount to the credit of profit and loss account, including balance brought forward, is £8,529. 12s. 3d., from which it is proposed to pay a dividend of 2½ per cent., to place £3,000 to reserve, and to carry forward £4,279. 19s. 3d. During the year the Company's indebtedness in London was reduced by £1,275, and exceptional expenses had to be incurred in Oporto to the extent of about £900, and loss on exchange amounted to £2,170. The expenditure on capital account for the year amounted to £3,048. 2s. 11d. The number of paying subscribers to December 31st last was: In Lisbon 1,212, of a gross annual value of £9,237, and in Oporto 1,233 (£6,832) at total annual value of £16,069. This gives an increase in subscribers of 68, and in value of £431 over the preceding year. The continuance of the high rate of exchange between the two countries has again entailed a loss amounting to £2,170 4s. 7d., equivalent to over 4 per cent. on the share capital. This loss and the expenditure on capital account have tended most seriously to cripple the available financial resources of the Company.

Metropolitan Electric Supply Company (Limited).

The following report of the Directors of this Company for the year ended December 31st last will be presented to the ninth ordinary general meeting, to be held at Winchester House, London, E.C., on Tuesday next, the 31st inst., at 12 o'clock:—

The capital expenditure, which at the end of 1894 amounted to £628,931. 7s. 1d., has now reached a total of £675,484. 3s. This increase is caused by the development of the Company's operations, and principally consists of the cost of mains, transformers and meters for the purpose of supplying consumers. In order to meet the growing demand for current it has been found necessary to push forward with extensions both of building and plant at the Sardinia-street and Amberley-road stations, and when these extensions are fully equipped they will provide for a considerable increase of business.

A serious fire occurred at the Sardinia-street station on June 24th last, resulting in the complete destruction of the dynamo room and contents, and damage to the station generally, but, owing to the system of trunk mains and to the assistance promptly rendered by the City of London and the London Electric Supply Companies, the inconvenience to the Company's customers was reduced to a minimum. The Directors anticipate that the amounts received from the insurance companies will be sufficient to provide for the reinstatement of the buildings and plant, but as the permanent arrangements are not completed, the accounts relating to the fire cannot yet be closed, and they appear in the balance-sheet for the present as an item in suspense.

The gross revenue for the year amounted to £106,447. 8s. 9d., against £85,345. 18s. 7d. in 1894, an increase of £21,101. 10s. 2d., compared with the increase of £16,150. 14s. 3d. in 1894, which the Directors consider satisfactory. The balance to the credit of the revenue account, before providing for depreciation, is £39,154. 0s. 7d. The Directors have set aside £12,000 as an addition to the depreciation fund, carrying to the credit of the net revenue account (No. V.) the sum of £27,154. 0s. 7d., which, with the balance brought forward from last account and other receipts, makes a total of £28,961. 0s. 8d. After deducting debenture interest and other charges, there is a balance of £22,082. 4s. 4d. of which the Directors have appropriated a further sum of £1,000 in reduction of the preliminary expenses account, which is now diminished to £1,052. 10s. 4d. An interim dividend of 3s. on the Ordinary shares was paid on November 13th last, amounting to £7,485, and the Directors recommend that a further dividend of 5s. per share be now paid, making a total of 8s. per share for the year, or 4 per cent. This will absorb a further £12,475, and leave a balance of £1,122. 4s. 4d. to be carried forward.

The number of 8 c.p. lamps supplied by the Company increased during the year from 209,000 to 260,000. The present number of lamps connected is 272,000, and the applications shows no signs of decrease.

Sir John Pender, G.C.M.G., M.P., Admiral of the Fleet Lord John Hay, G.C.B., and Mr. Joseph Charles Parkinson, offer themselves for re-election as Directors, as do the auditors, Messrs. Deloitte, Dever, Griffiths and Co.

The report of the Company's chief engineer, dated March 16, 1896, is as follows:—

"I have pleasure in certifying that the Company's stations, machinery and plant are being maintained in an efficient condition, and have worked satisfactorily up to the present date."—FRANK BAILEY, Chief Engineer."

County of London and Brush Provincial Electric Lighting Company (Limited).

The report of the Directors for the year to December 31st last, to be presented to the shareholders at the general meeting to be held at Winchester House, Old Broad-street, E.C., at 2 p.m., on Monday, April 13th, states that the capital expended during the year on the London stations amounted to £92,151. 10s. 9d., and the investments in shares and debentures of, and the sums advanced to, associated companies to £73,396. 5s. 10d.—total of £165,647. 16s. 7d. This expenditure has been met by instalments falling due on Ordinary shares, and by the issue of 10,000 Six per Cent. Preference shares at par, which were applied for several times over. The balance to credit of revenue account amounts to £2,714. 7s. 9d., which, with £332. 5s. 10d. brought forward, makes a total of £3,046. 13s. 7d., out of which payment for the half-year to June 30th on the Six per Cent. Preference shares has been paid, and the payment of the balance for the period to December 31st last will leave £1,208. 19s. 1d. to be carried forward.

In the St. Luke and Clerkenwell Districts the cables required for the compulsory streets have been drawn in, and the transformer sub-stations have been constructed; but, owing to a strike, much delay has taken place in the completion of the generating station. Applications have been received for the equivalent of 7,000 8 c.p. lamps, of which 5,700 are now connected to the Company's mains, and the Directors anticipate that there will be a sufficient number of lamps applied for by the time the station is completed, to ensure a profit being earned from the commencement of working. The Company's operations in the Wandsworth district have been retarded owing to objections having been taken by the Local Authority to the construction of transformer boxes in the streets. All questions have now, however, been satisfactorily arranged, and the generating station on the Wandle will soon be completed. The conduits for cables have been laid throughout the district, cables are being drawn in, and it is expected that about September next a supply of current will be available.

Owing to the dissolution of the late Parliament, the St. Olave's Provisional Order was not confirmed in the last Session. It will, however, come up for confirmation in the present Session. Application has also been made by the Company for a Provisional Order for other areas in South London, and the Camberwell Vestry has consented to the granting of an Order for the district within its jurisdiction. The Company will be in a postion to supply the parishes of St. Olave, St. George the Martyr, and Camberwell from one generating station.

In reference to the provincial section of the Company's operations, the report states that during the past year the Bournemouth Company's station has been completely remodelled and enlarged, and additional plant and mains have been laid, giving a plant capacity for 27,500 8 c.p. lamps, and the equivalent of 21,000 8 c.p. lamps connected. The work of laying mains and equipping the Dover Company's station was completed last year, and an uninterrupted supply of current has been given since April, 1895. The Richmond station has yielded, with an equivalent of 5,486 8 c.p. lamps connected at December 31st last (an increase of 1,746 8 c.p. lights within the year), a profit of £230. 2s. 1d. upon the twelve months's working, against a loss of £978. 19s. 8d. in the previous year. Additional mains have lately been laid in order to reach new consumers, and further extensions are now under consideration.

Mr. A. N. Denny has resigned his seat at the Board, and the Directors have elected Mr. Emile Garcke to fill the vacancy thus created. The retiring Directors Mr. J. B. Braithwaite, junr., and Mr. A. H. Sanderson, who offer themselves for re-election, as does the auditor, Mr. R. H. Marsh.

Tramways Electrical Traction Company (Limited).

The report of the Directors of this Company, to be presented at the ordinary general meeting on Monday next, states that as the primary object of the Company was to assist the Rouen Tramways Company to electrically equip its system, contracts were entered into with the French Thomson-Houston Company and others early last year. The necessary works were immediately commenced, and sufficient progress was made to allow of some of the sections being worked electrically at the beginning of February last. The French Thomson-Houston Company has entered into an agreement to take over all the liabilities of the Company in connection with the Rouen Tramways Company, to repay the cash advances made on account of that company (with interest at 6 per cent.), and to acquire for £100,000 the 7,094 Ordinary and 48 Jouissance shares of this Company in the Rouen Company. The net result of the sale is, that there is a balance to the credit of profit and loss of £81,214. 14s. 9d., which it is proposed to appropriate as follows:—payment of interest at 6 per cent. per annum on 15,000 Preference shares (on amounts paid up, being 5s. 6d. per share) £4,125, dividend of £5 per share on 15,000 fully-paid Ordinary shares £75,000, and to carry forward the balance £2,089. 14s. 9d. The Directors propose in due course to take the necessary steps to wind up the Company.

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NEW COMPANIES, STATUTORY RETURNS, &c.

In addition to the information given under this heading, detailed particulars of many of the Companies whose returns appear below will be found in "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK, 1896, pages *318-346, &c., &c.*

ELECTRO-METALLURGICAL COMPANY (LIMITED).—This Company was registered on March 17th with a capital of £100, in £1 shares, to purchase patents, licences, secret processes, &c., regarding any invention relating to the production of chrome and other metals, and alloys of the said metals, by electrolysis or other kindred methods, and to manufacture, sell or otherwise dispose of any of the articles manufactured under any of the patents acquired by the Company.

UNITED ELECTRIC WIRE AND TELEGRAPH WORKS (LIMITED).—This Company was registered on March 18th, with a nominal capital of £6,000, in shares of £1 each, to establish, engage in, acquire and carry on the business of electricians and mechanical engineers, and manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, accumulation, distribution, supply and utilisation of electricity. The first subscribers, with one share each, are: G. Whitaker, W. Coleman, P. M. Dickins, electrician, E. Watson, A. M. Martin, electrician, H. Conduit, electrician, and J. Boss.

GENERAL ELECTRIC COMPANY (LIMITED).—The annual return to December 13th was filed on March 10th. The nominal capital is £85,000, divided into 7,000 First Preference, 1,000 Second Preference, 5,000 Third Preference, and 4,000 Ordinary shares, all of £5; 12,925 of these have been taken up, and 4,000 Ordinary and 1,000 Second Preference have been issued as fully paid. The full amount has been called and paid on the remainder.

GORDON ELECTRIC TRACTION SYNDICATE (LIMITED).—The annual return to December 31st has only just been filed. The whole nominal capital of £2,400, in £10 shares, has been taken up, and 60 shares have been issued as fully paid. The full amount has been called and paid on the remainder.

IMPROVED ELECTRIC GLOW LAMP SYNDICATE (LIMITED).—The statutory return to March 11th has been filed. The whole of the capital of £5.000, in £1 shares, has been taken up, and 1,318 shares have been issued as fully paid. The full amount has been called and paid on the remaining 3,682 shares. The capital was recently increased to £20,000 by the creation of 15,000 new shares of £1 each.

LYNTON AND LYNMOUTH ELECTRIC LIGHT COMPANY (LIMITED).—The annual return to December 25th has been filed. The capital is £8,000, in 1,000 Preference and 7,000 Ordinary shares of £1 each. All the Preference and 2,908 Ordinary have been taken up. £8 has been paid on 8 Ordinary shares, and the remainder have been issued as fully paid.

MADRAS ELECTRIC TRAMWAYS COMPANY (LIMITED).—The annual return to January 10th has been filed. The capital is £100,000, in £1 shares (or Rs.15). 60,669 shares have been taken up, and 7,760 issued as fully paid. The full amount has been called on the remaining 52,909, and £57,652. 17s. has been paid, including £4,743. 17s. 10d. in respect of 8,584 forfeited shares.

MAZARRON ELECTRIC LIGHT COMPANY (LIMITED).—The annual return to March 1st has been filed. The capital is £15,000, in 500 £10 Preference shares, and 10,000 £1 Ordinary shares. 151 Preference and all the Ordinary have been taken up, and 9,993 Ordinary have been issued as fully paid. The full amount has been called and paid on the remainder.

MINERS' LAMP ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return to August 29, 1895, was filed on the 2nd inst. The capital is £3,000, in £5 shares, and 301 of these have been taken up; 190 have been issued as fully paid, and the full amount has been called and paid on the remainder.

MUNICIPAL ELECTRIC LIGHT AND POWER CORPORATION (LIMITED).—The annual return to January 14th has been filed. The capital is £25,000, in 2,495 £10 Ordinary, and 100 £1 Founders' shares. Thirty-seven of the former and 30 of the latter class have been taken up, and the full amount has been called.

NATIONAL ELECTRIC SUPPLY COMPANY (LIMITED)—The annual return to March 4th has been filed. The capital is £100,000, in 100 Founders' and 19,900 Ordinary shares of £5 each. All the Founders' and 10,550 of the Ordinary have been taken up, and the full amount has been called.

NORTHAMPTON ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual return to March 12th has been filed. The capital is £50 000, in 10 "A" and 49,990 "B" shares of £1 each. All the former have been taken up, but no calls have been made; 13,200 of the "B" shares have been taken up, and the full amount has been paid.

EVERED AND CO. (LIMITED).—The Directors of this Company recommend that, after payment of debenture interest, amounting to £2,416, a dividend at the rate of 7½ per cent. per annum be paid for the six months ended December 31st last, making, with an interim dividend of the same amount, 7½ per cent. for the year. The Directors also propose to pay a bonus of 1½ per cent., making a total distribution of 8¾ per cent. for the year; that £1,000 be written off plant, &c., that £1,000 be added to building fund, and that £4,809 be carried forward.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31 5/16d. per oz. (March 26th). Consols (2¾ per cent.) 109⅝—109 7/16 for money, 109¾—109¼ for account; 2½ per cent. 105½—105⅝ (March 26th). Stock Exchange Settling Days: Consols, March 30th; Stocks and Shares Continuation Day, April 13th; Ticket Day, April 14th; Pay Day, April 15th; Mining Share Carry-over Day, April 11th.

CALLS DUE.—April 27th, Rand Central Electric Works (Limited), 5s. per share.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—The Directors of this Company, after placing £6,000 to the credit of the renewal fund, have declared an interim dividend for the quarter ending March 31st current of 12s. per cent. on the Ordinary stock and 24s. per cent. on the Preferred stock (less income-tax), payable on May 1st.

BOMBAY TELEPHONE COMPANY (LIMITED).—The fourteenth annual general meeting of the shareholders of this Company was recently held at Bombay. The Chairman (the Hon. Fazulbboy Visram, C.I.E.) said the accounts for the year ended December 31, 1895, showed a credit balance of Rs.65,880-6-0, including Rs.616-11-8 from last year. The Directors proposed to pay a dividend of Re.1-4 per share (which would absorb Rs.41,968-12-0), to place Rs.6,540-6-9 to reserve, to set aside Rs.17,000 for depreciation, and to carry forward the balance of Rs.371-3-3. He said they had made satisfactory progress during the year; 86 additional lines were connected, yielding a revenue of Rs.14,525, and on December 31, 1895, there were 691 exchange and private lines at work in Bombay and Kurrachee, with a total gross revenue of Rs.123,274. The Company's exchange at Malabar Hill has been removed to Cumballa Hill, and this change would enable them to provide accommodation for a larger number of wires, and as the new exchange was more central and easier of access, they would be able to effect a saving in the construction of new lines. Mr. A. L. Paul, the parent Company's nominee, has resigned his seat on the Board, and Mr. J. B. Saunders has been elected a Director in his place. The report and accounts were then adopted.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended March 22nd were £952, against £893 in the corresponding week of 1895, an increase of £59. The total receipts for the half-year amount to £11,738, against £11,716 for the corresponding period of 1895, an increase of £22.

COTTONWOOD WATER-POWER AND ELECTRIC COMPANY (LIMITED).—Letters of allotment in connection with the recent issue of this Company have, it is stated, been posted.

COUNTY OF LONDON AND BRUSH PROVINCIAL ELECTRIC LIGHTING COMPANY (LIMITED).—The transfer books and register of members of this Company will be closed from the 1st to the 13th April inclusive, preparatory to the payment of a dividend upon the Preference shares for the six months ended December 31, 1895.

GREAT NORTHERN TELEGRAPH COMPANY.—The ordinary general meeting of this Company will be held in Copenhagen on Saturday, April 25th, at 3 p.m., at the Exchange, when the report and accounts for the past year will be submitted.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 22nd inst. amounted to £1,149, against £943 for the corresponding week last year, an increase of £206.

MEVAGISSEY ELECTRIC LIGHT COMPANY (LIMITED).—The first meeting of this Company was held on Tuesday last. The Chairman, Mr. C. M. Grier, explained the position of the Company and the progress that had been made with the installation for street lighting. The engineer, Mr. F. H. Headley, stated that everything was in readiness for supplying electric current. On Wednesday evening last current was switched on by Mrs. Laverton.

ORIENTAL TELEPHONE AND ELECTRIC COMPANY (LIMITED).—Subject to final audit, it has been decided by the Directors of this Company to recommend a dividend for the year ended December 31st last of 5 per cent., free of income tax.

OSWESTRY ELECTRIC LIGHTING AND POWER COMPANY (LIMITED).—The report of the Directors of this Company for the year ended December 31st last, submitted to the annual general meeting of shareholders on the 20th inst., states that the balance of profit and loss account is £33. 6s. 1d., which it is proposed to carry forward. Up to date 24 applications for the supply of current have been received, including three contracts with the Corporation. Mains have been laid in the streets included in the compulsory area, the supply to which will be shortly completed, and the Directors are about to lay mains in Salop-road, Victoria-road, and Queen's-road. The Directors have decided to reduce, as from January 1st last, the maximum price to 6d. per unit, and all current used in any half-year beyond the amount which would be consumed during 365 hours at the highest rate of actual consumption at any moment during the half-year, will be charged for at the rate of 3½d. per unit.

POSTAL TELEGRAPH COMPANY (NEW YORK).—The Directors of this Company have declared a dividend of 1 per cent.

STOCK EXCHANGE NOTICE.—Application has been made to the Stock Exchange Committee to allow £300,000 Four per Cent. First Mortgage Debentures of the India Rubber, Gutta Percha, and Telegraph Works Company (Limited) to be quoted in the official list, in lieu of the £200,000 Four and a-Half per Cent. Debentures now quoted.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended March 20th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,694.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Mar. 18.		Price Wednesday, Mar. 25.		Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending Mar. 21.	
								£ s. d.		Highest	Lowest
			TELEGRAPHS.								
£1,012,880	Stock	18/0	Anglo-American	46	48	47	47	5 2 0	Jan., Apr., July, Oct.	—	..
£2,993,560	Stock	36/0	Do. Preferred	87½	83½	89	90	5 11 1	" "	89	87½
£2,993,560	Stock	5/0	Do. Deferred	7½	7⅝	7⅞	8¼	..	" "	7⅞	7⅞
£178,400	100	4%	*African Direct Telég. 4% Deb. (Reg. & Bearer)	100	104	100	104	3 17 6	January and July	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	10½	11	10½	11	..	..	..	..
130,000	£10	9/0	Brazilian Submarine	14½	14⅞	14¼	14⅝	4 14 11	Mar., June, Oct., Dec.	14⅝	14½
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1966)	111	115	112	116	4 7 2	June and December	..	..
10,000,000	$100	$1½	Commercial Cable Capital Stock	166	170	160	170	4 3 2	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12½	12⅝	13⅛	13⅝	5 14 4	February and August	..	..
6,000	10	10%	Do. Preference 10 per Cent.	20½	21⅛	20⅞	21⅛	4 13 0	" "	20⅞	20⅜
12,981	5	2/0	Direct Spanish (fully paid)	4	5	4	5	4 0 0	April and October	4	..
6,000	5	10%	Do. Preference 10 per Cent.	10	10½	10	10½	4 15 8	" "	..	..
£80,000	Stock	4½%	Do. 4½% Debentures of £50 each	103%	109%	100%	109%	4 8 6	.. ..	..	..
60,719	20	2/0	Direct United States Cable, 1877	9⅛	9⅜	9⅛	9⅜	4 1 1	Jan., Apr., July, Oct.	9⅜	9⅜
400,000	10	2/6	Eastern	17	17⅛	17	17⅛	3 14 4	" "	17⅛	17⅛
78,000	10	6%	Do. 6 per Cent. Preference	18	18½	18	18½	3 4 10	" "	18 5/16	18 1/4
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	129	132	129	132	3 1 2	May and November	131	131
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	105	108	105	108	4 13 7	February & August	..	..
250,000	10	2/6	Eastern Extension	17⅜	18½	17⅜	18½	3 16 9	Jan., Apr., July, Oct.	18⅜	18
£329,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128	131	128	131	3 1 4	February & August	128½	128
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	101	105	101	105	4 15 11	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	101	105	101	105	4 15 11	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	105	108	105	108	3 14 1	February & August	—	—
£220,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112%	115%	112%	115%	3 10 2	May and November	..	..
130,227	10	1/6	Globe Telegraph and Trust	10½	10⅝	10½	10⅝	3 16 9	Jan., Apr., July, Oct.	10⅜	10⅜
130,042	10	6%	Do 6 per Cent. Preference	16⅝	17⅛	16⅝	17⅛	3 9 7	" "	..	..
150,000	10	5/0	Great Northern	22⅜	23	22⅝	23⅛	3 13 0	Jan., April, and July	23⅛	23⅛
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1888 issue	103	105	103	106	4 14 4	March & September	..	..
17,000	25	12/6	Indo-European	47	50	47	50	5 0 0	May and November	48½	..
87,548	10	..	London Platino-Brazilian	..	..	..	..	..	" "	17⅛	16⅞
£100,000	100	6%	* Do. 6 per Cent. Debentures	108	109	107	1 0	5 9 1	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	108	111	108	111	3 12 7	.. ..	..	..
11,339	8	4/0	Reuter's	5	6	5	6	..	April and October	..	..
3,381	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	182	187	182	187	4 7 7	" "	..	..
15,609	10	2/0	West African Telegraph	5⅝	6⅛	5⅝	6⅛	..	January and July	..	..
£288,300	100	5%	* Do. 5 per Cent. Debentures (red.)	101	104	101	104	4 13 2	March & September	..	..
30,000	10	2/0	West Coast of America	1	2	1	2	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	94	99	95	100	8 3 8	June and December	..	..
88,321	10	1/8	West India and Panama	1	1½	1	1½	..	..	1 3/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10⅜	11½	10⅜	11½	5 6 8	May and November	11 5/16	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9	10	9	10	6 0 0	" "	9⅜	..
£90,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108	111	108	111	4 10 8	June and December	103⅜	103
64,248	15	8/0	Western and Brazilian	8½	9	8½	9	5 5 8	May and November	8 1/16	8⅛
33,129	7½	8/0	Do. 5 per Cent. Cumulative Preferred	6½	6⅞	6½	6⅞	..	—	6 1/16	6⅛
33,129	7½	1/6	Do. Deferred Ordinary	2¼	2⅝	2¼	2⅝	..	—	2⅝	2¼
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	102	106	103	107	5 12 8	February & August	..	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	102	106	103	107	5 12 8	" "	—	—
$1,177,000	$1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	113	118	113	118	6 0 11	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	1 05	105	102	1 05	5 14 3	March & September	..	—
			TELEPHONES.								
44,000	5	2/6	Chili Telephone (fully paid)	3	3⅛	3	3⅛	..	—	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	1/16	1/16	1/16	1/16	..	May and November	1/16	—
171,504	£1	3·215	Oriental Telephone and Electric (fully paid)	1/16	1/16	1/16	1/16	..	Yearly	—	..
484,597	5	3/0	National	6¾	7	6¾	7	3 18 7	June and December	6 15/16	6 11/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16	18	16	18	3 6 8	" "	17⅛	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	16½	17½	16½	17½	3 8 7	" "	17⅛	17
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅜	6¾	6⅜	6¾	3 12 9	—	6⅝	..
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	103	108	103	108	3 5 3	January and July	107	103⅜
58,000	5	3/0	United River Plate	3½	4	3½	4	..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	97	102	97	102	4 10 0	" "	98⅜	98
			ELECTRICITY SUPPLY COMPANIES.								
40,000	£10	10/0	City of London Electric Lighting (fully paid)	14	15	14⅜	15⅜	3 4 6	—	14 1/16	14⅛
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	16	17	16	17	3 10 7	—	16 15/16	..
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	134	138	134	138	3 13 0	June and December	..	..
19,900	£5	..	Electricity Supply Co. for Spain	..	..	..	..	..	—	..	..
£30,000	£5	3/0	Charing Cross & Strand Electricity Supply Corp.	7	7½	7⅛	7⅜	..	—	7 1/16	7 1/16
£67,400	£100	5%	Do. 5 per Cent. Debentures, 1900	..	..	..	..	..	—	..	..
22,475	£8	..	County of London & Brush Prov. Ord. (fully paid)	8	9	14⅜	15⅜	..	—	..	..
10,000	£10	9½d.	Do. Pref. (£8 paid)	10	11	16	17	..	—	..	..
8,822	£5	..	House-to-House Electric	..	..	..	..	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	..	..	..	..	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	..	..	..	..	..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅜	7⅞	7⅜	7⅞	3 16 2	—	..	..
111,000	5	..	London Electric Supply	..	..	..	..	..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	13	13½	12½	13⅜	2 7 1	—	13⅜	13
£150,000	Stock	4½%	* Do. 4½% Debs.	118	120	118	120	3 15 8	June and December	119	..
6,452	£10	4/0	Notting Hill Electric	8⅜	9½	8½	9½	..	—	..	..
..	..	..	Rand Electric	1/16	1/16 prem	1/16	1/16 prem.	..	—	..	..
19,980	£5	5/3	St. James and Pall Mall	9⅜	10½	9⅜	10½	..	—	9 15/16	9⅞
20,000	£5	7%	Do. 7 per Cent. Preference	9½	9⅝	9⅝	10	3 10 0	—	9⅝	9⅝
59,900	5	4/6	Westminster Electric Supply (fully paid)	9½	10	9½	10	3 10 0	—	9⅝	9⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
90,000	2	1/6	Brush Electrical Engineering	1⅝	1⅞	1⅝	1⅞	5 3 8	—	1⅞	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅝	1⅞	1⅝	1⅞	3 4 0	—	1 15/16	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	110	113	110	113	3 19 8	March & September	—	..
28,182	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2½	2⅝	2½	2⅝	..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1½	1⅝	1½	1⅝	..	..	1⅝	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	103	106	103	106	4 5 9	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	..	..	..	..	..	..	—	..
110,000	2	..	Electric Construction	1⅛	1⅜	1⅛	1⅜	..	—	..	..
12,845	2	2/9⅜	Do. 7 per Cent. Cumulative Pref.	2½	2⅝	2½	2⅝	5 1 10	—	1½	..
91,193	2	10/0	Elmore's Patent Copper Depositing	⅜	⅝	⅜	⅝	..	—	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	⅜	⅝	⅜	⅝	..	—	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	19½	20½	20	21	4 15 3	February & August	20½	19½
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	103	105	..	..	4 7 5	March & September	..	..
15,925	£10	..	International Okonite Ordinary	..	..	..	..	..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	..	..	..	..	..	December and June	..	..
23,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	⅜	⅝	⅜	⅝	..	..	..	..
37,350	12	24/0	Telegraph Construction and Maintenance xd	38	41	38	41	4 7 10	March and July	39½	38
£150,000	100	5%	* Do. 5 per Cent. Bonds	102	105	102	105	4 16 2	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)	..	..	..	..	..	—	..	..
41,098	£5	..	Do. Preference (fully paid)	..	..	..	..	..	—	..	..
£100,000	10	6/0	W. T. Henley's Telegraph Works Ordinary	16	17	16½	17⅛	3 8 7	—	16⅝	16½
£30,000	10	7/0	Do. 7 per Cent. Preference	17	18	17	18	3 17 9	—	17⅝	17½
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	107	112	107	112	4 0 4	—	..	..
			RAILWAYS AND TRAMWAYS.								
£630,000	Stock	1½%	City and South London Railway Con. Ordy.	40	42	40	42	2 19 0	May and November	41	41
7,650	10	5%	Do. 5% Perpetual Preference	14½	15	14½	15	3 6 8	..	14½	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	182	184	182	184	3 0 8	May and November	..	..
£7,540	£10	3½%	Liverpool Overhead Railway	13⅞	14½	14	14½	1 8 2	..	..	..
10,000	10	5%	Do. 5% Preference	16⅜	16⅞	16⅜	16⅞	2 19 3	—	..	..
145,000	Stock	4%	Do. 4% Debenture	114½	116½	114½	116½	3 10 2	January and July	..	..

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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NOTES.

THERE were present at the last meeting of the Institution of Electrical Engineers 34 members and 66 associates, and 143 students and visitors, or 243 persons in all, exactly 100 of whom were qualified to vote. The serious step—for serious step it is, unless the Institution is to be regarded as a place of light amusement—of referring back the accounts for amendment was therefore determined by a little more than a quarter of the voters actually present. The register of the Institution contains the names of 595 members and 1,583 associates, 2,178 in all; so that this vote of censure upon the Council was carried by the action of about 1·24 per cent. of the electorate. We do not suggest that this is necessarily all the active support the motion would have received had timely notice been given to *all* concerned. But we do suggest that it would be well for the Council to provide in the revised Articles of Association, which it is rumoured they have in hand, that grave decisions relative to the affairs of the Institution shall not be settled by snap divisions. Members resident in the United Kingdom, but out of London, should certainly have an opportunity of voting by post on all important questions.

To the non-telephonic member perhaps the most attractive feature in connection with the reading of Mr. DANE SINCLAIR'S instructive Paper at the Institution of Electrical Engineers last week was its excellent delivery. Notwithstanding the unfortunate delay which occurred before Mr. SINCLAIR was able to get to work, he refused to be hurried, and read his Paper with a deliberation, an emphasis and a clear enunciation which contributed not a little to lighten the usually wearisome task of listening. Mr. SINCLAIR'S Paper should bring out all the long-latent debating powers of the telephone world.

THE conversion of the energy of combustion of carbon directly into electrical energy is now being seriously attempted in many quarters, witness two articles appearing elsewhere. The latter of these is of American origin, and does not appear to us wholly convincing. The deviser of the process described therein is Dr. W. W. JACQUES, and the method used by him may be stated briefly as consisting in blowing air through a bath of fused caustic soda having a carbon anode and an iron cathode. The carbon is said to be oxidised and a current produced which is naively described as "very large," though the voltage "is low." The product of the oxidation of the carbon anode—carbon dioxide—obligingly bubbles up through the electrolyte, caustic soda to wit, the ordinary tendency of these substances to unite being apparently in abeyance under the conditions prescribed by the inventor. It is admitted, however, that the whole of the carbon dioxide cannot be trusted to remain unattached, and a notable device is adopted to correct its tendency towards combination. This consists in the addition to the electrolyte of magnesia, with which the carbon dioxide (clearly a tractable variety) unites in preference to associating itself with caustic soda. Further, the magnesium carbonate thus formed quickly decomposes, and magnesia is regenerated in a state fit for the repetition of its function. It is matter for regret that Dr. JACQUES does not describe more minutely the new modifications of caustic soda, carbon dioxide, magnesia and magnesium carbonate, which he has evidently discovered and pressed into his service.

THE other Paper, by Dr. COEHN, is of a wholly different type. It opens by a clear enunciation of the principle that a method for obtaining electrical energy directly from the oxidation of carbon may reasonably be sought, first by determining the conditions under which carbon can be attacked in an electrolyte by the aid of an external current, and then by adapting these conditions for the production of a current. How far success has been achieved by working in this direction may be gathered from the Paper itself. In friendly criticism it may be said that the precise strength and temperature of the sulphuric acid used as the electrolyte should be given, and some data afforded for calculating the efficiency of the cell. Moreover, it would be interesting to know whether any of the sensible heat applied to the electrolyte appears as electricity, in short whether any part of the current observed is of thermo-electric origin. Possibly Dr. COEHN may be disposed to enlighten us on these points.

WE commence to-day the publication of a translation of a series of articles recently contributed by M. ANDRÉ BLONDEL, the well-known arc light expert, to a French technical contemporary. In the articles which appeared in these columns last autumn M. BLONDEL treated mainly of the theoretical aspect of the problem, in the present series he deals rather with the practical side of "Public Lighting by Arc Lamps." We cannot doubt that the author's indefatigable propaganda

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on behalf of the importation of more thought into our street arc lighting arrangements will in due course have its outward and visible embodiment. Generally speaking, M. BLONDEL advocates smaller carbons, dioptric diffusion and distribution of the light, and last, but not least, more elegant pillars. The gain accruing upon the use of smaller negatives was well brought out by Mr. TROTTER in the Paper he read before the Institution of Electrical Engineers in April, 1892, and it is a hard fact which will probably be generally acted upon wherever exigencies permit. The same gentleman also fathered a notable dioptric device, but to no purpose; prosaic questions of cost and cleaning have always availed to more than counterbalance the scientific advantages of proper dioptric dodges. We trust M. BLONDEL will fare better in this matter.

M. BLONDEL has a good deal to say on the "aspect fort disgracieux" of most of our home-made designs for arc-lamp pillars and lanterns. There is, it must be confessed, an excessive solidity about most English arc lamp supports; their elegance is a negligible quantity, and a factor of safety of about 1,000 has evidently been applied to them. At the same time it must be confessed that there is a certain depressing meanness about the average English street, sufficient to damp artistic effort and to render expenditure on "elegance" so much money wasted. A few of our London thoroughfares and some of our sea fronts, however, deserve better things, and we trust that whenever the electric lighting of the Thames Embankment is seriously undertaken, the design of the arc-lamp pillars will equal, if not surpass, in artistic merit the elegant and appropriate gas lamps on the parapet. The fact that the Glasgow city fathers have recently so far unbent as to ask students of the Schools of Art and Design to send in drawings for wrought-iron lamp brackets, and furthermore have actually agreed to offer "a small premium," shows to what a length the insidious cult of the beautiful has gone, and augurs well for the artistic improvement of our English arc lighting.

Two startling suggestions are put forward by Messrs. E. W. COWAN and A. STILL, in the Paper on "The Regulation of Pressure and the Reduction of Light Load Losses on Alternate Current Systems o Electric Supply," which they have recently read before the Northern Society of Electrical Engineers. One is that during periods of light loads engines and alternators should be run at one-third less than full speed, in order to reduce the losses. The other is that distribution by alternate current should be carried out, not by means of subtations nor by means of house transformers, but by placing transformers of equal size at various points along the line of distributors, the closeness of one transformer to the next being regulated by the magnitude of the load in each part. We shall be interested to see how the alternate current electrical world will receive these two proposals. In regard to the reduction of engine speed, the authors state that the experiment has been tried with hopeful results at Altrincham. Despite the upsetting of frequency and all the "constants" of the alternating transformer system, the authors recommend it. A saving in I.H.P. of 16·1 per cent. was obtained when the engine speed was dropped from 350 to 246. The loss must surely have been unusually large before, to admit of so large a saving? We are told that the effect of the alteration of frequency upon the meters is not serious, though this must depend on the kind of meter used; but the authors do not appear to consider the alternate current motor an important factor in the consideration. Arc lamps are said to stand the change-over, which is surprising considering the effect it ought to have on the coils.

Prof. FLEMING's researches on the Edison effect in glow lamps, an account of which he gave to the Physical Society last Friday, throw a great deal of light upon the apparent anomalies in the effect. But while they have added to our knowledge, they have also increased our conscious ignorance of the complex phenomena which may take place in the rarefied space between the legs of a glowing filament. Until Prof. FLEMING systematically and laboriously investigated the conditions of the Edison effect, little else was known about it than that a current would flow through a galvanometer connected to the positive leg and a middle plate in the lamp bulb, while no current would flow when the connection was between this plate and the negative leg. This apparent anomaly has now been satisfactorily explained, but in seeking the explanation Prof. FLEMING has lighted upon a host of intricate phenomena which, as Prof. SILVANUS THOMPSON pointed out in the discussion, requires to be further systematised. Evidently the few millimetres of rarefied space around a glowing lamp filament are a field rich in material for the experimenter, and promise to yield important results in regard to the conductivity of rarefied gases under various conditions of temperature and magnetic induction.

PERHAPS the most fundamental fact educed by Prof. FLEMING is that the Edison effect will only take place when the cathode is incandescent. This explains why, in ordinary circumstances no effect is observed when the negative leg is connected to the middle plate. To produce the discharge the middle plate must be made incandescent. Thus a rarefied space between a glowing and a cold electrode possesses a uni-directional conductivity. It will permit of the passage in one direction of a current from a battery of only a few volts electromotive force, while it will offer practically infinite resistance to a reverse current. The apparatus acts, in respect of an alternating potential difference, as a sieve, to sift out the currents in one direction from those in the other, and two such pieces of apparatus joined in parallel, with their heated electrodes at opposite ends, would constitute a rectifier. It may be remarked, in connection with this curiously low conductivity of rarefied gases, that Prof. J. J. THOMSON has already shown that the enormously high resistance of gases arises not so much in the bulk of the gas as immediately around the cathode. Raise the cathode to incandescence and the trouble vanishes.

STUDENTS who compare modern expositions of electromagnetic theory, such as that by OLIVER HEAVISIDE, with the older exposition by CLERK MAXWELL, doubtless notice the comparative disuse into which electromagnetic vector potential has fallen, and the growing tendency to replace it by an expression

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in terms of magnetic lines of induction. Indeed, we believe that OLIVER HEAVISIDE sees no reason whatever for perpetuating vector potential, and this view is shared by many authorities. Others, doubtless schooled in a Maxwellian train of thought, prefer that the electromagnetic equations should be written in terms of it. Between the two forms of expression, magnetic induction and vector potential, there may or may not be any difference in merit, as regards mathematical treatment; but there can be little doubt that the possibility of directly measuring induction, and the impossibility of constructing an instrument to measure vector potential, constitute an enormous advantage to the former. The mention of vector potential to most electrical engineers who have once "done" theory, would conjure up visions of a bygone professorial blackboard and hard grinds at "Electricity and Magnetism," by J. C. M. There are still many youths who are laying the foundations of practical life in close study of theory, and to these the article on "The Graphic Representation of Vector Potential," by H. N. ALLEN, which we publish this week, may serve as a welcome introduction to a somewhat intricate subject.

Cable Interruptions and Repair :—

	Date of Interruption.	Date of Repair.
Aden—Zanzibar	March 16, 1896. ...	March 22, 1896.
Puerto Plata—Martinique.	December 19, 1895. ...	—
Fantarem—Manoas	March 27, 1896. ...	—

Institution of Civil Engineers—The students of this Institution will, on Wednesday next, visit the works of the Waterloo and City Railway, assembling at 2:30 p.m. at 15 Upper Ground-street, Blackfriars.

The Telegraph Revenue.—The receipts from the telegraph service for the financial year ending March 31, 1896, amounted to £2,840,000, against £2,580,000 for the year ending March 31, 1895, an increase of £260,000, or 10 per cent.

University College, Bristol.—Courses on civil engineering, mining engineering and electrical engineering will be held at this college during the third term, commencing on April 21st. Lectures will also be delivered on electrical technology.

Prof. Perry.—Prof. Perry has been appointed to the chair of Mechanics and Mathematics at the Royal College of Science. An enthusiastic worker at Finsbury Technical College since 1882, Prof. Perry will carry to South Kensington not only the best wishes of his colleagues and students at Leonard-street, but also their regrets. The City's loss is Kensington's gain.

Royal Institution.—The following are some further particulars with regard to the Friday evening meetings after Easter: April 17th, M. G. Lippmann, Membre de l'Institut (France), "Colour Photography;" May 8th, Prof. Silvanus P. Thompson, D.Sc., F.R.S., "Electric Shadows and Luminescence;" May 22nd, Prof. J. A. Ewing, F.R.S., "Hysteresis;" June 5th, Prof. J. A. Fleming, D.Sc., F.R.S., "Electric and Magnetic Research at Low Temperatures."

Expiring Patents.—On Sunday next, the 5th inst., will expire patent No. 1,642 of 1882, granted to W. H. Akester for "IMPROVEMENTS IN INCANDESCENT ELECTRIC LAMPS." The Akester lamp was well known in the early days of incandescent lamp manufacture.——On Sunday next will also expire patent No. 1,647 of 1882, granted to St. George Lane-Fox for "IMPROVEMENTS IN THE MANUFACTURE OF INCANDESCENT ELECTRIC LAMPS." The claim advanced is for "producing by means of an electric arc . . . the necessary heat to cause a deposit of carbon upon the ends of carbon filaments for incandescent electric lamps when immersed in a medium of coal gas or other carbon compound."

Fire Office Rules.—The Liverpool, London, and Globe Insurance Company have issued a new set of rules for electric light and power installations, covering pressures not exceeding 250 volts. The continuous insulation of the cable is not to be less than 300 megohms per mile when tested in water at 60°F. after one minute's electrification. And the complete installation must be "so insulated from earth that the total leakage to earth does not exceed $\frac{1}{20000}$th of the maximum current used, when tested at double the working voltage, or at 200 volts." This Insurance Company have also issued a large sheet for hanging in dynamo rooms, containing suggestions for insuring safety.

Heavy Claims against Tramway Companies in America.—The New York City authorities have filed claims against tramway companies aggregating about £130,000. By the terms of their franchises the tramways are required to pave between their tracks and for two feet on either side, and to keep this pavement in constant repair. The claims sent to the Law Department represent work done by the city in paving and repairing. There are 50 claims, and 20 tramway companies are involved. The companies claim that they were willing to keep the old pavement repaired, but that they were under no obligation to put down a new pavement every time the city determined to repair a street.

Cast Iron Pipes.—A correspondent has pointed out to us that the quotations for cast iron spigot-and-socket pipes, which were made in the article on "Cast Iron and Stoneware Conduits," in our issue of the 13th ult., are considerably above the average ruling prices. On comparing the quotations given with the price actually paid by an electric supply concern, we find that this is the case. The quotations, which were taken from various price books, should be subjected to a discount of at least 25 per cent., the actual cost varying both with the quantity of pipe concerned and with local considerations. The engineer of an electric supply concern in the north of England recently informed us that he pays 1s. 6d. per yard for 2in. cast iron pipe delivered.

Electric Heating.—Mr. H. J. Dowsing has resigned his appointment as manager of the electrical heating and cooking department of Messrs. Crompton and Co. (Limited), and has taken offices at 14, Budge-row, Cannon-street, E.C., where he will carry on the business of electric heating, adding several other special departments in the application of electricity. Mr. Dowsing has been nearly 15 years connected with Crompton and Co., first on the outdoor staff, then as London office manager, and finally manager of the heating department which he established, the patents covering the processes bearing his name in conjunction with that of Mr. Crompton. Mr. Dowsing will place his experience at the disposal of those thinking of adopting electric heating.

Personal.—Mr. W. B. Sayers has resigned his position as works manager to Messrs. Mavor and Coulson, a post which he has held for the past 5½ years. Mr. Sayers, who has had some 16 years' experience in the design, construction and installation of machinery and apparatus for electric lighting and electric transmission of power, &c., now proposes to start business as a consulting engineer and electrician at 189, St. Vincent-street, Glasgow. Mr. Sayers' name is perhaps best known in connection with an ingenious and useful device for the prevention and control of sparking, and the production of continuous-current dynamos without winding on the field magnets and constant-pressure dynamos without series winding, a device which a leading authority on dynamo design described, at the time his Paper was read before the Institution of Electrical Engineers, as "the greatest advance that had been made in the design of direct-current dynamos during the past 10 years."

South Shields.—Mr. J. A. Jeckell, the electrical engineer to the borough of South Shields, following the example set by some of his *confrères*, has published a pamphlet setting forth the advantages of the electric light and the terms upon which it is to be obtained at South Shields. As we have stated, this has been done before in other places; and we understand that engineers who have tried the plan say they have reason to believe in its success. The great thing to aim at in a pamphlet of this kind is lucidity; for the plain man is apt to be frightened if he meets an intricate array of scientific phraseology. No doubt "the greater or lesser brilliancy of the light from gas, oil or candles depends upon the greater or lesser

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amount of oxygen (which is the one ingredient in the atmosphere necessary to sustain human life) which they abstract from the air"; but a tradesman would probably seize the point quicker if just told that gas makes the air unhealthy while electric light cannot.

The Lyons Power Transmission Scheme.—The Société Lyonnaise des Forces Motrices du Rhône, which proposes to utilise part of the water-power of the Rhone for the generation of electricity for light and power, has awarded the contracts for part of the plant. The complete plant is expected to produce 20,000 H.P., and will consist of 16 turbines of 1,250 H.P. each. The available fall varies from 30ft. to 40ft. The turbines have vertical shafts and are of the reaction type, working with a suction tube, and the generators are connected direct to the vertical turbine shaft. By a special arrangement the large turbines can be made to run at 120 revolutions, while the turbines driving the exciter dynamos run at 250 revolutions. The generators are each to have an output of 1,250 H.P. To start with, 8 turbines of 1,250 H.P. each, with generators, and the necessary exciter dynamos with their turbines, will be erected, the dynamos being made by Brown, Boveri and Co., of Baden, the turbines by the well-known Swiss firm of Escher, Wyss and Co., of Zurich.

Röntgen Rays at the Académie des Sciences.—The *Comptes Rendus* for March contains no less than twelve communications relating to X-rays. M. A. LAFAY describes the following experiment: Underneath a Crookes tube, about ½cm. from the most brilliant portion, he arranged a leaden screen pierced by a slit 2mm. wide. Some 4cm. lower he placed a second lead screen pierced by a 5mm. slit, completely closed by a very thin strip of silver foil supporting a platinum wire 1·5mm. in diameter, exactly in the axis of the slit. The silver foil was connected to the negative pole of the induction coil. The rays then passed between the poles of an electro-magnet capable of generating a field of 400 C.G.S. units, the lines being parallel to the slit. In a first experiment M. Lafay with a sensitive plate, 8cm. away from the poles of the electro-magnet, obtained no certain trace of deflection. With the plate 15cm. off, however, there were unmistakable evidences of deflection of the ray in the same direction as would be the case with cathode rays.

Lord Kelvin's Jubilee.—Lord Kelvin will, in the autumn of this year, complete the fiftieth year of his tenure of the Chair of Natural Philosophy in the University of Glasgow. The prospective jubilee is regarded with great interest in the University and City of Glasgow. It has been thought fitting that the occasion should receive a wide recognition, and a joint Committee, including representatives of the University and the Municipality, are taking measures to secure the participation of Universities, and scientific and learned bodies, both in the United Kingdom and abroad. These bodies are now being invited to send representatives to the celebration to be held in Glasgow on June 15th and 16th, on the former of which days a *conversazione* will be held in the University, and on the latter a dinner in the City Chambers, the arrangements comprising, among other items germane to the occasion, an exhibition of mechanical, electrical, and scientific apparatus, illustrating Lord Kelvin's inventive and constructive genius. Invitations will also be issued to others besides representatives of the bodies mentioned, including men of note in academic and professional circles, and in the arts and industries to which Lord Kelvin's life-work has been most directly related, as well as prominent citizens of Glasgow and others connected with the University by official and other ties. It is believed that there will be a cordial response to the invitations, and that in June next a distinguished company will be brought together to do honour to Lord Kelvin on the occasion of the jubilee of his Professorship in Glasgow University.

Influence of Röntgen Rays on the Conductivity of Dielectrics.—At a recent meeting of the Cambridge Philosophical Society, a Paper on "The Leakage of Electricity through Dielectrics traversed by Röntgen Rays" was read by Prof. J. J. Thomson and Mr. J. A. McClelland. This Paper, says *Nature*, contains an account of a series of experiments made with the object of investigating the laws regulating the passage of electricity through dielectrics transmitting Röntgen rays. This phenomenon has been discussed by one of the authors in a Paper read before the Philosophical Society on January 27th, and also in one read before the Royal Society on February 13th. The first experiments relate to the rate of leak through different gases under similar conditions as to pressure and potential gradient. The gases used were hydrogen, ammonia, carbonic acid, air, coal gas, sulphuretted hydrogen, chloroform, chlorine, bromine, iodine, sulphur chloride and mercury vapour. Numbers showing the rate of leakage in these gases relatively to that in air are given. In general, though the rule is not without exceptions, the greater the molecular weight of the gas the more rapid the leakage. In hydrogen the leak was slowest, and in mercury vapour fastest; the rate in the vapour of boiling mercury was about 28 times as fast as hydrogen. The rapid rate in mercury vapour is interesting, for this gas offers great opposition to the passage of an ordinary electric discharge. The rate of leak in the halogens is also very rapid, and a tube containing a charged plate in chlorine gas is a very sensitive and convenient method of measuring the intensity of these rays. The rates of leakage in air at different pressures were investigated; it was found that the rate of leak was lower at a low pressure than at a high one, and was over a considerable range of pressure approximately proportional to the square root of the pressure. The effect of temperature was also investigated, and it was found that through air the rate of leak was lower at a very high temperature than at the temperature of the room, but there was an intermediate temperature at which the rate was a maximum. The most remarkable thing about this leakage under the influence of these rays is that the rate is almost independent of the potential difference. Thus when the high potential plate was 5 volts above that of the low, the rate of leak was appreciably greater than when the potential difference was 1 volt, but the rate was no greater when the potential difference was 500 volts than when it was 5. A series of experiments were made to find how the rate of leakage varied with the distance from the bulb; the bulb was placed behind a metal plate with a hole in it; it was found that in the neighbourhood of the phosphorescent glass the reciprocal of the rate of leakage was a linear function of the distance from the phosphorescent patch, but at a greater distance it diminished more rapidly than is indicated by this law. The measurements are not inconsistent with the view that the rate varies inversely as the square of the distance from a place in the neighbourhood of the *negative electrode*. Some experiments on the rate of leakage produced by the rays after passing through a varying number of strips of tinfoil seem to indicate that these rays are not all of one kind.

Contemporary Electrical Science.—The management of electric waves is making rapid progress. Herr VON LANG, in *Wiedemann's Annalen*, describes Quincke's familiar apparatus for showing the interference of sound waves passing through two branches of a tube of unequal length, except that electric waves are substituted for sound waves. As the length of one of the branches is varied, distinct maxima and minima are shown by the "coherer" employed for their detection. Filling one of the branches with another dielectric, such as paraffin or sulphur, enables the observer to determine the velocity of the waves in those substances, and hence their refractive indices. They come out rather higher than usual.——L. ZEHNDER gives one more rule for the directions and signs of the various occurrences in the electromagnetic field. It is perfectly general and very simple in form, but its application seems to require profound study.——JOSEPH VON GEITLER examines the wave systems given out by the more complicated forms of Hertz generators. He finds that for every length of the secondary circuit the primary circuit emits several wave systems of different thicknesses and intensities. He determines these intensities by means of resonators.——W. HOLTZ recalls that in 1880 he found that conductors were more opaque to the electric glow discharge than dielectrics. This result was at the time so "absurd" that he began to doubt it himself. It has now been made very probably by Röntgen's discoveries. Herr Holtz calls upon physicists to make further experiments in this direction, being himself prevented by illness from doing so.——About certain other Papers of great interest we shall have something more to say.

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THE ZUFIKON-BREMGARTEN WATER POWER TRANSMISSION PLANT.

To *l'Industrie Électrique*, of February 10th, Mr. P. Gasnier contributed a detailed description of an interesting plant for the electric transmission of water power from Zufikon, in the Bremgarten district of Canton Aargau, Switzerland, to Wohlen in one direction, and to Zurich in the opposite direction. The turbine house is conveniently situated on the river Reuss, at a place where the declivity of the stream is great, and where the sharp curvature of the course enables a considerable length of stream to be included in the available fall. The fall is improved by a weir, which has raised the head from 5·0 metres (16·4ft.) to 5·65 metres (about 18·5ft.). The bend of the river, extending some 1,300 metres (4,264ft.) along the stream on a 3·8 per cent. declivity, is artificially bridged across by a straight tunnel 350 metres (1,148ft.) in length, the upper end of which terminates in a short canal or penstock and sluice weir just above the main river weir. The plan of this mill-site is shown in Fig. 1. At the lower end of the fall the outlet from the turbine house is protected from being choked by the rush of the by-water by means of a curved discontinuous weir, as shown in Fig. 1. The tunnel and, indeed, the entire plant, has been constructed to take a maximum flow of 25 cubic metres (883 cubic ft. = 5,500 gallons) per second, but it is anticipated that in summer the flow will not exceed 15 cubic metres (3,300 gallons) per second. With the maximum flow of 25 cubic metres, the loss of head in the tunnel is 0·32 metres (1·05ft.) leaving a head available at the turbines of 5·33 metres (17·45ft.). With the lesser flow the loss of head would, of course, be less, and the available head greater. The tunnel is constructed with a regular declivity of 1·2 per cent., and with a sectional area of 13·62 sq. metres (146·6 sq. ft.). It is cemented throughout. The velocity of flow through the tunnel is 1·85 metres (6·17ft.) per second.

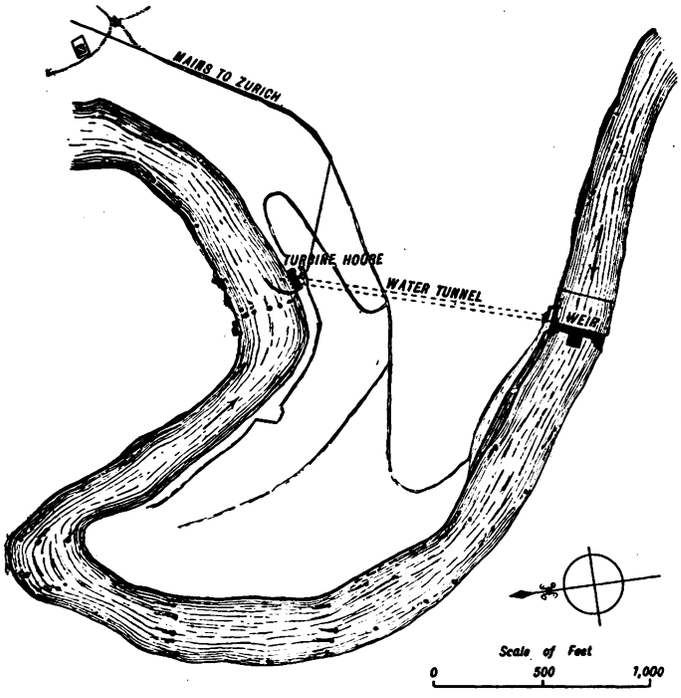

FIG. 1.—Zufikon-Bremgarten Installation. Plan of Mill Site.
Mains. Roads.

The turbine house is equipped with plant for a total of 1,300 H.P., usefully developed. There are four pairs of vertical turbines, each pair capable of developing 325 H.P. at 115 revolutions per minute. These engines were built by Messrs. Escher Wyss & Cie., whose works at Zürich are among the establishments supplied with power. Fig. 2 shows a vertical section through the power house. It will be seen that each pair of turbines is mounted on the same vertical shaft, which is carried up through the roof of the wheel pit. The admission of the water to the upper machine is downwards, and to the lower machines upwards, a balance of the reaction thrusts being obtained by this arrangement. It should be explained that beyond this equalisation of the reactions, equilibrium is further assisted by means of a plain disc on the lower engine, the upward pressure of the water on this disc serving to support the weight of the moving parts, including the dynamo. Thus the load on the footstep bearing is reduced to a minimum. The turbines are of the parallel-flow "drowned" type, and are assisted by a suction tube built into the masonry of the wheel pit.

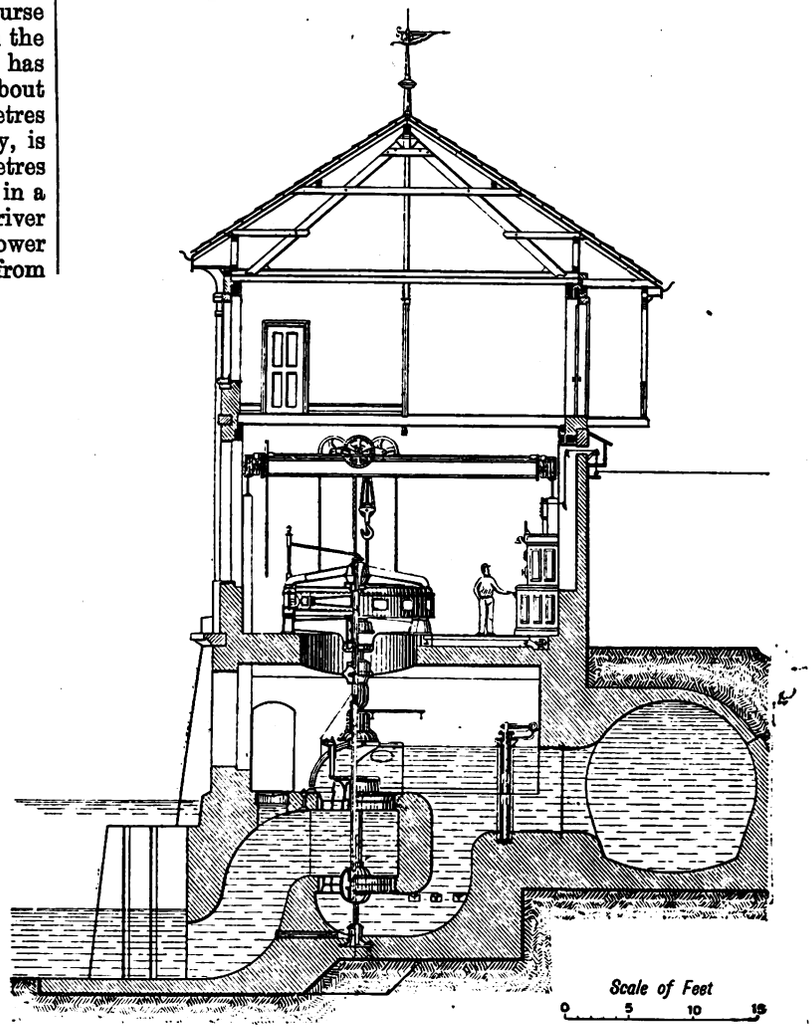

FIG. 2.—Zufikon-Bremgarten Installation. Vertical Section of Generating Station.

Built into the roof of the wheel pit, which also forms the floor of the dynamo room, are the frames of the four electric generators. These machines are constructed to develop three-phase current at 5,000 volts, the normal output from each machine being 224 kilowatts. They were built at the Oerlikon works, and have fixed armature coils, within the pitch circle of each of which rotates an inductor consisting of 52 magnet poles. There are 78 bobbins on each armature, the induced frequency being 50 per second. Each complete machine has a diameter of 3·60 metres (11·8ft), and weighs 20,000 kilogrammes (19·68 tons), the moving parts of the machine having an extreme diameter 2·984 metres (9·77ft.), and weighing 12,000 kilogrammes (11·81 tons). The four generators are excited by either of two 11 kilowatt continuous-current machines, the running machine also serving to light the buildings. The exciters are of the 4-pole Oerlikon type, and develop 130 volts at a speed of 600 revolutions per minute. They are driven by a separate little turbine of 34 H.P. by means of bevel gear and friction clutches.

The electric power thus generated is distributed as follows: The greater part is transmitted over 20 kilometres (12·5 miles) to the environs and town of Zurich, where 400 H.P. is taken

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by the works of Escher Wyss et Cie, and 250 H.P. by another large works; the remainder of the power, some 80 H.P. is transmitted a distance of 7 kilometres (4½ miles) to Wohlen, for electric light and power supply. Overhead lines are used throughout, a duplicate line of two sets of three wires being erected between the station and Zurich. A single three-wire line conveys the power to Wohlen. The wires on the Zurich lines are of 7·7mm. diameter, and on the Wohlen lines 4mm. Oil insulators are used throughout all the circuits. Crossing a railway *en route* to Zurich the lines are carried through a protecting staging, supported by light steel girders 16·5m. (54ft.) apart. The ordinary poles are 148ft. apart.

A total efficiency of 77 per cent. has been obtained on this installation. This is composed of the following items:—Efficiency of generators comprising excitation, 94 per cent.; efficiency of the Zurich lines, 85 per cent.; efficiency of transformers, 97 per cent.

THE GRAPHIC REPRESENTATION OF VECTOR POTENTIAL.

BY H. N. ALLEN (University of Nebraska).

The object of the present Paper is to show how the distribution of electromagnetic vector potential can in certain cases be represented graphically. The electromagnetic vector potential is a quantity having a fixed magnitude and direction at every point of the field, such that if any closed curve be taken in the field, and if the product of the tangential component of the vector potential into the length of the element

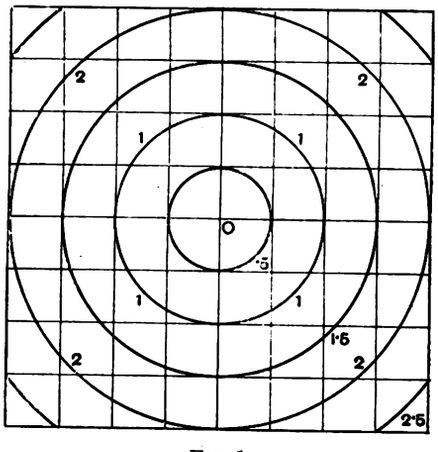

FIG. 1.

of the curve be integrated right round, the result will be equal to the electromagnetic induction through the surface bounded by the curve. The simplest example is that of a uniform field. Any line parallel to the field may be taken as having zero vector potential, and a series of cylinders, with this line as axis, will be surfaces of equal vector potential.

In Fig. 1 is represented a section at right angles to a field of unit intensity, the sectional area of each tube of induction being 1 sq. cm. The field is directed upward. Then along the circumference of a circle drawn with the point of zero vector potential as centre, and with radius r, the vector potential is $\frac{1}{2}r$, is tangent at each point to the circumference, and is in the counter-clockwise direction. For under these circumstances the integration round the curve is obtained by multiplying the constant value of the vector potential by the length of the curve. This gives $\frac{1}{2}r \times 2\pi r = \pi r^2$. This is also equal to the area of the circle, and so, since the induction is unity, to the induction through the surface.

In general the vector potential at a distance r from the origin is $\frac{1}{2}Br$, where B is the induction. In the case of infinitely long straight parallel wires the surfaces of equal vector potential coincide with the surfaces bounding the tubes of induction. The direction of the vector potential is parallel to the wires.

In Fig. 2, for example, the induction tubes due to two equal parallel currents in opposite directions are represented. Let the current on the right be directed upward at right angles to the plane of the paper. The positive direction of the vector potential will be the same. The line o C being taken as having zero vector potential, the lines on the right will have the values 1, 2, 3, &c., in order, and those on the left negative values, indicating an opposite direction.

At the two points, D and E erect perpendiculars to the plane of the paper 1cm. long, and join the extremities to form a rectangle. The induction through the surface is seen to be 5.

The vector potential at E is 3, and the integration outwards along the centimetre long side of the rectangle gives also 3. The integration from E′ to D′* parallel to the plane of the paper gives zero, since there is no component in this direction.

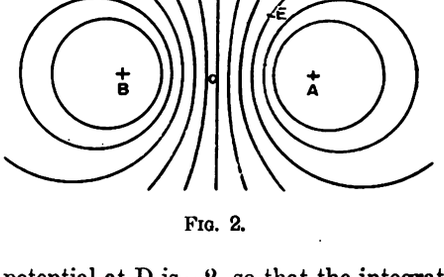

FIG. 2.

The vector potential at D is −2, so that the integration in the negative direction from D′ to D gives the value + 2. The component along D E is zero. The total integration round the boundary is then 5, the same as the induction through the surface.

In this connection Fig. 3 may be of interest. It shows the induction tubes and surfaces of equal vector potential both within and without two parallel cylindrical conductors conveying equal currents in opposite directions. Only half of one of the wires is shown, its section being indicated by the line O B A. In general the surfaces of equal vector potential do not coincide with the surfaces bounding the induction tubes. They can, however, be drawn easily when the latter can be constructed.

In Fig. 4, for example, I., II., III., IV. are lines of force, such that, when the figure is rotated about the horizontal line,

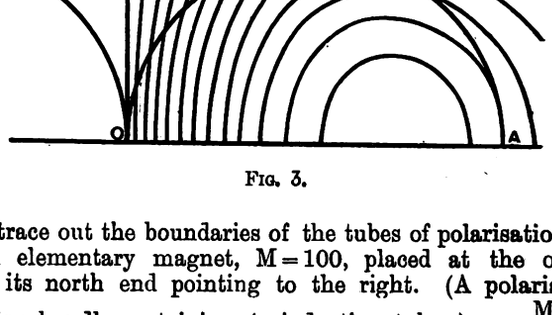

FIG. 3.

they trace out the boundaries of the tubes of polarisation due to an elementary magnet, M = 100, placed at the origin, with its north end pointing to the right. (A polarisation tube is a bundle containing 4π induction tubes.) $r = \frac{M \sin^2\theta}{2n}$ is the equation of the nth line of force.

Take a point on the line of force I., the perpendicular distance of which from the axis of symmetry is 2cm. The vector potential at this point will be unity, directed perpendicularly upward from the plane of the paper. The vector potential will have the same value at a point on the line II. distant 4cm. from the axis, at a point on III. distant 6cm., and at a point on IV. distant 8cm. If n be the number of the lines of force, and y the perpendicular distance of a point

* Points perpendicularly above E and D, at right angles to the plane of the paper.—ED. *E.*

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on it from the axis, this point, when the figure is rotated about the axis of the magnet, will trace out a circle through which pass n polarisation tubes, or $4\pi n$ tubes of induction.

The vector potential is always tangential to this circle, and has a constant value A for all points on it. The length of the circumference being $2\pi y$, the integration round the curve will give $2\pi y$ A. Since this is equal to the induction $4\pi n$, it follows that A equals $\frac{2n}{y}$. If, then, we seek on the line of force n a point the ordinate of which is equal to $\frac{2n}{A}$, we obtain a point where the vector potential is A, and continuing this for the other lines of force we obtain a series of points through

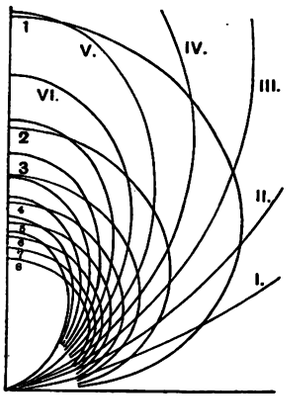

FIG. 4.

which a curve of equal vector potential, like the curves 1, 2, 3, 4 in Fig. 4, can be drawn. In this figure it can be shown that the equation of the vector potential surface A is $r = \sqrt{\frac{M \sin \theta}{A}}$. The form is the same in this case as that of the surfaces of equal scalar potential, though the axis of symmetry of these latter is at right angles to that of the vector potential surfaces.

The method described is applicable to all cases in which the lines of force can be drawn by Maxwell's method. It is hoped that it may help some to form a more tangible conception of this important quantity.

THEORY AND CALCULATIONS OF ASYNCHRONOUS ALTERNATE CURRENT MOTORS.

BY A. HEYLAND (BUDAPEST).

(*Continued from page 653*).

PART II.—MONOPHASE MOTORS.

The novelty of this simple theory of monophase motors to be developed as follows, is that *all the conclusions arrived at with regard to polyphase motors can also be applied to monophase motors.* The different conditions with which we shall have to deal can essentially be met by introducing an *apparent stray coefficient* (leakage factor) instead of the stray coefficient as previously defined

No Load.

For the present we will assume that there is perfect synchronism between the periods of the primary alternating current and the short-circuit armature.

The monophase inducing armature would in itself produce a simple alternating field, whose sense would be determined by the coils on the primary armature. This field would, however, not appear as such in the short-circuit armature turning in synchronism, since this armature passes through 180deg. during one alternation; an *intermittent field* of constant direction would result. This intermittent field would, in its turn, induce current in the coils which by their magnetising effect would counteract the pulsations of the field, so that we have in reality to deal with a field of *mean intensity*, and not with one varying between zero and a maximum. The less the resistance of the short-circuit coils, the more this opposing tendency will document itself. Where the intermittent field would exceed the mean strength, the induced currents will weaken the magnetisation; in the opposite case they will strengthen the field.

Figs. 1 to 4 illustrate the four characteristic positions of one period, as viewed from the fixed inducing armature. The

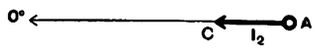

FIG. 1.

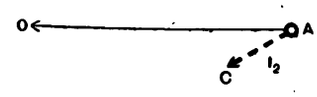

FIG. 1A.

phases of the primary currents and the positions of the short-circuit armature are indicated. In positions Figs. 2 and 4, the induced currents I_2 of the short-circuited armature flow contrary to both the primary current I_1 and to the field; the magnetising current is hence represented by the difference $I_1 - I_2 = I$. In Figs. 3 and 1, I_2 follows the sense of the field, and is the magnetising current.

For coils of small resistance the armature field will be constant. Under this supposition the rotary field can be resolved into two components at right angles to each other, the one

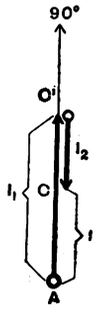

FIG. 2.

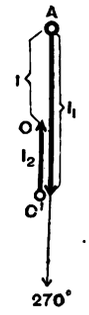

FIG. 4.

which we will call the first being $I = I_1 - I_2$ (Figs. 2 and 4), the second I_2 (Figs. 3 and 1). We will assume the magnetising effects of those two components as equal to one another. The first component, combined with the stray field, must call forth in the inducing coils an E.M.F. which corresponds to the tension K at the terminals. The second component has no influence upon the primary circuit. It only serves to produce a rotating field, by which means the primary phase component, our first component, is enabled to act as if there were a second primary phase at right angles to the first, such as exists in the

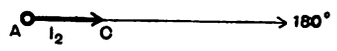

FIG. 3.

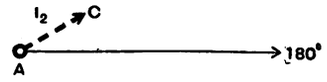

FIG. 3A.

diphase motor. If we have a synchronous diphase motor, and suddenly cut out the primary phase II., primary phase I. will continue to function, and will replace the magnetising current of the missing primary phase II. by inducing in the short-circuit armature the first-mentioned component II.

The induction currents I_2 will claim a certain expenditure of energy. Theoretically, therefore, *i.e.*, apart from losses by friction, perfect synchronism will not be attained at no load in the case

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of the monophase motor, whilst it was attained in the case of the polyphase motor. The energy absorbed by l_2 is, however, insignificant in comparison with the losses by friction; we may, therefore, state that theoretically the conditions of no load coincide with those of synchronism.

There is an essential difference between the monophase and the diphase motors, though. The current at no load, which for polyphase connections also represents the magnetising current I_1 of phase I., here rises to $I_1 = A C^1$ (Fig. 2) which is the sum of the magnetising current I. of phase I. and of I_2 magnetising current of phase II.

Indirectly I_1 becomes the magnetising current of both phases; we will therefore term it the *apparent magnetising current* of monophase motors, I^I, whilst I^M would be the actual magnetising current of polyphase motors.

With regard to I^I, we know that at positions I. and II. the armature field remains constant; in position I. the main field together with the primary stray field would be the same as with diphase connections.

If H_2 is the armature field, H_1 the primary field (main field plus primary stray field), c a constant dependent upon iron dimensions and number of coils, then in position I. (Figs. 2 and 4) $H_2 = c(i - \tau_2 i_2)$;

position II. (Figs. 3 and 1) $H_2 = c(i_2 + \tau_2 i_2)$,

and therefore, H_2 being constant, $I = I_2(I + 2\tau_2)$.

Further, $H_1 = c(i + \tau i^I)$

and $i^I = i + i_2$,

hence $H_1 = c\, i^I \dfrac{1 + 2\tau_1 + 2\tau_2}{2 + 2\tau_2}$.

As regards i^M, we know that for diphase connections

$$H_1 = c\, i^M (1 + \tau_1),$$

therefore $$\frac{i^I}{i^M} = \frac{1 + 2\tau_1 + 2\tau_2}{2 + 2\tau_1 + 2\tau_2};$$

now $$\tau = \frac{\tau_1 + \tau_2}{2},$$

$$\frac{i^I}{i^M} = \frac{1 + 4\tau}{2 + 4\tau} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

We recognise that i^I is approximately equal $2 i^M$. So far only one difference has arisen between monophase and polyphase motors; the i^M of the latter has to be replaced by a greater i^I in the case of the former. The other relations deduced for polyphase motors should also hold, provided we further substitute, as remarked above, an *apparent stray coefficient* τ^I for the stray coefficient τ, as previously defined.

We had derived

$$\tau_1 = \frac{\frac{h_1}{i_1}}{\frac{H}{i^M}} \qquad \tau_2 = \frac{\frac{h_2}{i_2}}{\frac{H}{i^M}} \qquad \tau = \frac{\tau_1 + \tau_2}{2}.$$

Analogously

$$\tau_1{}^I = \frac{\frac{h_1}{i_1}}{\frac{H}{i^I}} \qquad \tau_2{}^I = \frac{\frac{h_2}{i_2}}{\frac{H}{i^I}} \qquad \tau^I = \frac{\tau_1{}^I + \tau_2{}^I}{2}.$$

As $\frac{h_1}{i_1}$, $\frac{h_2}{i_2}$ and H have undergone no change, we find

$$\tau^I = \tau \frac{i^I}{i^M} = \frac{2\tau}{1 + 4\tau} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Motor Under Load.

The motor under load lags behind synchronism by a slip, S. We at once recognise a striking difference in the behaviour of the monophase motors. In their case, the component II. of the rotating field is carried round by the armature, as is indicated in Figs. 1A and 3A, and will hence show the same slip, S. There is, therefore, no phase difference between the armature and the component II. The explanation is that the latter component does not do any work; it simply magnetises. The slip between the armature and the component I., on the contrary, is doubled; the motor works as if the slip were 2 S, and not S.* For the further study of this peculiarity, it will be found profitable to introduce an *apparent short-circuit resistance* $W_2{}^I$. Electrically the conditions of a polyphase motor remain unchanged, as we have seen, so long as the ratio $\frac{\text{slip S}}{\text{short-circuit resistance } W_2}$ is not affected. For the monophase motor, we have to substitute $\frac{S}{W_2{}^I} = \frac{2S}{W_2}$; hence

$$W_2{}^I = \frac{W_2}{2}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The lag of the component II. finally diminishes the torque of the monophase motor. When the field of phase II. lags behind by an angle of S × 90deg., the (1 − S)th part only of the live primary turns can exercise any attraction upon the field of the armature. The pull of the motor is hence diminished by the factor (1 − S) per phase, as compared with that of an equivalent diphase motor; that is to say, if the torque of a diphase motor is Z′ per phase, its total pull therefore 2 Z′, and the pull of the monophase motor is Z^I, then

$$Z^I = Z'(1 - S). \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The work L done per phase is given by the product torque × angular velocity. The torque curve of a monophase motor will, therefore, be identical with the power curve of an equivalent diphase motor.

$$Z^I = \frac{\frac{W_1}{W_2{}^I} S}{1 + \frac{2}{f^I}\frac{W_1}{W_2{}^I} S + \frac{1 - f^I}{(1 + f^I)\epsilon_1{}^2 f^I{}^2}\frac{W_1{}^2}{W_2{}^I{}^2} S^2} (1 - S)$$

$$= \frac{a^I S}{1 + b^I S + c^I S^2}(1 - S). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4a)$$

The results may be summarised as follows:—

The characteristic of a monophase motor is identical with the characteristic of a polyphase motor with approximately *twice the magnetising current, twice the stray coefficient, and half the short-circuit resistance.*

The "approximately twice" is represented by $\frac{2 + 4\tau}{1 + 4\tau}$.

The torque curve of the monophase motor is identical with the power curve of the polyphase motor.

The apparent magnetising current is $I^I = i^M \frac{2 + 4\tau}{1 + 4\tau}$, (1)

the apparent stray coefficient is $\tau^I = \frac{2\tau}{1 + 4\tau}$, . (2)

the apparent short-circuit resistance $W_2{}^I = \frac{W_2}{2}$, . . (3)

the torque of the monophase motor $Z^I = Z'(1 - S)$. (4)

COMPARISON BETWEEN MONO- AND POLYPHASE MOTORS.

Characteristics.

We are now in a position to proceed to a comparison between motors of the two types. We will take two extreme cases—(*a*) slight straying (magnetic leakage), $\tau = 0{\cdot}0131$; (*b*) considerable straying, $\tau = 0{\cdot}0625$; and we will inquire into the changes consequent upon the variations in these coefficients.

Example (*a*) $\tau = 0{\cdot}0131$ is illustrated in Fig. 5A. The larger outer circle C C″ is the characteristic of the polyphase motor, the inner circle $C^I C^{I\prime\prime}$ that of the monophase motor of the same construction. Fig. 5B depicts case (*b*) in the same manner.

The apparent magnetising current is ..... $i^I = A C^I$.
,, actual ,, ,, of phase I.... $i = A C$.
,, ,, ,, ,, of phase II... $i_2 = C^I C$.

The characteristic of the polyphase motor is based upon the actual magnetising current i^M and τ, as $\frac{A C}{O C_c} = 4\tau$. The characteristic of the monophase motor is based upon the apparent magnetising current $i^I = i^M \frac{2 + 4\tau}{1 + 4\tau}$, and the apparent stray

* Cahen, *Elektrotechnische Zeitschrift*, 1895, No. 30, has come to the same conclusion in a different way.

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coefficient $\tau^I = \frac{2\tau}{1+4\tau}$, as $\frac{A\,C^I}{C^I O_c^I} = 4\tau^I$. The $i_2 = C^I C, C^{I'} C, C^{I''} C$ exceed the corresponding quantities of the polyphase motor by the wattless component $C^I C$. D, which approximately denotes the position of rest, is common to both circles, and signifies that at rest the two motors do not differ electrically; this must, of course, be so.

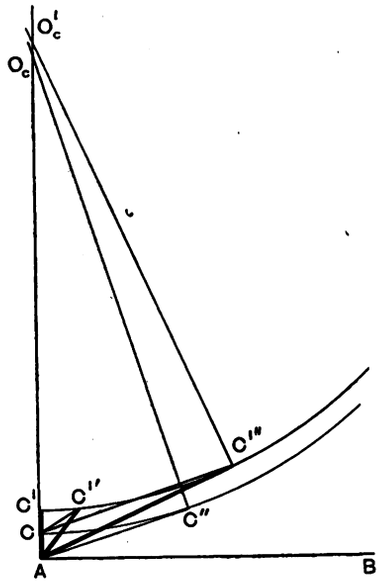

FIG. 5A.

The maximum power factor f^I can be deduced, as has been explained with regard to polyphase motors. For the latter, f would, in case (a), be:—$f = \frac{1}{1+4\tau} = 0{\cdot}95$; for the monophase motor we have $f^I = \frac{1}{1+4\tau^I} = \frac{1}{3-2f} = 0{\cdot}91$. In case ($b$) we find $f = 0{\cdot}80$, $f^I = 0{\cdot}715$.

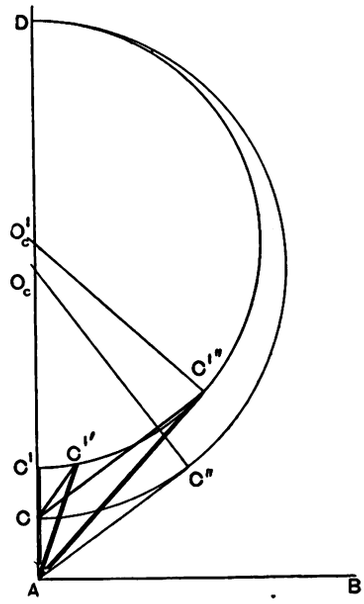

FIG. 5B.

We recognise that, for normal and for other loads, the power factor of the monophase motor will always be less than that of the polyphase motor, and considerably less for higher values. For this reason already we should strive to keep the leakage down, more so still than in the case of polyphase motors.

Torque.

The relations between slip and torque are defined by the equations—

For the polyphase motor, per phase, $Z = C \cdot \frac{a\,S}{1+b\,S+c\,S^2}$;

For the monophase motor, $Z^I = C \cdot \frac{a^I S}{1+b^I S+c^I S^2}(1-S)$, where

$$a = \frac{W_1}{W_2},$$

$$b = \frac{2}{f} \cdot \frac{W_1}{W_2},$$

$$c = \frac{1-f}{(1+f)^2 \epsilon_1^2 f^2} \frac{W_1^2}{W_2^2}.$$

For the constants a^I, b^I, c^I we have to substitute

$$W_2^I = \frac{W_2}{2} \text{ for } W_2 \quad \ldots\ldots \quad (3)$$

and

$$f^I = \frac{1}{3-2f} \text{ for } f. \quad \ldots\ldots \quad (5)$$

In order to establish a comparison between the motors of the examples (a) and (b), we will presume that they develop, as polyphase motors, the same power, the same normal slip S_{norm}, and the same normal torque Z_{norm}. We should then have, in both cases, $S_{norm} = 4$ per cent.

$$Z_{norm} = 1$$

$$\frac{W_1}{W_2} = 0{\cdot}80.$$

Examples of torque curves for both of these cases are given in Fig. 6.

For motor (a).—Z_a is the torque curve of the motor as *polyphase motor* ($\tau = 0{\cdot}01315$); Z_a^I the curve of the motor as *monophase motor* ($\tau^I = \frac{2\tau}{1+4\tau} = 0{\cdot}025$).

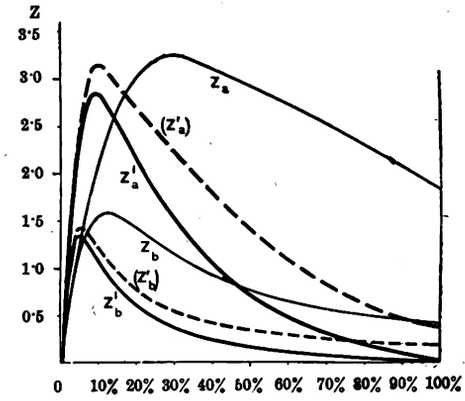

FIG. 6.

Z_a' would be the torque curve of the equivalent polyphase motor, as defined above, whose power curve would be given by

$$Z_a'(1-S) = Z_a^I.$$

For motor (b).—Z_b is the torque curve of the motor as *polyphase motor* ($\tau = 0{\cdot}0625$); Z_b^I the same of the *monophase motor* ($\tau^I = \frac{2\tau}{1+4\tau} = 0{\cdot}10$).

Z_b' would again be the torque curve of the equivalent polyphase motor whose power curve would be determined by $Z_b'(1-S) = Z_b^I$.

On comparing the curves Z_a^I and Z_a, and Z_b^I and Z_b, we observe that for small slips the torques of the motors of the two types vary in approximately the same manner. The torque of the monophase motor reaches its maximum, which is less than that of the other type, at a comparatively small slip. Beyond its maximum, the torque of the monophase motor decreases suddenly and rapidly; for a slip $S = 1$, the torque is zero. This rapid decline in the torque is brought about by the factor $(1-S)$, and further by the term $c^I S^2$ in the formula for Z^I. In case (a) $c^I = 92$, whilst $c = 11{\cdot}4$; case (b), $c^I = 330$, whilst $c = 70$.

Excessive Loads.

The capacity for taking excessive loads is: For motor (a), 2·84 ($S = 10$ per cent); for motor (b), 1·35 ($S = 5$ per cent).

These numbers demonstrate that the monophase motor behaves in this respect like the polyphase motor; the capacity increases when the stray decreases. The highest capacity will

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be realised in the case of the ideal motor, where there is no stray field. For this ideal motor, there would be $\tau = \tau^I = 0$, $f = f^I = 1$, hence $c = c^I = 0$; the torque of the ideal motor would be $Z = C \cdot \frac{aS}{1+bS}$, and that of the *ideal monophase motor*

$$Z^I = C \cdot \frac{a^I S}{1+b^I S}(1-S) \quad . \quad . \quad . \quad . \quad (4B)$$

Fig. 7 traces this curve, likewise for $S_{norm.} = 4$ per cent. The capacity of the ideal monophase motor for taking excessive loads proves to be 5·25 (S = 30 per cent.). The assertion that the highest capacity will be obtained with the least straying is thus confirmed.* Electrical considerations as well as the mechanical efficiency render it advisable, therefore, to prevent so far as possible all straying; the rule holds for monophase motors still more than for polyphase motors.

Comparative Dimensions.

So far we have regarded the monophase motor as arisen from the diphase motor by the elimination of one of the two phases. In such a motor only half the space available would be covered with coils; the apparatus would give incomplete satisfaction only. The torque of the motor would be inferior to that of the original diphase motor. In other words, for equal power such a motor would have to be built *more than twice as large as a* polyphase motor.

In practice we shall either make use of a large portion of the space, leaving a small portion for auxiliary starting coils, or we fix coils all round, dispensing with automatic starting.

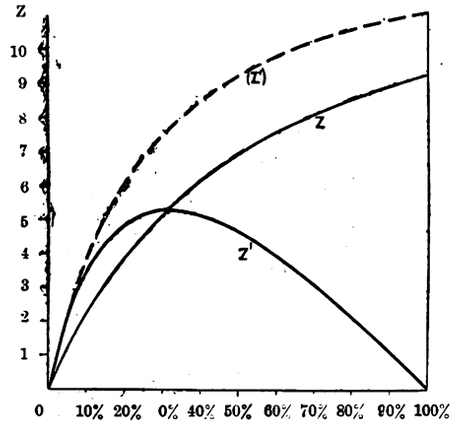

FIG. 7.

If we cover $\frac{2}{3}$ of the core with coils, we may consider the motor as a triphase machine, one of whose three feeders has been disconnected. If we cut out the third phase the current will be reduced to $\frac{\sqrt{3}}{2}$ of its value, and the power absorbed to

$$A_1^I = K\frac{\sqrt{3}}{2} i_1 = \frac{\sqrt{3}}{2} K i_1 = \frac{A_1^M}{2},$$

that is, to half the power of a polyphase motor. In other respects such a motor would resemble those considered above.

But we can keep the ampere-turns up to their full value by applying fewer turns of larger cross-section; the power can thus be augmented by $\frac{2}{\sqrt{3}}$. The motor would now do $\frac{1}{\sqrt{3}}$ as much as originally, and to have *equal power* at disposal the monophase motor would have to be designed $\sqrt{3}$ times as large as a polyphase motor.

A monophase motor which is fully wound may be likened to a diphase motor whose two windings have been connected in series. In this instance, the current would be reduced to $\frac{1}{\sqrt{2}}$ and A^I would become $\frac{A_1^M}{2}$. By judiciously arranging the coils, we can increase the current to $\sqrt{2}$ times its intensity and bring A_1^I up to $\frac{A_1^M\sqrt{2}}{2} = \frac{A_1^M}{\sqrt{2}}$. Here, again, the dimensions of monophase motors would have to be increased in the ratio $\sqrt{2}:1$ this time, in order to render the motor equal to a polyphase machine.

In general, we may say that *a monophase motor has to be constructed about half as large again* in order to do as much work as a polyphase motor.

On the whole we shall do well to make the monophase motor rather large. We need space for starting coils, and we have learned that the stray field should be reduced to its possible minimum; both conditions demand ample dimensions.

A monophase motor, which is correct as to the stray field, enables us to secure a strong starting torque with the help of an auxiliary phase. A glance at the curves Z_a^I and Z_a will show this. The auxiliary phase has to create a rotating field. The more perfect this field, the more the starting torque of Z_a will manifest itself.

* It has several times been stated (G. Kapp, "Transmission of Power," and others) that a considerable stray field is essential if the monophase motor is to do work. Those authors have fallen into an error when, in replacing the field of a monophase motor by two equal rotating fields, they did not consider that the one of these rotating fields tends to vanish for small slips.

THE CONSUMPTION OF CARBON IN AN ELECTROLYTIC CELL.

A noteworthy Paper by Dr. Alfred Coehn was recently read before the German Electrotechnical Association and printed in the *Elektrotechnische Zeitschrift*, from which we transcribe its essential argument. It deals primarily with the question whether carbon is competent to form ions and thus take active part in an electrolytic circuit; in other words, can carbon be caused to dissolve from an anode in the manner characteristic of a metal? An observation bearing on this point has been made by Bartoti and Papasogli, who found that on passing a current between carbon electrodes immersed in dilute sulphuric acid, both carbon monoxide and carbon dioxide appear at the anode, in addition to oxygen, whence it follows that the anode takes an active part and suffers oxidation. Dr. Coehn has attempted to extend this result by varying the concentration, temperature and current density so as to induce complete suppression of oxygen at the anode and its replacement by products of the oxidation of carbon, and he has so far succeeded that the gas escaping at the anode may consist substantially of 70 per cent. of carbon dioxide and 30 per cent. of carbon monoxide. A small quantity of oxygen (about 1 per cent.) is, however, usually present. In these researches it was noticed that at moderate temperatures disintegration of the anode occurs, and particles of carbon appear in suspension in the electrolyte. At higher temperatures this disintegration does not take place, but a significant coloration of the acid is perceptible. The liquid is at first yellow, and, in longer trials, becomes dark red and red-brown in colour. If this colour be due to dissolved carbon, it may fairly be concluded that the carbon is in the ionic state and dirigible by the current.

Seeing that the carbon thus present is not capable of decomposing water, the solution containing it should be in a condition to deposit the carbon at the cathode. Experiment bears out this deduction, for on substituting a platinum for a carbon cathode, carbon is deposited thereon in the manner characteristic of a metal. The first film of carbon exhibits the colours of thin plates, but as the deposit thickens it becomes black and graphitic. The phenomena of solution and precipitation can be obtained with various forms of carbon, including carbon rods for arc lighting and blast furnace coke.

After obtaining this remarkable result, Dr. Coehn took care to ascertain that the deposits formed in the manner described are really carbon and not some metallic impurity derived from the anode. The deposited material is insoluble in hydrochloric acid, slightly soluble in boiling nitric acid—recalling in that respect the behaviour of carbon in steel upon which is based the Eggertz colorimetric method of determining carbon. The film disappears completely on heating in contact with air. A determination by combustion (such as is practised in ultimate organic analysis) suffices to establish the belief that the deposit is chiefly carbon, associated, however, with

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oxygen and hydrogen in the proportions to form water, and thus to be regarded as hydrated. This hypothesis is borne out by the behaviour of the film with strong sulphuric acid, which acts upon it much as if it were a carbohydrate.

The establishment of these facts led Dr. Coehn a step farther. To construct a cell capable of yielding electrical energy by the oxidation of carbon, it is necessary to find a cathode electronegative to the carbon, which has to function as anode.

Lead peroxide, in the form of a plate from a secondary cell, fulfils this need. When such a cathode is opposed to a carbon anode in a bath of sulphuric acid of the right temperature and concentration, a primary cell is obtained in which the carbon is the material attacked; a cell made in this manner gives a voltage of 1 03 on a circuit having an external resistance of 100 ohms. [Dr. Coehn does not state what fraction of the total energy appears as electrical energy.]

The question now arises, how far the results recorded are really due to carbon acting as a soluble anode. Platinum, when opposed to lead peroxide in a sulphuric acid electrolyte, becomes an anode, and gives a current which, however, decreases to a vanishing point as soon as the platinum electrode has acquired its complement of oxygen. No such arrest of the output of a carbon-lead peroxide cell takes place. Current is obtained until the cathode is exhausted, and the cell regains it efficiency when a fresh plate of lead peroxide is supplied.

Dr. Coehn ends his Paper by the following conclusions :—

1. It is possible to prepare a solution of carbon by electrolytic means.

2. Carbon can be separated from such a solution at the cathode.

3. A cell may be made having its soluble electrode of carbon.

PUBLIC LIGHTING BY ARC LAMPS.*

BY ANDRÉ BLONDEL.

The problem of the distribution and diffusion of light[1] from whatever source is an interesting study. If we consider only gas[2] or incandescent electric lamps, the question of diffusion has but a secondary importance, and that of distribution is the most prominent one; with the electric arc, on the contrary, good diffusion is quite as necessary as good distribution. The study of the electric arc thus brings the problem under consideration the most completely before us. I shall deal more especially with continuous-current arcs, seeing that they have, up to the present, been the most frequently used, though I shall treat in some detail of the problems of the alternating arc. I purpose making a close examination of the means actually employed in the production and utilisation of this source of light, indicating possible improvements. To this end it is necessary, first of all, to consider the arc lamps and accessories at present in use on public thoroughfares.

I.—GENERAL REMARKS.

LAMPS.

Notes on Arc Lamps from the Point of View of Production of Light.—An investigation of the construction and action of arc lamps is foreign to my subject. The lamps most generally used for public lighting, whether for continuous or alternating currents (Brush, Thomson-Houston, Brockie-Pell, Crompton-Pochin, Cance, Bardon, Siemens, Pilsen, Brianne, Pieper, Helios, Piette and Krizit, and Zipernowsky) are well known in their respective countries, and give almost equally good results so far as steadiness of working is concerned. The only point to which I would draw attention here is the economic value of arc lamps as instruments for transforming electrical energy into light.[3] This economic value may vary between wide limits according to the way in which the lamps are connected and the methods adopted in their management.

First as to the grouping of lamps; this question, properly speaking, belongs to the question of distribution of currents. I will only note in passing that to obtain steadiness in the arc necessitates the use of a resistance in series with it, and in consequence a certain loss in voltage. This loss varies according to the number of lamps in series and its *relative* value is less as the lamps are more numerous. For a single arc the loss may be 10 to 15 volts (that is to say, a voltage of 60 is necessary, although not more than 44 or 45 volts are consumed in the arc), while two arcs in series are easily run off 110 volts and four off 220-volt circuits (as is done in Paris). Again, on a five-wire system, with 440 volts between the outers, eight or even nine arcs can be connected in series, as is the case in the Avenue de Clichy. The corresponding loss of energy is, therefore, proportionately less, as we use a greater number of lamps in series. Hence, to obtain light in the most economical manner possible, the circuits should be arranged in this way. Distribution by constant current on the Brush, Thomson-Houston, and similar systems is, from this point of view, evidently most advantageous, but the lower efficiency of the special machines necessarily employed cancels the gain. Besides, it is more expensive to use special machines for arc lighting. It is far better where possible to connect up the public arc lamps to the existing circuits, taking care only to connect them in series between the conductors between which there is the highest

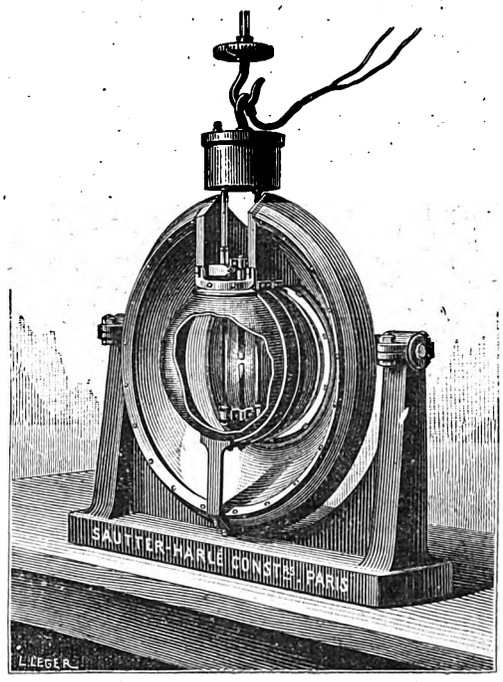

FIG 1.—Lumen Meter for Measuring the Total Luminous Flux of an Arc Lamp.

difference of potential. The alternating arc, to which I shall refer later, offers a slight advantage so far as stability is concerned, for it may be rendered stable by the use of impedance coils consuming but a small quantity of energy.

As to the management of lamps and sizes of carbons, I wish particularly to draw attention to the fact already mentioned in my "Theory of Public Lighting" (*The Electrician*, November 15, 1895, page 92), that the choice of carbons plays a most important part in the luminous output. For equal currents an increase in the length of the arc, or a diminution in the diameter of the carbons in continuous current arcs, increases the luminous flux produced[4], which is easily explained, seeing that more of the positive crater, the actual source of the light of the arc, is exposed. Prof. Carhart found with a certain lamp a maximum efficiency with 55 volts, and a decrease with any variation. I myself have observed similar results. But in practice other considerations limit us in this direction. On the one hand the length of the arc must not exceed, say, 4 to 5 millimetres, corresponding to 45 to 50 volts, for beyond that the arc becomes unstable, and gives a flaring arc, which consumes the upper carbon very rapidly, and may even damage the rods, &c. On the other hand, the reduction in the diameter is limited by the rapidity with which the carbons are consumed, which according to some writers[6]

* From *La Révue Technique*. Translated by Mr. John Hesketh.

[1] *See* "Street Lighting by Arc Lamps," by A. Blondel, *The Electrician*, Vol. XXXV., p. 646, *et seq.*

[2] This does not apply to the light from an Auer burner, for which diffusion is very desirable.

[3] I am for the moment only considering continuous-current arcs, reserving for later treatment the more difficult and very indifferently-treated questions involved in the consideration of the alternating arc; the conclusions will nevertheless be general

[4] It is not absolutely so with the alternating arc.

[5] See *Comptes Rendus du Congres des Electriciens à Chicago*, 1893.

[6] Marks. *The Electrician*, Vol. XXV., p. 150, June 13, 1890. It appears rational to expect the consumption to be inversely proportional to the section. The volume of the carbon consumed in a given time would then be independent of the diameter. This law seems to have been established by the numerous experiments made by M. Sabouret at the Gare d'Orleans.

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varies almost inversely as the section. The advantage of small diameters is no longer doubtful. Herr Schreihage[7] who made the first experiments on this subject, found that the mean spherical candle-power is almost inversely proportional to the diameter of the carbon. For the purpose of making more rapid measurements on these points I recently invented an instrument "The Lumen Metre" (Fig. 1) which allows either the total luminous flux, or the hemispherical flux of an arc, to be obtained by one measurement. By the aid of this instrument, M. Jean Rey[8], for instance, obtained the following results when comparing a pair of carbons 21 and 13 millimetres in diameter with a pair of 14 and 8 millimetres.

Table I.

Amperes.	Volts.	With carbons 21 and 13mm.		With carbons 14 and 8mm.	
		Flux obtained in lumens.	Spherical intensity, pyrs per watt.	Flux obtained in lumens.	Spherical intensity, pyrs per watt.
20	44	7·900	0·70	21·330	1·92
25	44	9·430	0·68	33·830	2 43
30	45	12 270	0·72	46·330	2·72
35	46	28 100	1·38	61·330	3·03

These arcs are too powerful for ordinary uses, but the table clearly shows that the efficiency is trebled by the use of small carbons.

Similar results have been obtained from tests of the author as will be seen latter on.

Few engineers think of this fact, and those who are aware of it do not believe that the effect is so very marked, and therefore do not take any trouble to improve existing methods. These are inspired wholly by considerations of the consumption of carbon. It is imperative that a lamp shall work the longest nights without renewal of carbons. Hence, lamps burning from 14 to 16 hours are indispensable. To attain this object lamp makers first of all increased the stroke of the lamp and the length of the carbons, but they restricted themselves quite unnecessarily by keeping the carbon-holders within the ordinary globes, which are 35 to 40cm. in diameter. The result was that even after placing the source of light right at the top of the globe—a very unhappy expedient, since the eye instictively looks for it at the centre—they were not able to use very great lengths of carbon, and were consequently driven to the device of increasing the diameter. In France it therefore happens that carbons of enormous diameters are employed. For instance, on the main boulevards the carbons are respectively 17mm. in diameter and 250mm. long, and 12mm. in diameter and 220mm. long. On the Avenue de Clichy, we find 18mm. and 12mm. with lengths af 160mm. and 200mm. In both cases 10-ampere lamps are used. In England the same diameters are used in the Crompton-Pochin lamps. In America 16mm. and 12mm. are used. Under such conditions, the crater from which the light is emitted eats right into the positive carbon instead of being quite open, and is therefore too much hidden by the negative carbon. To show how unnecessarily great are ordinary sizes adopted for carbons, I may mention that in French electric lighthouses, where everything possible is done to obtain the best efficiency, carbons of 10mm. are used for currents of 25 amperes. That is to say, there is a current density eight times that in use on the Avenue de Clichy! The blame for this state of things does not rest with the engineers, but almost entirely with the lamp makers. They sometimes, it is true, make praiseworthy efforts to alter this absurd state of things, by increasing the length of carbons and slightly lessening their diameter. For instance, the 1891 type of the Bardon 16-hour lamp used 15mm. and 10mm. carbons, 280mm. and 260mm. long respectively. This tendency is an excellent one, and deserves to be followed, especially in the direction of the reduction in the size of the negative carbon. But enough has not yet been done, and we must not be satisfied until the diameters of carbons for 10-ampere lamps has been reduced to 10mm. and 7 or 8mm. The experience of Messrs. Siemens shows that 10-ampere lamps may be worked with 10mm. positive carbons and 3mm. negatives. The latter, however, is rather too small. More generally the maximum diameter of the carbon in millimetres should not exceed the number of amperes.

Two methods of obtaining this result are available. The first is to increase the travel of the carbon holders, and let the lower holder pass through the globe. Under these conditions a travel of 50cm. for each carbon is not impossible; carbons of this length can easily be made and used, as is shown by lighthouse experience, where carbons of 45cm. are used. All that would be necessary would be to arrange the lamps and their pillars accordingly, narrowing the lower ends of the guides so as to allow the carbon holders to pass into a small cylinder fixed on the lamp-post. If a lantern be used the arrangement is still easier, for nothing prevents the rods from dropping into the shaft of the lantern. A second solution, and one already applied with success in England and America, is to use double carbon lamps, the second pair of carbons being brought into use when the first pair is burnt out. We thus have a length of carbon double that of the travel of the holders.[9] We are indebted to the ever practical American for the first double-carbon lamps, of which the best known are the Thomson-Houston and the Brush (Fig. 2), which are also employed in many European installations. But unfortunately these lamps are non-focussing, so that the arc is sometimes at the top and sometimes at the bottom of the globe, In America, where clear glass globes are mostly used, the public are too dazzled by the arc to notice its position, but under diffusing globes this variation in the position of the arc is insupportable.[10] In England, where the movement in favour of double-carbon lamps has been well taken up, a much more satisfactory focussing lamp has been obtained. The Crompton-Pochin (Fig. 3) and Brockie-Pell lamps, between which there seems to be but

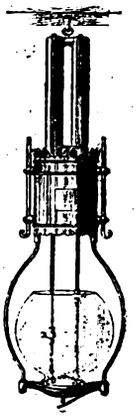

Fig. 2.—American Non-focussing Double-carbon Lamp.

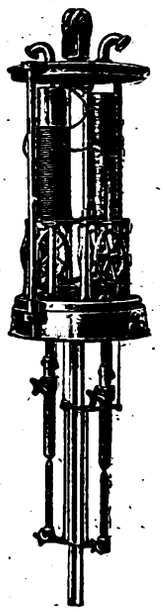

Fig. 3.—Crompton-Pochin Double-carbon Lamp.

little difference of principle, are constructed for either one or two pairs of carbons, for 16 or 32 hours. The following are the particulars of the carbons used in the 10-ampere lamp (which I shall always consider as the standard of comparison.

Table II.

Type of lamp.	Carbons.				Duration in hours.
	Positive.		Negative.		
	Diameter	Length.	Diameter	Length.	
Crompton-Pochin	18	300	12	200	16 or 32
Brockie-Pell	13	360	12	220	16 or 32

It would seem, however, that the real advantage of the double-carbon lamp is not yet understood; the object with which they are now principally used is to reduce the number of attendances of the lamp trimmer from once daily, as in Paris, to once every two days. It appears to me that the aim in view should be quite different. Double-carbon 16-hour lamps with carbons of reduced section should be used, and the carbons should be changed daily.[11] An

[7] *Centralblatt für Electrotechnik.*

[8] *Bulletin de la Société Internationale des Electriciens*, May, 1895.

[9] Even assuming that carbons of the same large diameter are still used this solution of the problem, which complicates the mechanism of the lamp a little, has a practical advantage over the preceding, for it allows the carbons to be used up to the end without any fear of the lamp going out when most wanted. With the ordinary system it is either necessary to use different lengths of carbon for different seasons, as is done in some districts of Paris, or to carefully preserve the partly burned carbons during each night of a given month to be used up during one night six months later, as is done in other parts of Paris. We can easily see the complications which it involves. With double carbon lamps, on the contrary, the same kind of carbons are always used, the interval between their renewal being the only variable.

[10] It is, of course, understood that I am speaking here of lamps with two *independent* pairs of carbons. The others, which were detestable, are happily scarcely used at all at the present time.

[11] In this case the advantage of using the carbons to the end is lost.

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enormous quantity of light would then be gained without the service being in anyway complicated, and with no increase in expense at all comparable with the benefits obtained. In France, unfortunately, no steps have been made in this direction, for there are no double-carbon focussing lamps on the market.[12] Surely the day will come when engineers will fix in their specifications on a maximum allowable diameter of carbons; or, which will amount to the same thing, a minimum current density. The contractor will then be limited in his choice, and must choose between the two solutions we have just indicated, or some other attaining the same result.[13] It is no exaggeration to say that this simple change in the size of carbons would allow more light to be obtained from an 8-ampere arc than is now given by one taking 10 amperes.

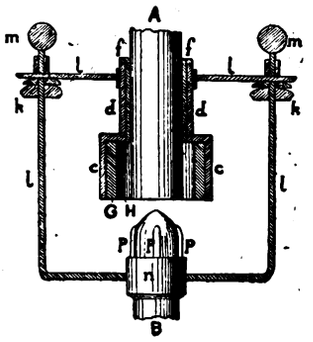

FIG. 4.—Hardtmuth's Carbon Economiser for Continuous-current Arc Lamps. H, Air Chamber. *f* and G, Lining of Refractory Substance. *c*, *d*, Metal Sheath.

M. Sabouret, of the Compagnie d'Orleans, who has long taken an interest in the question of the important waste caused by the use of single-carbon lamps for railway station lighting purposes,[14] has invented an ingenious arrangement for easily changing almost all the existing types of single into double-carbon lamps without adding to the ordinary mechanism, increasing the economy of the carbons from 60 to 90 per cent. Fig. 5 shows M. Sabouret's invention applied to a Siemens ribbon lamp, made in France by the Société Alsacienne de Belfort, and in use on the Avenue de Clichy in Paris and on the main boulevards. The two drums C_1 and C_2 are loose on the spindle A, which receives the regulating motions. The arm B is fixed to the spindle A; it carries two projections D_1 and D_2 moved by springs which encounter the studs T_1 and T_2 on the drums D_1 and D_2. In Fig. 5 the arrangement is shown at the moment when the ribbon 1, nearly at the end of its stroke, comes in contact with the trunnion arm T. The spindle A is carried round by the weight of the carbon attached to band 1. Drum C_2 does not unroll, its band being gripped by T; moreover, during the rotation of the drum C_1, the projection D_2 escapes the stud T_2 of the drum C_2. But from the moment when band 2 is freed, drum C_2 is carried round by its carbon, and it, in its turn, rotates the spindle. Band 1, when it has run its course, keeps drum C_1 immovable. The Siemens lamp is non-focussing, but the same appliance can be used with focussing lamps. MM. Sautter et Harlé are going to apply it to their brake lamps, such as are used on the Sceaux line. It may, therefore, be hoped that before long we shall see some trials of double-carbon lamps for public lighting in France.

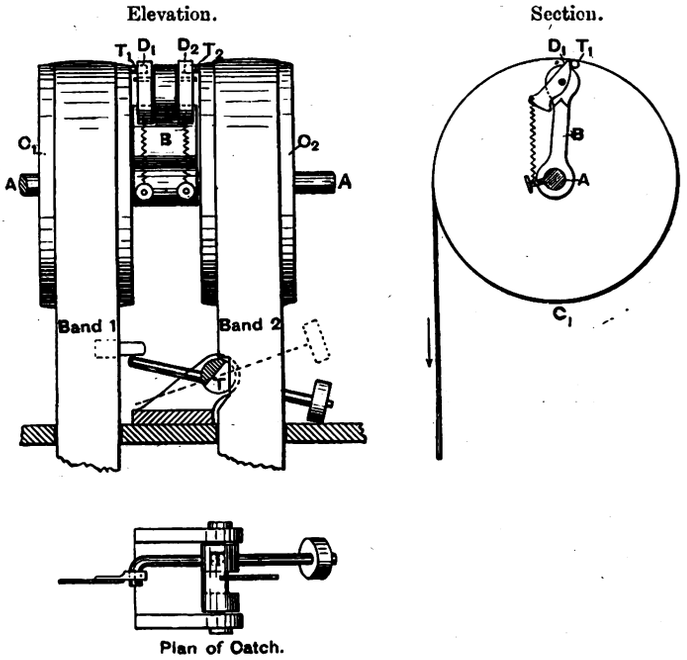

FIG. 5.—Sabouret Arrangement for Transforming Single into Double-carbon Lamps.

There is still another point to be discussed here, and that is the current to be used. Large arcs give a better efficiency than small ones. The subject was treated superficially in my "Theory of Public Lighting" (*The Electrician*, November 15, 1895, page 89), but sufficient experimental data is lacking to enable me to discuss the subject in the present paper. I intend to discuss it fully in a near future.

(To be continued.)

Arc Lighting by a Tramway Power Station.—A somewhat interesting piece of street arc lighting came into operation in Paris at the beginning of the month. The thoroughfares concerned are the Avenue de la République and the Avenue Gambetta, and the lighting is carried out by 108 Eck arc lamps. Along a portion of the Avenue de la République the posts are placed on refuges in the middle of the road 40 metres (130ft.) apart; elsewhere they are arranged in *quincunx* on the pavements. Current is supplied from the power house of the Paris-Romainville electric tramway, the lamps being nine in series across the 500 volt mains. In the base of the pillar of the leading lamp of the series there is a special switch and regulating rheostat controlling the group; in addition each lamp is provided with a resistance of 4 ohms, which is automatically switched into circuit should the lamp by any chance fail,

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[12] Since writing these lines Messrs. Tresel, 7, Rue du Perche, have introduced a simple and practical double-carbon lamp, some of which are already in service at the Lyons and Orleans railway stations. The mechanism is the same as for a single pair of carbons; the two pairs are parallel, but one of the carbons of the second is out of alignment, and only comes into line after the first pair has burnt out.

[13] Other solutions to increase the life of carbons without lengthening them have been suggested. Flat carbons have been tried, offering a large surface without any additional thickness, but with these carbons the arc constantly shifts, and the result is bad. Carbon discs placed at right angles to each other, and slowly revolved at the same time as they approached have been tried. The arc naturally occurs at the shortest gap, so that its position is very definite, but such an arrangement is too delicate. The shielding of the light plays too important a part, and the continual movement of the incandesced particles evidently lowers the efficiency. Another interesting method which has often been tried is to enclose the arc in a globe as air tight as possible, so that the combustion of the carbons may be retarded. This arrangement, which has already been invented many times, and which was last invented by Mr. Marks in America, is very attractive. In practice it was found that the carbons were not shaped so evenly, and that the globe was rapidly covered with a non-transparent deposit due to the condensation of the saline residues contained in the carbons, and of the carbon vapour from the arc. Even when pure carbons are used this last inconvenience is not overcome, so lamps fitted with sealed globes have not been a practical success. The life of carbons has been lengthened by dipping them in a bath of metaphosphoric acid, which retards combustion in a very marked manner, or by electrolytically coating them with copper or zinc, which at the same time augments their conductivity. This last device markedly increases the price of the carbons. As to the results obtained, opinions are very divided. My own experience is rather unfavourable, the copper plating causing accidental extinctions; if, in fact, a drop of copper falls through the arc and volatilises, the current suddenly jumps by way of the low resistance path so formed and leaves the arc, which goes out. Messrs. Hardtmuth have recently placed on the market a protection for the positive carbon consisting (Fig. 4) of a tube of refractory matter encircling the end of the carbon and preventing combustion. The economy is very great, but there is a difficulty in keeping the tube always at the desired height. According to trials made at Vienna (*Elektrot. Zeit.*, November 15, 1894), the luminous flux is very little reduced by the use of this instrument, while the consumption of carbon varies in the following proportion for a 6-ampere lamp.

	+ carbon (16mm.)	− carbon (11mm.)
Without protector.....	14·1cm.	15·5cm.
With protector	4·9cm.	10·0cm.

These figures are of course to be accepted with reservations, being the result of the inventor's trials. Not being able to procure the apparatus in France, I have not been able to verify the results. The device appears to have given good results in the trials in the Edison sector.

[14] The question of the losses on account of carbons is not important in towns where 1fr. or more is paid per kilowatt-hour for the energy, but it plays a very important part in railway station lighting, where the energy is produced at a much lower figure. At the Gare d'Orleans, where the cost of energy is less than 0·25fr. per kilowatt-hour, the cost of carbons is one-quarter or one-third the cost of fuel.

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ENGINEERING CHEMISTRY.

Much has been said and written lately about the interdependence of chemical and electrical theory, and on the connection between chemical phenomena and the electrical condition of atoms. It may be of interest, therefore, and it is certainly natural, to turn our attention to the practical side of the matter, and to examine some of the relationships which exist between chemistry and electro-technics and engineering. For convenience we shall include electro-technics in the greater subject of engineering, of which it is naturally a part. The oft-repeated definition of engineering which has been immortalised by the Institution of Civil Engineers in its Charter would become tiresome from frequent repetition if it were not so profoundly true. "The art of directing the forces of Nature for the use and convenience of man," covers every branch of the profession, except perhaps the military branch, which someone has profanely defined to be "the art of directing the forces of Nature for the abuse and inconvenience of the other man." We have only to compare an accurate definition of chemistry with that of engineering just given, in order to discover that technical chemistry falls completely under that head. If chemistry is the science of the composition of substances and the changes which they undergo, it is to be noted that to these very changes mankind owes the manifestation of some of the most potent "forces of Nature," and also that almost all the forms of energy in Nature are applied in bringing about commercial chemical reactions "for the use and convenience of man." Thus does chemistry aid engineering on every hand; and engineering repays the debt by affording means for carrying out chemical industries on a commercial scale.

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A survey of the various ways in which engineering is aided by chemistry will show that these fall under two heads: first, the chemistry of energy; second, the chemistry of structural materials. By the chemistry of energy we mean those processes by which any form of energy is chemically generated or stored for useful purposes. Practically the whole of the energy used in the industries of the world is derived from chemical processes directly under human control. The estimation of fuels, their preparation for use in boilers and gas engines; the detection and treatment of injurious and of valuable constituents; the selection of boiler waters and their treatment when unsuitable; the choice of materials for primary and secondary batteries, are instances of the influence of chemistry in this relation.

The chemistry of structural materials is even more varied and extensive than that of energy. In an excellent work, entitled "Chemistry for Engineers and Manufacturers," by Messrs. Bertram Blount and A. G. Bloxam, which has recently come into our hands, the authors aptly state that "the permanence of a given structure and the degree in which it is fitted for its use do not depend exclusively upon the mechanical strength of the materials composing it, but are largely influenced by the chemical composition of these materials and by the chemical conditions to which they are exposed." We are not now concerning ourselves with chemical processes for manufacturing materials, but with the light which chemistry throws upon the suitability or otherwise of any given material for any given purpose. To cite a few examples: we are enabled to select bronzes and other materials for the bearings of shafts in machinery, and lubricating materials which shall not act chemically upon them; we decide upon materials for the foundations and superstructure of our buildings according to the chemical conditions to which they will be subjected; preservative compounds, coatings, electro-plating, &c., owe their existence largely to chemical considerations. The art of directing that terrible force of Nature—decay—so that it shall not render our machinery or our buildings useless, is not the least important branch of engineering.

Turning now to the contrary side of the question, we discover no less widespread activity in the assistance which engineering affords to the processes of commercial chemistry. Superfluous it might seem to mention particularly the aids of the building engineer, in the construction of furnaces, vats, &c.; or of the mechanical engineer, in adapting boilers, furnaces and other plant for directing energy to the chemical process in hand. Let us narrow the consideration down somewhat, and speak only of the applications of electrical engineering to these ends. And here, too, it will be convenient to classify our matter under two heads, each relating to a distinctly different type of chemical process. We refer to what are technically known as the "wet processes" and the "dry processes." Formerly, commercial chemistry was carried on exclusively by wet methods, by electrolysis from aqueous, alkaline or acid solutions at ordinary temperatures, or at any rate not at furnace temperatures. The electro-plating of wrought goods constituted the principal branch of this industry; but at a comparatively early date Messrs. Siemens and Halske introduced an electrolytic process for obtaining copper from the pyrites, the ore having been previously leached with a solution of ferric sulphate; and one of the earlier applications of electricity to metallurgy by the wet way was in the extraction of gold by cyanide processes. At the present time, the number and importance of the wet electrolytic processes for extracting metals and for the manufacture of chemical compounds, such as caustic alkali and bleach, chlorate of potash, &c., rank much higher than formerly; but it is in the direction of dry processes that the most startling of recent developments in electro-chemistry have taken place. An interesting and promising development of electrolytic wet process in sanitation, however, should not escape notice. We refer to the Hermite process, which has met with considerable success at Ipswich and in other towns. Among electrolytic dry processes we may mention the extraction of aluminium from its ores in the electric furnace, and the discovery and subsequent manufacture of carborundum and calcium carbide by means of the same furnace. Electrical dry processes in metallurgy have, however, been confined principally to the production of metals which have hitherto resisted extraction by ordinary furnaces, the high cost of electrical energy having rendered prohibitive its application to older and more common metallurgical work. Perhaps the time may come when the work of the blast furnace, the puddling hearth and the converter will everywhere be done by the heat of powerful electric currents; but the barest calculation of cost leads one to fear that that time is still a long way in the future.

But although there are many metallurgical and other chemical processes which for some time may be much more cheaply performed by the aid of ordinary furnaces than by electrical methods, there are probably not a few as yet untouched which would well repay development by the electro-chemist. Unfortunately the genus "electro-chemist"—as a commercial factor—is a rarity. What with secondary battery improvement and electro-chemical manufactures, there is a deal of useful work he might be doing; and we hope he will speedily increase and multiply. Prof H. E. Armstrong, in his recent Presidential Address before the Chemical Society, complained, in regard to a certain point of electro-chemical theory, that it had been ignored by chemists, adding: "Unfortunately the physicists have also neglected this subject, having apparently left it to the chemists; . . . the result is blank ignorance of all that is fundamental with regard to such matters on the part of both chemists and physicists." An exact and deplorable parallel to this is to be found in regard to many of the possibilities of commercial electro-chemistry. The chemist is ignorant of the electrical aspect of the question, and has left it to the electrical engineer, who, in turn, has consoled himself with the reflection that if anyone ought to know anything about chemical processes it should be the chemist. The result, as Dr. Armstrong put it, has been "blank ignorance"—and fertile ground untilled. This state of affairs is no doubt a consequence of the modern tendency towards specialism. Ten half-starved men may nowadays know perfectly ten facts, which if all known to any one of the ten would enable him to "make his pile." The extensive field of commercial electro-chemistry adjoins the overcrowded regions of electric lighting and power supply; and all that is required to develop it is that there should be a coalescence of technical knowledge of chemistry and electricity.

REVIEW.

Chemistry for Engineers and Manufacturers. By Bertram Blount and A. G. Bloxham, FF.I.C. and FF.C.S. Vol. I., Chemistry of Engineering, Building and Metallurgy. (London: C. Griffin and Co., 1896.)

The volume before us is the first of a two-volume treatise on the chemical technology of engineering and manufacturing operations. The present volume deals with the chemical principles of mechanical engineering, building, and metallurgical and other chemical operations. A second volume, shortly to be published, will treat of many of the manufactures

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which have a distinctly chemical basis, and will therefore supplement the present volume on the descriptive and practical side. A reader of the volume before us could scarcely fail to notice the convenient and pleasing order in which the matter throughout is arranged, and the perspicuity of the style adopted by the authors. The nature and scope of the subject have rendered condensation necessary; but the subject matter appears to have lost nothing in clearness and precision from the compression to which it has been subjected; while the judicious selection of material of prime importance, and the equally judicious rejection of secondary matter and questions of side issue, are apparent upon nearly every page. Here and there we notice exceptions—not, however, of great importance—where the authors have departed from the general simplicity of style; as, for example, where fuel is defined as "any substance capable of exothermic oxidation with sufficient rapidity to leave an available balance of energy after the leakages of energy surrounding the point of combustion (*e.g.*, radiation, convection and conduction) have been supplied." In attempting to give a definition, the authors have merely summarised the behaviour of fuels; and the use of the word "combustion" begs the question entirely, and carries the definition in a circle. Moreover, in practice, when the combustion of a fuel is proceeding at a steady rate, the temperature is constant and there is no "balance of energy after," &c. Exception may also be taken to the authors' use of the phrase "yield point" in place of the more common term "elastic limit." There seems to be no reason why a material under stress should be said to "yield" at the elastic limit any more than under a greater or lesser stress than occurs at that point; while the term "elastic limit" has the advantage that it fixes the limit of stress, on the removal of which the material recovers practically perfectly from its deformation.

Introductory matter fills the first half of this volume, and deals with the chemistry of constructive materials, of the sources of energy, of steam raising, and of lubricants and lubrication. The second part of the volume is entitled "Metallurgy," and deals with the treatment of metalliferous ores, iron and steel manufacture, the processes for the production of commercial copper, lead, zinc and other metals, and the parting of gold. It is with the first part of the volume that the constructive engineer, whether electrical or otherwise, is chiefly concerned; while the metallurgical section will interest that side of the electrical profession which is devoted to electrolytic production of metals. The first chapter in Part I. shows the chemical properties of building materials, such as stone, brick, concrete, and iron and other metals; and it should form a valuable guide to the choice of materials in constructive work, and to the treatment of them in regard to the chemical forces of decay, &c., to which they are liable to be subjected. In Chapter II. various fuels are discussed, in regard to their preparation for commercial use, combustion and thermal value. In the section on "Liquid Fuel" a diagram of a Priestman spray-maker is shown, in a connection which would naturally suggest that this form of spray-maker is used where liquid fuel is burned for steam raising; whereas such a nozzle is quite useless for the purpose. Fuel gas generated from fixed solid fuels receives a considerable share of the authors' attention, and the various processes of its manufacture and use are accurately and clearly described. Primary batteries, as a chemical source of energy, are dealt with in this chapter; but the work gains little in real value by the few pages devoted to this subject. In the chapter on "The Chemistry of Steam Raising," we find a collection of useful information about boiler waters and their treatment for hardness, saltness, &c., and about the use of anti-incrustators. Steam users are warned that these latter "all are sold at prices bearing but a remote relation to their intrinsic values," a kind of negative advertisement; but the authors appear to have omitted to give the important advice that these compounds should not be introduced directly into the boiler, but into the feed-heater or economiser. The electrical branch of metallurgy occupies but a small proportion of Part II., no doubt chiefly because electro-metallurgy has so scantily supplanted older methods of separating and refining metals. The chief references to the electrolytic extraction of metals occur in the section on "Copper," where the Siemens and Halske wet process is described; and in the section on "Aluminium," where a short account of the electrolysis of fused cryolite is given.

The letterpress and illustration of this latest contribution to the literature of technical chemistry are as well executed as the literary matter, and they enhance the value of a treatise which should prove decidedly useful to the constructive engineer and electro-chemist.

THE REGULATION OF PRESSURE AND THE REDUCTION OF LIGHT LOAD LOSSES IN ALTERNATING CURRENT SYSTEMS OF ELECTRIC SUPPLY.*

BY E. W. COWAN AND ALFRED STILL.

On account of the greater facility with which the pressure can be maintained on a system of distribution when the supply is a high-tension one, provision for its regulation has come to be somewhat neglected in this country. The standard of permissible variation of pressure with a low-tension system has not been a high one, and because with a high-tension supply it has been found easy to improve upon this, few efforts have been made towards the attainment of a higher standard. But with the heavier loads of to-day, and the advantage of our more complete knowledge of alternating currents, we should not rest satisfied with so low a standard; and complaints from consumers connected to the tail end of long distributors of the falling off in their light at times of heavy load, when its full brilliance is most desired, should belong to the history of the past. We can do better and we ought to. The object of the first part of this Paper is to set forth what we believe to be the best methods of maintaining constant pressure in all parts of a distribution system under varying conditions of load.

The first point to which attention must naturally be paid is the arrangement of the mains and transformers. This subject has already been dealt with to some extent before this Society by Mr. Clirehugh and Mr. Rider; but as each district must be considered on its own merits, it is not possible to formulate any definite rules. There are, perhaps, four systems open to us:—

1. High-tension distributors with transformers on consumer's premises.
2. Feeders in connection with high-tension distributors, and transformers on consumer's premises.
3. Feeders with transformers in sub-stations and low-pressure distribution.
4. Feeders with transformers in street boxes and both high and low tension distributors.

From the point of view of the subject of this Paper—viz., the regulation of pressure—the first of the above systems is the worst and the last one the best. It is on the relative advantages of the third and fourth systems that we should like to offer a few remarks.

Sub-stations with banks of transformers have become very popular; but we are inclined to think that their advantages are somewhat overrated, and that a cheaper, and in some respects more efficient arrangement, is to space out the transformers under the footway in the manner indicated at D, in Fig. 1. With this arrangement a much better regulation can be obtained than the low-pressure distribution system shown at C. It has the further advantage of simplicity in the first laying of the mains when the distribution of the load is uncertain. Most of us have been surprised when a station has been running for some time to find that our lamp connections have not distributed themselves according to our expectations, and that we have heavy cables lightly loaded and light cables heavily loaded. With this system it is simple and inexpensive to lay both high and low tension cables of large enough capacity for the ultimate requirements of the district. The transformers, which may be of uniform size, are fixed according to the position and amount of load as it arises; the final result being that transformers are close together where the load is heavy and comparatively remote in those positions where the demand is small. It may be argued that many transformers of a small size cannot be so efficient as a small number of larger size; but 12 to 15 kilowatt transformers may have a very high efficiency, and they are more readily handled than the very large sizes often fixed in sub-stations.

If underground switches are arranged to connect the low-tension service mains of one transformer to those of the transformers on each side of it when required, it will be possible to remove a transformer without interfering with the supply. And if similar switches are fitted at intervals in the high tension main, a fault in the cable can readily be cut out and the supply continued in the whole district fed by this main, with the exception of the particular length which contains the fault. Such underground switches can be made at a low cost, and will work quite satisfactorily.

* Paper read before the Northern Society of Electrical Engineers.

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Whatever system may be adopted, it is certain that feeders will form part of it, and the important question arises as to what cross section they should have. Apart from the question of regulation, there can be no doubt that they should be proportioned in accordance with Thomson's law; but here a difficulty arises—the loss of pressure will frequently be so great, that, at times of full load, uniformity of pressure cannot be maintained at the feeding points, unless all the feeders are of the same length and subject to corresponding fluctuations of load; a condition which does not obtain in practice. It follows, therefore, that a regulating device must be connected to each feeder, preferably at the generating station end, or inequality of pressure at the feeding points will result. The other alternative being to lay feeders which are uneconomical on account of their large cross-section and corresponding first cost. Mr. Crompton, we think, makes too much of "efficiency of distribution," this being a question which cannot properly be dealt with, except in connection with first cost.

We propose now to describe a simple graphic method of determining the sectional area of feeders according to Thomson's law, as the usual formula needs some modification to adapt it to cables of which the insulation bears a large proportion to the total cost, and which do not carry a constant load. We will afterwards deal with the various regulating devices which are available at the present time for compensating for the drop on the feeders.

Feeders.—The most economical cross-section for a feeder depends upon two things only—the first cost of the cable, and the cost of production of the energy lost in it on account of its ohmic resistance

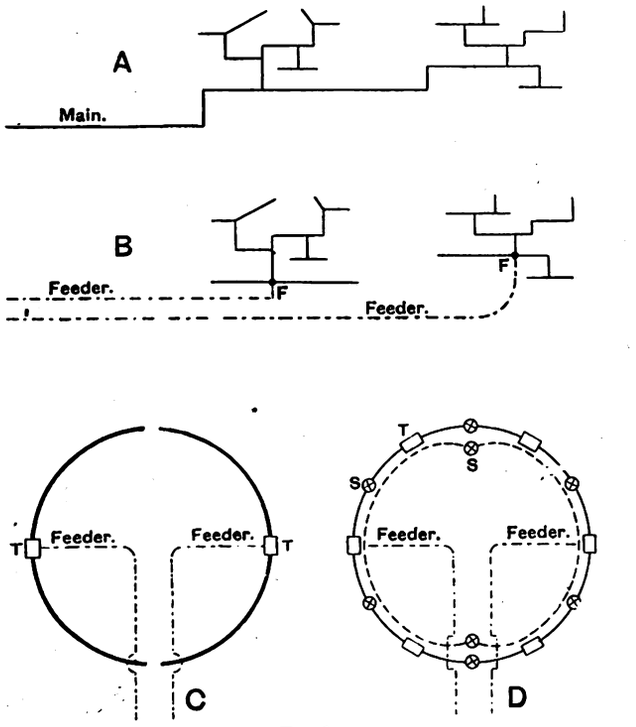

FIG. 1.

Thomson's law, which takes into account the annual cost of the watts lost in the conductor, and the allowance for depreciation and interest on first cost of the cables, may be expressed as follows:—

The most economical section of a conductor supplying electric current to a distance is such that the annual allowance for interest and depreciation on original cost of the cable will be equal to the annual cost of the energy wasted in overcoming its ohmic resistance. The cross-section should, therefore, be determined solely by the current which it has to carry, and not by its length, or an arbitrary limit of the percentage full-load drop in pressure—the drop, even if considerable (and it is not likely to be so on a high-tension system), must take care of itself.

There are possibly two reasons why Thomson's law is not more generally followed in calculating the sizes of feeders for systems of electric light supply:—

Firstly—because it applies only to bare conductors, of which the cost per mile may be taken as being proportional to the weight of the copper, and therefore to the cross-sectional area; and secondly—because it assumes the current to be constant from one year's end to the other: a condition of things which unfortunately has not been realised by electric supply stations. Although Thomson's law, in its usual form, is not directly applicable to existing conditions, the *spirit* of it should never be deliberately neglected. All that we have to attend to is this: to see that the annual cost of the energy wasted in a mile of the feeder, added to the annual allowance (per mile) for depreciation and interest on first cost shall be a minimum. With regard to the question of varying current, this is easily dealt with. The energy lost in a given cable depends upon the square of the current and the time during which the current is flowing. If a cable conveys a current, C, only 12 hours out of the 24 hours, then the energy wasted per day is only half what it would have been had the current been flowing continuously, and the watt hours may be expressed as $12 \times c^2 \times r$, or as $24 \times \frac{1}{2} c^2 \times r$, and it is evident that in working out the energy lost per annum in the cable, we have to multiply the resistance, not by the square of the *maximum* current which the cable will carry, but by the mean value of the squares of the current during the year.

From measurements taken on actual load diagrams it would appear that, in the case of electric light supply stations having a small all day load, the full load or maximum current is from two to three times as great as the mean square value of the current taken for the whole year; this proportion depending upon whether the capacity of the feeder is appreciable or not, and also upon the nature of the districts supplied. It is evident that this multiplier can easily be worked out from a few typical load diagrams.

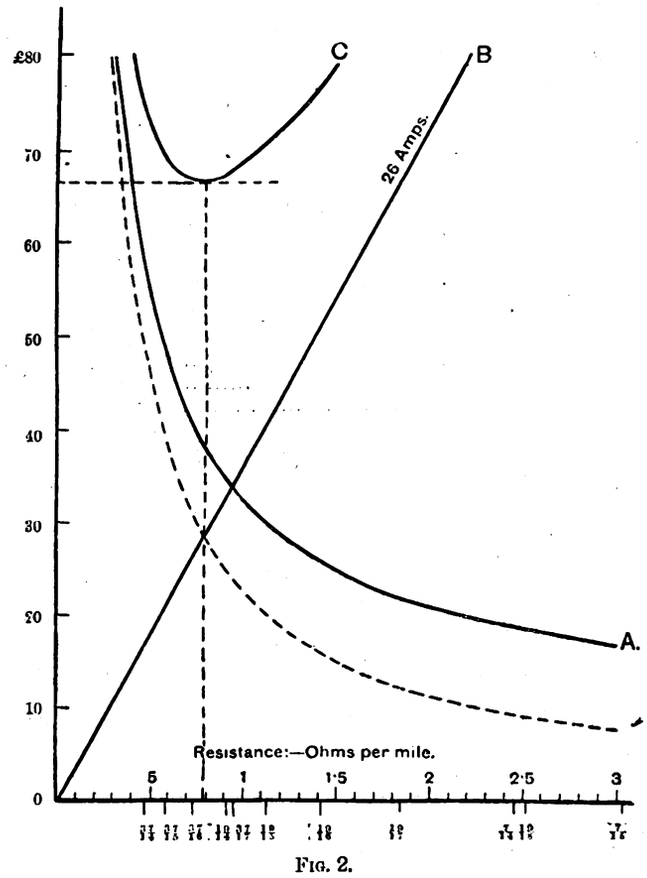

FIG. 2.

The following example and the diagram Fig. 2 will make it clear how the proper size of cable may be worked out in actual practice. And first it should be understood that it is the cost of the cable only on which the percentage for interest and depreciation should be taken, because the cost of trenching and laying, or drawing into pipes or culverts will be practically constant, and unaffected by the exact cross-section of the copper in the cable. Let us suppose that 10 per cent. is to be allowed for depreciation and interest on capital spent; then, in the diagram Fig. 2, where the horizontal distances represent resistance in ohms, and the vertical distances represent money, plot the curve A, which gives the relation between 10 per cent. of the cost per mile of the cable (taken from the maker's price list) and its resistance in ohms per mile (go and return)—this curve, which has been plotted from actual prices for concentric cables by a certain firm of well-known manufacturers is not a rectangular hyperbola as it would be if Thomson's law were to hold good. The dotted curve is a true hyperbola or the curve which makes the cost universally proportional to the resistance of the cable, and inspection of these two curves will show how the cost of the (insulated) cable is proportionately greater for the smaller sizes.

Now calculate the cost of the C^2R losses per mile of cable for any particular value of the resistance, and draw the straight line O B which will give us this cost for any other resistance of cable.

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In this diagram the losses have been calculated on the assumption that the current is 26 amperes, and that the cost of production is 1½d. per unit. It is evident that this must be taken on the low side, as during the lifetime of the cables the works cost of the unit may be expected to be reduced.

By adding the ordinates of the curves A and B, the curve C is obtained, whose minimum value corresponds with a resistance per mile of 0·78 ohms. The nearest cable to this (on the small side) is 19/14, and this, if the cost of production of electrical energy and the probable current have been estimated correctly, is the proper size of cable to use, whatever may be its length or the voltage required at the feeding point.

Assuming the maximum value of the current to be three times the square root of the mean square value, and the length of the feeder to be one mile, the "drop" at full loads would be :—$78 \times 0{\cdot}91 = 71$ volts.

Capacity.—The effect of capacity in a system of concentric mains is to increase the current entering the cable at the alternator end, although the current leaving the cable at the far end will, of course, depend only on the pressure and lamp load at that end.

In the long concentric feeders the capacity current should therefore be taken into account, especially as its effect in increasing the total current is more marked at light load than at full load. It is easily calculated with sufficient accuracy by the formula $C = 2\pi n K V$, where K = the capacity in farads,

n = the frequency in periods per second,

V = the mean voltage.

It must be remembered that this current is not in phase with the main current, but one-quarter period in advance of the impressed volts. Hence, if C = 10 amperes this will be the current indicated by the feed ammeter on open circuit. At full load, with 60 amperes taken out at the far end, the current read on station ammeter will be the square root of $60^2 + 10^2$, or about 61 amperes. The following capacities of concentric cables have been kindly furnished us by the makers, and may be found useful in estimating the probable value of the capacity current in a given system of mains :—

Capacities per mile (inner to outer) of 19/18 concentric cables :

British Insulated Wire Company (paper)...	0·31 microfarads.
Glover and Co. (vulcanised rubber)	0·615 ,,
Ditto (diatrine)	0·315 ,,

Drop on Feeders.—Having fixed the cross-section of the feeders and calculated the full load "drop," it will generally be found that the latter is considerable on the long feeders and inappreciable on the short. Some methods of dealing with this difficulty must, therefore, be adopted which will allow of each feeder being independently regulated, as, if we raise the pressure of the 'bus bars to compensate for the drop on the long or heavily-loaded feeders, we shall be at the same time increasing the pressure at the feeding points which are nearer the generating station, or at those which are more lightly loaded. There are three methods of effecting the desired result, all equally efficient in respect to regulation, but differing widely in their efficiency in respect to economy :—

1. Raise pressure of generators until 'bus-bar pressure equals that required for the feeder with the largest drop, and switch more or less resistance into all the other feeders to absorb the consequent excess of pressure above that required.

2. Same as above, but use variable choking coils instead of resistances.

3. Adjust pressure of generators until 'bus-bar pressure equals that required for the feeder with the least drop, and by means of a special induction apparatus add pressure as required to the remaining feeders.

Very few words will be required to show the great economical advantage of the third method over the two others. In the first plan the resistances dissipate energy which has cost fuel to produce, and so rob the station of a percentage of its output at the time of maximum load ; a serious disadvantage in itself. The second plan is much more economical than the first. But choking coils are not like transformers—the induction and consequent loss in the iron being very much higher on account of the E.M.F. of self induction being ¼ period out of phase with the main current. For a 10 per cent. reduction of pressure the amount of the induced volts will be over four times the volts deducted. But apart from this it will be readily seen that the generation of the E.M.F. by the dynamo and its subsequent destruction by the choking coils cannot be an economical arrangement, accompanied as it must be by the losses of a double operation. The third plan is free from the above objections —the volts required to compensate for drop are added when and where required, and the generators, being worked at a low pressure, work more economically. Without analysing the question, common sense tells us that such a plan is better engineering. When we want to light a part of a building, we do not think it right to switch on all the lamps and screen the light from those parts not needing illumination, and there is no more reason for regulating feeders upon a similar principle.

The use of a regulating transformer for this purpose was first brought under our notice by Mr. J. H. Rider, who designed and specified such an arrangement for the Bolton Corporation Electricity Supply Station. The principle was not, however, new, and it may be of some interest to trace its development. As far as we have been able to ascertain, the late Mr. J. E. H. Gordon was the first to make use of the idea of augmenting the E.M.F. of a circuit by connecting in series with it the secondary coil of a shunt transformer. In Fig. 3 this plan is illustrated. He terms the apparatus a "hitcher-up." Part II. on the same diagram shows a feeder-regulator designed by Mr. Gisbert Kapp ; this apparatus is the same as Gordon's, but is provided with a means of varying the augmentation. A segment switch is arranged to cut out the primary coils as desired ; as the coils are cut out the E.M.F. generated in the secondary is, of course, increased. Fig. 3, part III., shows the principle of an apparatus designed by Stillwell in America, and manufactured by the Westinghouse Company. This design is similar to Kapp's, and was indeed also suggested by him, the only difference being that instead of primary coils being cut out secondary coils are switched in.

IV. and V. at the bottom of the diagram illustrate another design of Mr. Kapp's, which was intended to get over the difficulties of a high-tension segment switch, with its necessary devices

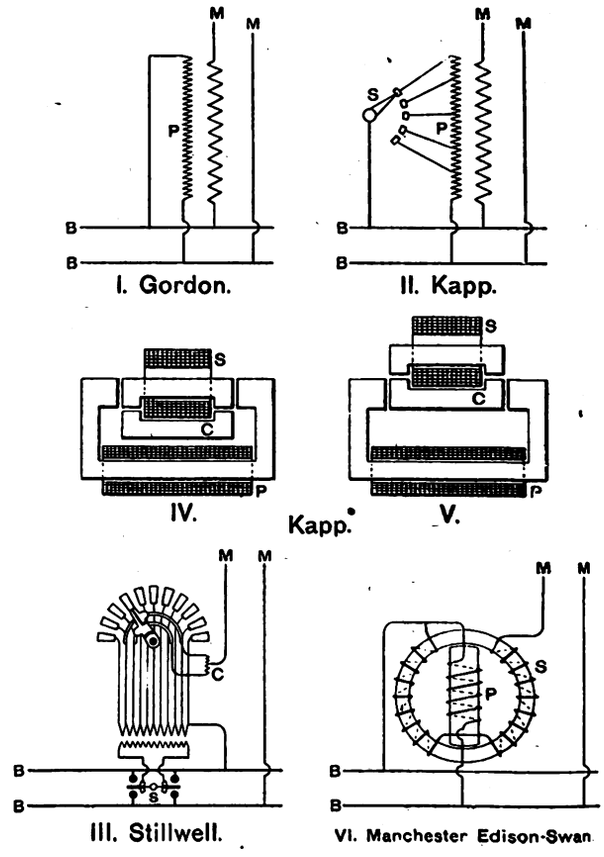

FIG. 3.

to avoid short-circuiting a coil when being moved from one segment to another, and also to get over the objection of the additions to the voltage taking place in jumps, the necessary result of using a segment switch. The principle of its action is entirely different to the others, the variation in effect being obtained by a movement of the iron core. IV. shows the apparatus in the position of maximum effect, the magnetism created by the primary coil cutting the secondary coil. In V. the core and secondary coil are removed to the position of no effect, the magnetic lines flowing along the core C, outside the secondary winding instead of through it. We are not aware that this regulator was ever made ; it is, perhaps, scarcely fair to criticise it, but it is apparent that in the position shown in V. the self-induction of the secondary would result in a serious loss of pressure in the feeder, and in the position shown in V. the magnetic leakage would be appalling.

Part VI. of Fig. 3, Fig. 4 and Fig. 4A illustrate the regulating transformer manufactured by the Manchester Edison-Swan Company (Limited), as first made for the Bolton Corporation. In this design the primary coil is wound upon a shuttle-shaped core, and the secondary winding upon a ring-shaped core. Between the positions of maximum effect and no effect the primary coil, with its core, rotates through an angle of 90deg. The action is as follows:—In the position of maximum effect the shuttle occupies a vertical

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position and the magnetic flux cuts the secondary coil, which is wound in two sections, one on each side of the ring, and generates the full volts required. In the position of no effect the shuttle is horizontal, and the magnetism cuts half the secondary turns in a positive sense and half in a negative sense, the resultant effect being of course nil. Between these two positions any gradation of augmentation can be obtained. It is evident that if the shuttle be rotated beyond the position of no effect (if the transformer is being used as a feeder regulator) volts will be subtracted from, instead of added to, the feeder volts. The points to which special attention were paid in the design of this apparatus were the constancy of magnetic flux in all positions, the reduction of the iron path to the shortest possible length to avoid iron loss; and the obtaining of a mechanical and compact apparatus which would lend itself to easy and safe manipulation by the switchboard attendant.

On the table we have one of the Manchester Edison-Swan regulators at work. The Manchester supply being a continuous current—a motor-alternator first converts it into an alternating

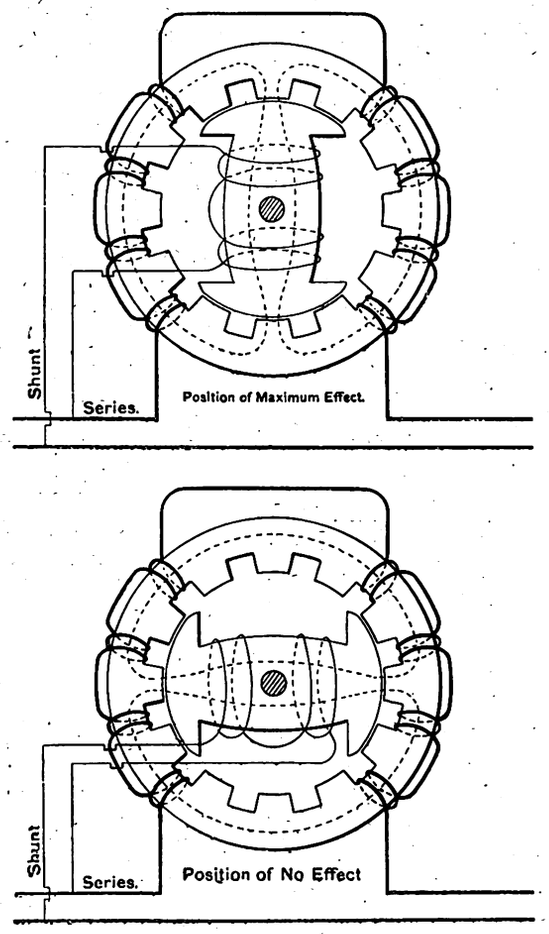

FIG. 4.

current of about 20 complete periods per second. The alternating current supplies an incandescent lamp, and the regulator is so connected that the pressure at the lamp terminals can be raised or lowered by hand adjustment of the lever on the side of the case.

Compensators.—With regard to the means of indicating the feeding point volts at the station end, there are several methods by which this can be done. Pilot wires brought back from the feeding points to the voltmeters naturally suggest themselves in the first place, but there are objections to their use, of which the principal one, perhaps, is their excessive cost, especially when they are used in connection with long feeders. A very simple method of indicating what is the required pressure at the station end of the feeders in order that the supply at the far end may be independent of variation in load, consists in marking on the feeder ammeters a second scale of numbers—let us say in red figures—these numbers to indicate the required value of the station volts for any position of the ammeter needle.

A step in advance of this, is a method which is more generally used in America than in this country. It consists in connecting the voltmeter in series with the secondaries of two transformers; a shunt transformer T_1 (A, Fig. 5) with its primary across the mains, and a series transformer T_2, of which the primary is traversed by the main current. The secondary of this transformer being closed through an adjustable resistance R, it will be readily seen that by suitably varying this resistance to suit the length and size of the feeder, the potential difference between the terminals $t\,t$ may be adjusted to any particular fraction of the volts lost in the feeder. It follows that by setting this potential difference against the potential difference at the secondary terminals of the shunt transformer, the readings on the voltmeter will be an indication of the actual pressure at the feeding point. In B on the same diagram is shown the way in which this method of "compounding" the feeder voltmeter is illustrated in Dr. J. A.

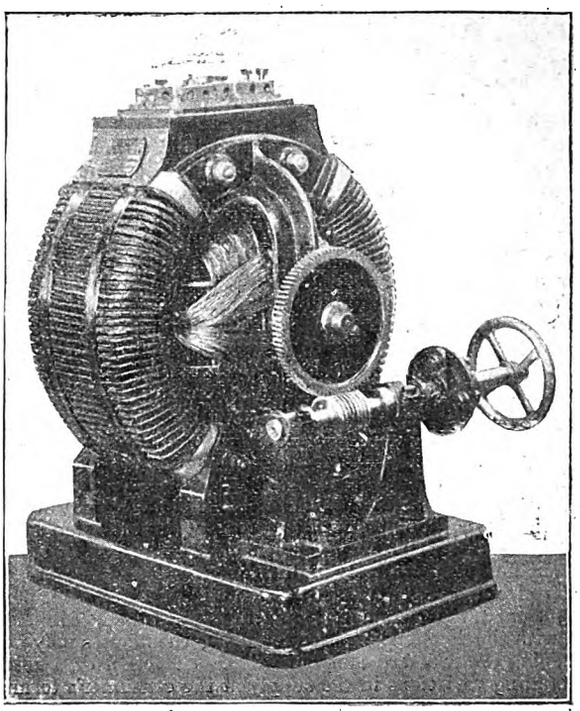

FIG 4A.

Fleming's book on transformers. In the text we read that "the electromotive forces of the two transformers are opposed to one another"; but this will not be the case unless the secondary of the series transformer is closed through a resistance, as in A. The secondary volts of the shunt transformer being in opposite phase to the primary volts, and the induced volts in the series transformer being approximately ¼ period behind the main current, these two E.M.F.'s cannot be set *against* one another, and their sum must necessarily be *greater* than the value of any one of them.

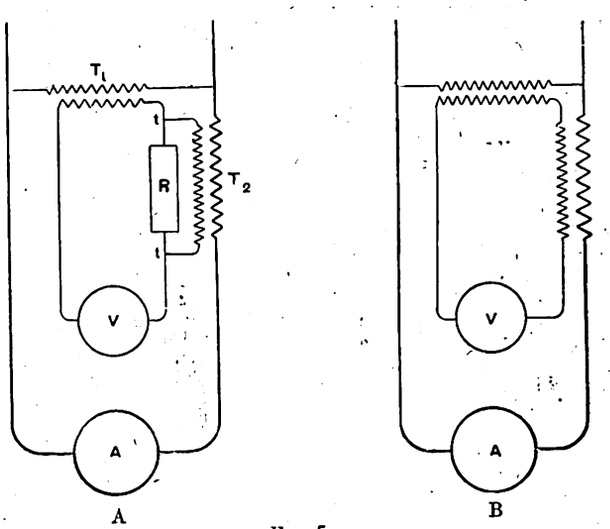

FIG. 5.

Drop in Distributors, &c.—We have so far dealt only with the loss of pressure in the feeders, and methods of keeping the volts constant at the feeding points. Beyond this the system must be self-regulating, that is to say, the loss in pressure between no load and full load must not exceed a certain definite amount. The amount of permissible variation at the consumer's terminals as fixed by the Board of Trade is 4 per cent. If, therefore, we proportion

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the distributors to give a maximum drop not exceeding 2 per cent., this leaves another 2 per cent. for permissible drop in transformers. And here it may be as well to point out the disadvantage of specifying for transformers having a very small drop between no load and full load, without considering the effect of the drop upon the first cost and efficiency at light loads. It should always be borne in mind that for the same cost of material a transformer may be made to give either a small drop with a comparatively large iron loss, or a fairly considerable drop with greatly reduced open circuit losses.

As an illustration in actual practice which bears out this statement, a few months ago we tested a transformer for which the makers claimed an unusually small loss at light loads. The tests proved that the claim was undoubtedly well justified, but at what cost? The drop on volts on secondary terminals between no load and full load was no less than 5 per cent. On the other hand, a transformer of the same output by another maker had an open circuit loss nearly 1½ times as great, and this, although the weight of the transformer, and, therefore, the amount of material in it, was greater than the first one; but this greater iron loss was necessary in order to bring the drop within reasonable limits, the maximum variation being just within 2 per cent. In very small transformers it is difficult to keep the drop much below 2½ per cent.; a better regulation than this is rarely found in practice, notwithstanding specifications and makers' published figures.

With regard to the drop of pressure in the house wiring, we believe there is very little that is new to be said on the subject. It should, however, be borne in mind in calculating sizes of wires that their effective resistance to alternating currents is always a little greater than when they are traversed by a continuous current. Mr. E. Hospitalier has worked out a very convenient table, which will be found reproduced in *The Electrician* of January 12, 1894, and from which the increased resistance of wires to alternating currents for various diameters and frequencies may be easily obtained. It is, perhaps, needless to remark that this increased resistance is practically negligible except for wires, say, over ½in. in diameter, and comparatively high frequencies.

Before leaving this first section of the Paper, it should, perhaps, be mentioned that a small regulating transformer connected in series with the low-tension wires entering the houses may be used for keeping the pressure constant within a fraction of a volt, notwithstanding variations in the supply at the consumer's terminals.

Reduction of Light Load Losses.

There are few subjects of greater interest to the electrical engineer in charge of an electricity supply station than the question of light load economy. The maintenance of a continuous supply cannot be avoided, but the cost of generation during the hours of light load is enormous. The waste—and no other word adequately expresses the loss which takes place—is not only in fuel, but in wages and capital. There is no occasion to define the lightness of the load during the small hours of the morning and the long hours of daylight; in the majority of electric light stations in this country the feeder ammeter needles rest persistently at zero. It is to such stations that our remarks will apply. An examination of the question shows us that there are perhaps four ways of meeting the difficulty:—

1. Installing accumulators which are charged during the hours of heavy load and employed during the hours of light load in driving a motor alternator.
2. By running a small, and therefore more economical, light load plant.
3. By a gas engine and gas generator plant.
4. By adapting one of the smaller units in the station to work at a relatively high economy when lightly loaded.

Below we deal briefly with these four methods.

Installing Accumulators.—Mr. J. C. Howell, supported by Mr. Crompton, endeavoured some time ago to persuade the members of this Society that accumulators offered a means of saving many tons of coal per diem, even if they were only used as resistances for shunting the balance of current required to raise to full load the output of a steam dynamo. This startling assertion was accepted in many quarters, but we are unable to allow that accumulators can possess such a virtue. The question of their adaptability to alternate-current stations in conjunction with a motor alternator to effect economy becomes a difficult one to decide. The Bolton Corporation are putting this plan to a practical test, and we shall look forward to hearing at a later date some account of their experiment. It is a question of interest on capital outlay, depreciation and maintenance on the one hand, against saving in fuel and wages, and also the undoubted advantage of being able at times to shut down the steam plant entirely, on the other.

Separate Light Load Plant.—This is the plan which has found most favour up to the present time. One objection is its first cost, and another the frequent necessity for changing over from one plant to another, which, as it involves paralleling, needs the presence of a skilled attendant. This is felt most in the early morning in winter time when the load is relatively heavy for an hour or two, and a small plant cannot meet the demand.

Gas Engine and Gas Generating Plant.—At first sight a gas engine appears particularly fitted for this purpose, as it is theoretically an engine with a high efficiency at light load, on account of the gas consumed being proportional to the indicated horse-power. But there is another factor which influences the gas consumption, viz., the friction of the engine. In order to adapt a gas engine to driving an alternator it must have two or more cylinders and a heavy flywheel, the consequence being that the standing friction losses are largely increased, thus seriously affecting the economy at light loads. The first cost of such a plant is, of course, much higher than that of a steam engine of similar power.

Adapting one of the smaller Units in the Station to work at relatively High Economy when Lightly Loaded.—We are fully aware that in recommending this plan as being the most effective and economical, we are laying ourselves open to considerable criticism, especially as some of the suggestions we shall make are in the direction of rather bold departures from present practice. But it must be remembered that in dealing with the difficulties of a low "load factor" we must expect to be obliged to surrender some of our prejudices. The difficulties are peculiar, and may have to be met in a peculiar manner. It is impossible to deal with this subject without saying something about the many arrangements which tend towards economy at light load in the generation and transmission of steam. Time will not admit of the discussion of the different types of boilers. It is, of course, unwise to install a small boiler for light load, and we do not suppose that anyone would think of doing so, but it does not seem to be generally so well known that a Lancashire boiler, at any rate, works at a much higher economy at quarter load than at full load if it is well lagged and carefully stoked. A boiler cannot have too much heating surface, though it can have too much grate area. With careful stoking, a consumption of 5lbs. of fuel per square foot of grate area per hour in a Lancashire boiler will give a splendid evaporative performance of over 12lbs. of steam from and at 212°F. per pound of coal, or 10 per cent. better than with a normal consumption of 20lbs. of coal per square foot of grate per hour.

Economiser.—It might be thought that an economiser would not effect much saving at light loads on account of the lower temperature of gases; but we have obtained an augmentation of temperature of the feed of 138°F. with a 96-tube Green economiser, when working a Lancashire boiler 30ft. by 7ft. at quarter load, and burning 5lbs. of fuel per square foot of grate per hour. Prof. Kennedy has obtained an evaporation of 12·4lbs. of water per pound of fuel with economiser, and 11·7 without, when burning only 6lbs. of fuel per square foot of grate per hour.

Boiler Feed.—The wastefulness of steam feed pumps is well known, and in many stations electrically-driven pumps are now being fitted. Where the feed water is heated above 150°F. a feed pump of some sort becomes necessary; but in other cases injectors offer a means of feeding the boiler which is simple, inexpensive, and, we venture to say, economical. The three objections generally made against the use of injectors are—unreliability, small range of regulation, and lastly, that they are uneconomical. As to the first objection of unreliability, this is not borne out in practice so far as our experience goes, but a steam pump as a stand-by should undoubtedly be erected. The second objection of the small range is easily got over by fixing three or four different-sized injectors delivering in parallel into a common or "omnibus" delivery pipe. They work perfectly well in parallel, and in this way any required rate of feed can be obtained. The third objection of their being uneconomical is not, we think, a true one. Both in theory and in practice, as far as we have been able to ascertain, they are more economical than steam pumps. As a pump pure and simple the injector is, of course, very inefficient, but energy cannot be extinguished, and it therefore follows that all the units of heat in the steam supplied to the injector are returned to the boiler, with the exception of the equivalent of the work done (the product of the volume of water injected and the back pressure) and a small loss due to radiation. It must of course be remembered that though all the heat is returned to the boiler, it is returned at a lower temperature—in fact the live steam is used to heat the feed water from, say, 60°F. to 150°F., and this process violates one of the first conditions of economy. But compare it with an ordinary steam pump; about 50 per cent. of the total heat in the steam supplied to the pump is rejected in the exhaust, to which must be added large losses due to radiation, and the more obscure losses due to reciprocation. It is difficult to compare the relative efficiencies of the one method, which raises the temperature of the water from 60°F. to 1[illegible]°F. by live steam, and from 150deg. to 320deg. in the boiler; and the method in which the temperature of the feed water is raised from 60deg. to 320deg. in the boiler; but common sense seems to point to there not being much difference between the two. The use of economiser or feed water heater will, of course, somewhat alter matters, and each case should be

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considered on its own merits. Our firm conclusion is that an injector is the best light load pump.

Steam Pipes.—There are grave objections to supplying the ligh load plant with steam from the main steam pipe. This plant should be erected as close as possible to the boilers, and supplied by a short auxiliary pipe of small diameter. It has been estimated that the radiated heat from every square foot of lagged steam pipe costs 300lb. of coal per annum, and Prof. Kennedy has found that the amount of condensed steam from pipes, drains, &c., amounted in one station to from 8 to 9 per cent., and in another from 5 to 6 per cent. of the total weight of feed water.

Auxiliaries—The economiser scrapers, centrifugal pump and exciting dynamo must be driven during the hours of light load; and it is evident that if these are driven separately by auxilliary engines the result will be a serious waste of steam. We prefer to arrange for their being driven by the main day load engine, using either belt, rope, or electrical transmission. As this engine is running in any case, its standing losses are not chargeable against the small extra power required, which can therefore be obtained at the very small expenditure of steam of about 12lb. per horse power.

Condensers.—We unhesitatingly recommend the ejector condenser as being the most economical light load type. No air pump is needed, and thereby a substantial standing loss avoided. It is an absolutely reliable, cheap, and efficient piece of apparatus. The type with a means of regulating the adjustment of the nozzles, is perhaps best suited to a variable load. The subject of the saving effected at light load by the removal of the standing loss of atmospheric back pressure by condensing the exhaust steam, has been so ably and fully dealt with by Mr. Willans that we do not propose to add any remarks of own, excepting to say that it is by far the most important of the means we are bringing before you for the reduction of light load losses. We show in Fig. 6 the saving of

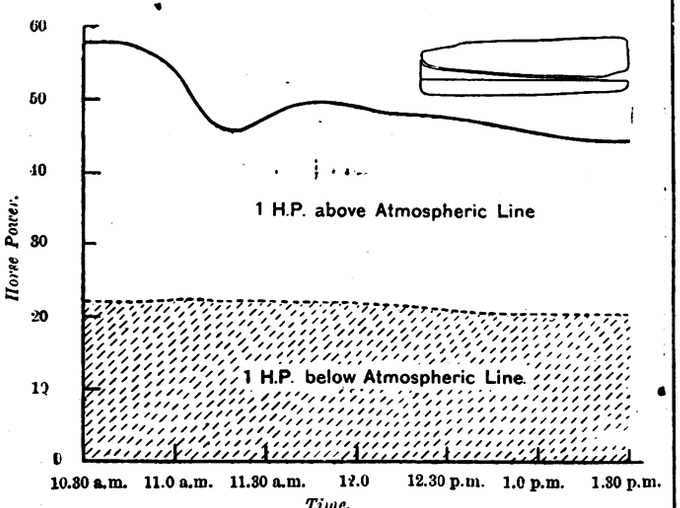

FIG. 6.

steam effected during the day time at Altrincham by the use of an ejector condenser. The diagram shows the indicated horse-power below and the indicated horse-power above the atmospheric line on the morning of December 20, 1895. The indicated horse-power below the atmospheric line amounted to about 46 per cent. of the whole, or a saving of steam consumption of about 50 per cent., against which must be set the horse-power required for centrifrugal pump, about 1 per cent. of the total horse-power of the engine.

Engine.—The discussion of the engine brings us back to our recommendation that one of the smaller units should be adapted to run economically at light load. A steam engine runs very wastefully under these conditions, partly on account of its standing losses being practically constant at all loads, and therefore bearing a larger proportion to the power developed at light load than at full load, and partly on account of the steam distribution between the high-pressure and low-pressure cylinders being unequal at light loads. The latter point should be dealt with by designing the engine with an automatic cut-off governor, which acts on both the high-pressure and the low-pressure valves. In this way a fairly equal range of temperature in the two cylinders can be maintained at all loads. The cylinders should also be steam-jacketed, on account of the range of expansion being relatively great at light loads. Of the standing losses, the back pressure of the exhaust has already been dealt with, and the loss due to radiation can only be met by careful lagging of the cylinders and their covers. Lastly, there are the important losses due to engine friction and vibration. The only way of reducing these is by lowering the engine speed. These losses are so much per revolution, and if we lower the speed we reduce them in like proportion. We recommend that the speed should be reduced by about one-third, and that the governor should be so designed as to allow of an adjustment of its springs being made by hand, in order that the engine may be under its control at this reduced speed. As far as the engine is concerned, there can be no doubt of the advantage of this plan; its effect on the electrical plant we deal with below.

Alternator.—The type of alternator which gives the highest efficiency at light load is undoubtedly the one having no iron core in its armature. But the reliability and mechanical strength of the iron-cored armature has so much to recommend it that it has found great favour, and we think rightly so, with central station engineers. Probably the protection which the self-induction of the machine affords to the whole system, in absolutely limiting the maximum current which it is possible to obtain from such an alternator to only a harmless amount above the normal, has also done its part in placing this type in the position which it occupies at the present time. Engineers will readily sacrifice some efficiency and self-regulation to obtain such a "factor of safety" as the iron-cored alternator possesses. It must be remembered, however, that the eddy current losses in an iron-cored armature are less at full load than on open circuit, a fact which was first, we believe, observed by Dr. John Hopkinson. We have recently made some experiments in connection with another matter in which this effect was very clearly marked. Apart from the windage and bearing friction, the hysteresis and eddy current losses in an iron-cored armature when lightly loaded may be considerable. On account of the peculiar raking of the magnetic lines, the iron losses in an armature, for any particular values of the induction and frequency, are greater than they would be if the same volume of iron were simply submitted to reversals of magnetism as in a transformer. The core losses in an alternator will increase approximately as the square of the induction; if therefore we could reduce the induction in the armature, a great saving of the all day losses would be effected. For instance, suppose the armature to consist (as it often does) of two separate windings connected in parallel; by switching these in series during the hours of light load the induction in the core would be halved, and the iron losses consequently reduced to one quarter of their former value; the losses in the exciting circuit being also reduced in the same proportion. Such an arrangement could not be worked without causing fluctuations in the light; but a little consideration will show that the same saving may be effected by the use of a step-up transformer. The alternator is excited to give, say, half its normal voltage, and its armature is connected in series with a transformer wound to add the remaining half of the required volts. The loss in such a transformer will be very small compared with the saving in the alternator. All that now remains to be done is to make this transformer a regulating one, which will enable the volts added to be varied without any sudden fluctuations. The change of the alternator from a small output machine to one capable of dealing with the full load it was designed for, can also be made without any variation in the light, by simultaneously reducing the volts added by the step-up transformer, and increasing the excitation of the alternator; as well as bringing up its speed, if this has been reduced as recommended when dealing with the question of engine efficiency.

The capital outlay on such an apparatus would not in any case amount to much; but where regulating transformers are used for equalising the pressure at the various feeding points, as recommended in the first part of the Paper, they can be, without any difficulty, adapted to do duty both as regulators of pressure and step-up transformers. The secondary must be wound with several separate windings which, by means of a special switch, can be connected either in series or in parallel. By means of a simple interlocking device this switch may be so arranged that it can only be thrown over at a time when the transformer is in the position of no effect.

In Fig. 7 are plotted the results of some experiments which we have made on an iron-cored alternator in order to prove what has just been said with regard to the saving of alternator losses The alternator was driven at constant speed on open circuit by means of a small continuous-current motor, and readings were taken of the power supplied to the motor for various inductions in the armature. In the diagram the vertical distances are proportional to the volts as read on an electrostatic voltmeter, and the horizontal distances are proportional to the power supplied to the motor, a correction being applied for the losses in the motor itself. The distance $O O_1$ represents the losses in windage and bearing friction; it is the power required to drive the alternator with the field-magnets unexcited. The curve $O_1 A$ is a parabola, the distance of any point on the curve from the vertical line $O_1 D$ being proportional to the square of its height above the horizontal datum line. The points enclosed by the small circles are the results of the experiments, and by their agreement with the curve $O_1 A$ serve to show that, in assuming the iron losses in the armature to be proportion to the square of the induction, the error—if any—is very small. The curves $O_1 B$ and $O_1 C$ are also parabolas, but for

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equal ordinates the horizontal distances from the line $O_1 D$ are respectively four-ninths and one-ninth of their value for corresponding points on the curve $O_1 A$. These are the curves which would be obtained by connecting the secondaries of the step-up transformers in series with the armature circuit, on the assumption that the losses in the transformers themselves are negligible. In the case of curve B the alternator generates two-thirds of the full volts, and the step-up transformer supplies the remaining one-third. Two experimental readings were taken, through which the curve B_1 has been drawn. These readings, of course, include the losses in

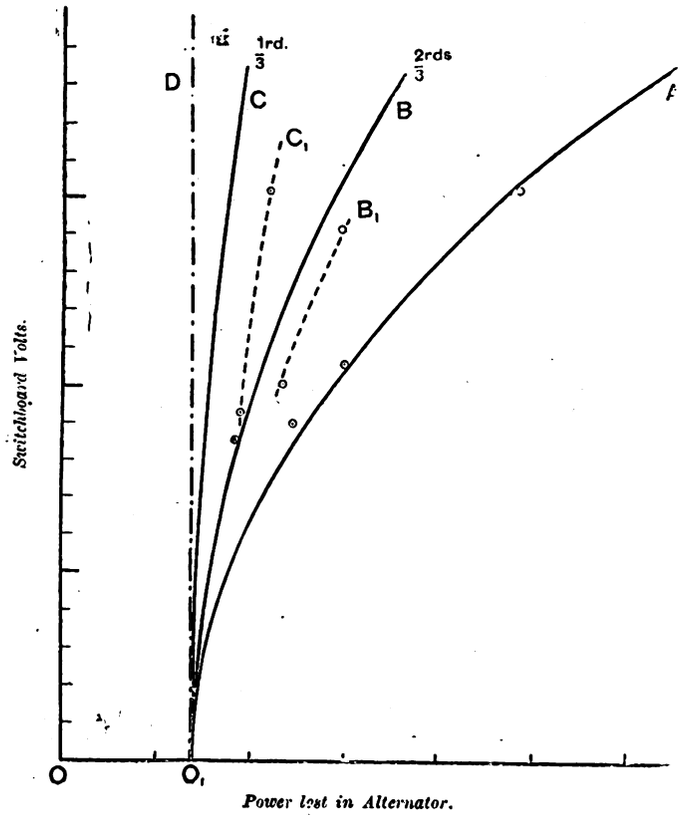

Fig. 7.

the transformer. The dotted curve C_1 was obtained when the alternator generated only one-third of the total volts. In this case, as will be seen by inspection of the diagram, the step-up transformer absorbed rather more power than in the previous experiment. Indicator diagrams of the horse-power of the engine showed the same saving.

In conclusion, we must deal with the effects of the alteration of frequency which result from the reduction of speed by one-third.

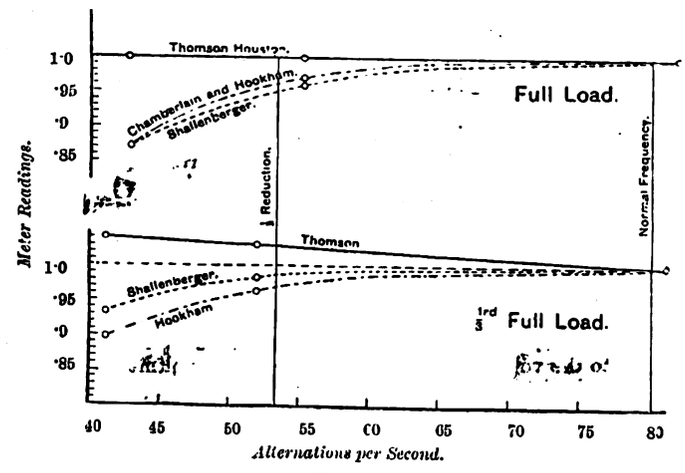

Fig. 8.

In the first place the hysteresis losses in the transformers are increased by about 25 per cent., while the eddy current losses remain approximately the same. As the C^2R losses are small when the load is light, the resulting temperature will not be abnormally high. The question therefore naturally arises as to whether the saving in the engine is not made up for by the increased losses in the transformers. The best answer to this question is to give you the result of a careful experiment made at Altrincham. In this experiment the speed of the engine was reduced from 350 to 246, and the saving in the indicated horse-power was 16·1 per cent., which is equivalent to a saving of 17 per cent. with a reduction of speed to two-thirds full speed. It must also be remembered that at Altrincham the transformers are for the most part fixed on consumer's premises, and are therefore of small size. Under ordinary circumstances with large transformers the saving should be at least 20 per cent. The effect of the alteration of frequency upon the meters is not serious. If Thomson meters are used the error for a third reduction is practically negligible. With Shallenberger and Hookham meters it amounts to from 1½ to 5 per cent. We have made experiments on these meters, the results of which are plotted in Fig. 8. In this diagram the horizontal distances represent the frequency, and the ordinates show the variations in the readings of the meters. Vertical lines are drawn at the points of normal frequency and at a third reduction. Curves are drawn for both full load and a third full load. As to the effect of the reduction of frequency upon arc lamps and alternate-current motors, there is little to be said. Our experience is that the effect upon the ordinary commercial arc lamp is not appreciable, and it will be time to consider its effect upon motors when they come into practical use. We have endeavoured in this Paper not only to make recommendations, but to support them as far as possible with figures ascertained from actual practice or experiment. We hope that some of the members present who have charge of central stations will be able to give us the result of their experience both with the difficulties of regulation of pressure and light load economy.

JACQUES' METHOD OF OBTAINING ELECTRICITY DIRECT FROM CARBON.*

The conversion of the energy of carbon directly into electrical energy, without the medium of the steam engine and dynamo, has long since become the goal for which electricians are striving. The most recent attempt at the solution of this problem is that embodied in a patent just issued to Dr. W. W. Jacques, of Newton, Mass., well known in connection with telephone work.

Dr. Jacques has discovered that if oxygen, whether pure or diluted, as in air, be caused to combine with carbon or carbonaceous materials, not directly, as in the case of combustion, but through an intervening electrolyte, the potential energy of the carbon may be converted directly into electrical energy instead of into heat.

A practical way of carrying out this method is to immerse a cylinder of carbon in molten sodium hydrate, and to force a current or blast of air into the molten sodium hydrate in such manner that it becomes impregnated with oxygen in excess over that which sodium hydrate normally contains. A circuit being completed from the sodium hydrate, which is the electrolyte, by means of a collecting electrode not chemically acted upon by the electrolyte and an extraneous conductor, to the carbon, an electric current flows continuously from the sodium hydrate through the collecting electrode and the exterior conductor to the carbon, the strength of the current depending primarily upon the rapidity with which the air is blown into the sodium hydrate, and the oxygen of the air caused to combine with the carbon.

The arrangement for carrying out the process is shown in the accompanying illustration. The carbon C is immersed in the caustic soda solution E. A pump, A, forces air into the rose R, which distributes it evenly into the electrolyte. The solution is contained in the Norway iron pot I, which forms the positive terminal, the negative B being clamped to the carbon C, which is supported by the insulating cover S. The caustic soda solution is admitted and removed by the pipes *i* and *o*. The whole is surrounded by a furnace, F, which maintains the active cell at a temperature of 400°C. to 500°C.

In this process the carbon is gradually converted into carbonic acid, which mostly bubbles up through the electrolyte and escapes. The resultant composition of the sodium hydrate remains unchanged, except as shown below, and oxygen of the air is consumed. The nitrogen with which the oxygen of the air is diluted, having no chemical affinity for any other substance present, simply bubbles through the electrolyte and escapes.

Dr. Jacques' conception of the function of the electrolyte is that it carries oxygen electrolytically from the air to the carbon, or that the phenomenon of electrolytic action causes the conversion of the potential energy of the carbon into electrical energy instead of into heat, as is the case when oxygen combines with carbon without the intervention of an electrolyte.

Although the greater part of the carbonic acid, whether resulting from the union of carbon and oxygen already existing in

* From the *Electrical Engineer* of New York.

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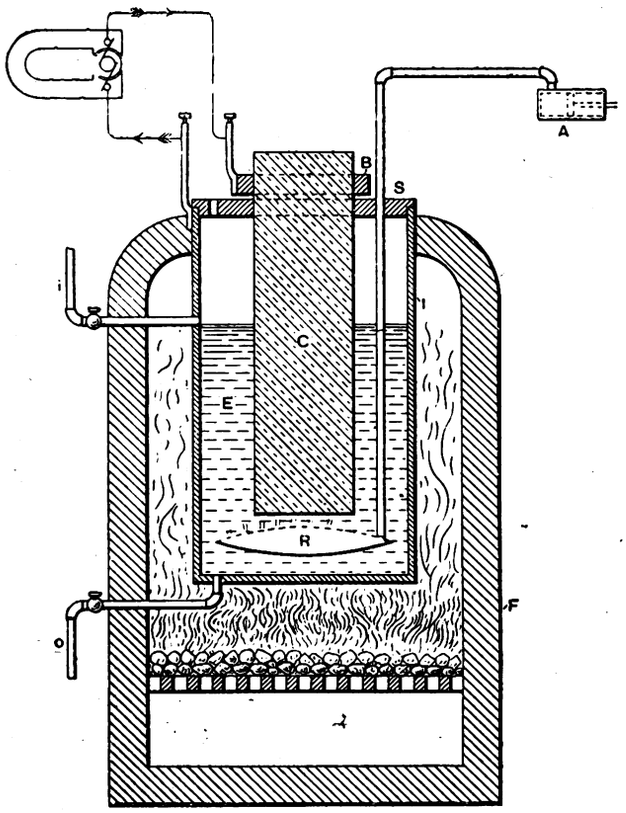
the air supply, bubbles up through the electrolyte and escapes, a portion of the carbonic acid combines with a portion of the caustic soda to form carbonate of soda, and this, together with the ash from the carbon, slowly contaminates the electrolyte, and in the course of time lessens its efficiency. The efficiency may be maintained by drawing off from time to time a portion of the contaminated electrolyte and admitting a fresh portion to take its place.

The contamination of the caustic soda by its union with carbonic acid may be reduced, and its life prolonged, by adding a small percentage of oxide of magnesium. According to Dr. Jacques, the action of the oxide of magnesium is that the free carbonic acid



Jacques' Carbon Consuming Electric Generator.

combines with it in preference to the caustic soda, and that the carbonate of magnesium so formed is quickly decomposed into carbonic acid, which escapes, and oxide of magnesium, which is again ready to repeat its action. Briefly, the oxide of magnesium serves as a carrier to convey the carbonic acid through the electrolyte.

The current obtainable by this type of generator is said to be very large, but the voltage, which is not given by Dr. Jacques, is low.

INSTITUTION OF ELECTRICAL ENGINEERS.

At the ordinary general meeting held on Thursday evening, March 26th, the President, Dr. John Hopkinson, F.R.S., occupied the chair. The formal business having been transacted,

The PRESIDENT said the balance sheet had been circulated amongst the members, and he would therefore suggest that it be taken as read. He moved that the statement of accounts and balance sheet for the year ending December 31, 1895, be received and adopted. Major-General WEBBER seconded.

Mr. J. S. RAWORTH rose to propose an amendment. The President requested Mr. Raworth to be as brief as possible as there was a Paper to be read, and doubtless there were many members present who had come especially to hear that Paper.

Mr. RAWORTH: I feel that strongly. Perhaps it would suit you, sir, to postpone this discussion on the balance sheet, so that we might not suffer any inconvenience.

The PRESIDENT: We can hardly do that.

Mr. RAWORTH, continuing, said he had received from the Secretary the balance sheet which had been just described and taken as read, and as it was part of his duty to deal with balance sheets, and he was therefore to a certain extent conversant with accountants' methods, he had taken the trouble to cast his eye over this particular sheet and to endeavour to understand it. At the very outset he found some peculiarities which set him to work to get right down to the very bottom of it, because he thought if he succeeded in understanding it he might, perhaps, be able to render some service to the Institution by enabling the members also to understand it. As the result of those endeavours he thought he had succeeded in thoroughly and completely understanding it. The gist of his remarks would be, in the first place commendatory; in the second place, explanatory; and in the third place, critical. To begin with, he found the Secretary had kept the accounts of the Institution in a thoroughly accurate manner; and after he (the speaker) had constructed a balance sheet of the accounts of the Institution as it should be constructed, he found that there was not one penny of difference, but that the balance sheet came out absolutely correct. He was sure they would be very much gratified with that. Now coming to the balance sheet in detail, they would have observed one remarkable thing in connection with it, that it was the first time in their history that they had been treated to a balance sheet. They had never had one before [Sir David Salomons: Oh, yes, every year]. On every previous occasion it had been called an estimate of assets and liabilities; on this occasion it was called a balance sheet, and he ventured to suggest that there was the greatest difference in the world between these two definitions. An estimate of assets and liabilities in the view of an accountant was quite a different thing from a balance sheet. They looked upon him probably as an engineer and not as a skilled accountant, and therefore having first of all submitted this balance sheet to his friend, Mr. Hodson, accountant to the Brush Company, and next to Mr. Garcke, who stood very high in the esteem of the financial world as a skilled accountant, and got their opinion of it, he took it to a gentleman who stood, he believed, in the very first rank as an accountant in the City of London. That gentleman said, "It is not very much worse than the generality of balance sheets of these institutions. They always are lax, and I always deplore it, because in their case it is more necessary than in the case of a mercantile company that their balance sheets should be on the very best lines possible, because what is everybody's business is nobody's business, and accounts are liable to get into a very bad condition." The first thing that struck him in looking over the Institution balance sheet was a figure at the bottom right-hand corner, where they found "furniture as per last balance sheet, less depreciation, say, £14." He looked to see if that depreciation had anywhere been provided for, and found that it had not. How they could possibly, on this method of constructing a balance sheet, write off £14 of depreciation, without in some other portion of it providing for that depreciation, he did no know. Then he found, looking at the item "books, pictures, &c.," that the sum total had risen from £1,043 last year to £1,093 this year, being an accretion of £50 without any apparent expenditure on that item except the small sum of £8. 2s. for books and periodicals. He thought he had shown them sufficient to make them believe that this balance sheet had some very strange peculiarities, and the excuse he had for bringing this matter before them was that he looked on a balance sheet, an absolutely sound balance sheet, as the greatest security an institution of this kind could have for the transmission of its funds and assets unimpaired to future generations. They who were now present would soon vanish from the scene, and others would take their places. The Institution of Electrical Engineers was now constituted of themselves and some others on the list, but in a few years those names would vanish and others appear, and he thought the best legacy they could hand down to their successors was a balance sheet sound, business-like and perfect, because if they put the time off until defalcations arose, how very difficult their position would be! Instead of being an easy task, as his was that night, to show up the defects of the balance sheet, it would be a very painful operation, and one which they or their successors would think might have been tackled by their predecessors. He did not want to press this matter home that night. He did not think their Council thoroughly understood the papers they had in their hands, and if the remarks he had made had not convinced them he would proceed. The next point he had to call their attention to was a fund of which they were all very proud—he referred to the Salomons Scholarship Fund. Now, in making a fresh balance sheet out for this Institution, and coming very close on to a balance, he found he could not make the accounts balance by the sum, if he remembered rightly, of £570. 13s. 6d. He had got that amount more in assets than he ought to have, and he scanned the balance sheet from top to bottom to find out where that money had come from. If it was possible for money to get into a balance sheet without being accounted for, it was equally possible for money to get out of a balance sheet without being noticed. He found at last that they were indebted to Sir David Salomons for this £570. 13s. 6d., and he remembered that at the general meeting which took place some months ago, it had been stated that Sir David Salomons had been so good as to give them £500—he had given them, as a matter of fact, £570. 13s. 6d.—and yet they had not acknowledged that in their balance sheet in the slightest degree. Two or three years ago, when Sir David kindly gave them an addition to the fund, they put a note at the bottom, "presented by Sir David Salomons to the Salomons Scholarship Fund," and that, he thought, was a perfectly right and proper thing to put in; but on this occasion they had dropped that out and made no acknowledgment whatever to Sir David Salomons. Sir David did not confine his gift to mere pelf, he was a very rich man they knew, but he had given them more than money, he had given them his services. He had learnt from a member of the Council—he thought he should not be betraying a confidence if he stated that Mr. Dane Sinclair had told him that since he had been on the Council he had found that nobody gave more attention to the affairs of the Institution, or looked more strictly after the honour of the Institution than Sir David Salomons; and yet when they came to the balance sheet, which would be a record to future generations of how they got their money, and who were their friends in early days, there was no mention made of Sir David Salomons' gift to this Institution. From the point of view of the balance sheet it was altogether wrong for any sum to get into that balance sheet without any explanation as to how it got there. He thought he had said quite enough to show that this was not a satisfactory balance sheet for the Institution of Electrical Engineers. Now to come to another benefactor of the Institution. He did not know what his

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name was, but he had given them four guineas to the library und, whatever that might be, and he found so far as he could judge from the balance sheet that they pocketed that four guineas, but had not done anything with it for the benefit of the library. They spent in 1895 £8. 2s. on books and periodicals, in 1894 £6. 19s. 8d., in 1893 £8. 18s. 7d., and in 1892 £12. 19s. 3d., so that if their good friend thought the interests of the Institution ought to be attended to in the matter of books to the extent of four guineas, he thought they might take it he had been disappointed, and they had applied that money to some other purpose. It might be said that if he did not complain why should they, but probably he was one of those individuals who would put up with a great deal rather than make any complaint whatever. There was another matter he wanted to bring before their notice, and that was that the funds of the Institution had gone up so successfully that their cash balance was £1,173. 16s. 6d., after making a provision for paying into the building fund the sum of £90 interest on their securities. He knew Sir David Salomons took great interest in this fund. He believed it was at his suggestion that it was founded, and a very good suggestion it was, and he (Mr. Raworth) thought they did owe to that fund that they should deal rightly, fairly and squarely by it. Last year they transferred the sum of £3,000 to it; this year they had transferred to it the sum of £500, making £3,500, and it had earned interest to the extent of £90, making it £3,590, but the fund only stood in the balance sheet at £3,500. He did not want to use hard words, but that poor fund had been swindled out of £90 somewhere. It seemed a nice thing to have £3,000, but if there was no interest it did not get much better. It might seem a very nice thing if he were to give them an oyster bed; but if there were a proviso that they were not to have any of the oysters it would not be of much use.

The PRESIDENT begged Mr. Raworth to shorten his remarks by dispensing with illustrations; they wanted to get along with Mr. Sinclair's Paper.

Mr. RAWORTH said that might be so. He thought it was a very important matter, but if they would allow him he would proceed at once.

The PRESIDENT: You have been already a quarter of an hour.

Mr. RAWORTH said this was the foundation of their business, so to speak, he wanted them to consider that they had a surplus this year of £1,173. 16s. 6d., and yet they had spent on premiums on Papers only the small sum of £23. 3s. This Institution was founded as they knew for the purpose of the advancement of electrical science, and by Clause V they were to make grants of money for books, apparatus, &c., for the purpose of promoting investigation; and yet having that surplus of £1,173 they had only spent £23 to stimulate their members, while the Institution of Civil Engineers had spent £412. 9s. 6d. Sometimes it was remarked that very good Papers that they might think ought to have been read before the Institution had been taken to the Civil Institution, and he thought the explanation was to be found in that particular fact. They had an enormous number of young members who had gained experience in the midst of business, which might be very valuable, and many of them would bring forward and read Papers if they could afford to do so.

The PRESIDENT: I do really think you are diverging on to matters which have nothing to do with the question.

Mr. RAWORTH said that the way in which their money was spent had a great deal to do with the question arising out of the balance sheet. However, as the President did not wish him to continue, he certainly would not. He had wished that it might not be necessary to move the resolution of which he had given notice, for he had hoped that the Council, after hearing his arguments would have come to the conclusion that this balance sheet, from which important matters were omitted, was not up to the standard to which the Institution of Electrical Engineers ought to attain, and that they would have withdrawn it. As, however, they had not done so, he had no alternative but to move "that the balance sheet be referred back to the Council for amendment."

Mr. W. M. MORDEY: I have very great pleasure in seconding the resolution.

The PRESIDENT: I will ask our accountant, Mr. Biggs, to give us the explanation of the points which Mr. Raworth has raised.

Mr. BIGGS (of Messrs. Wagstaff Blundell, Biggs and Co.) said the balance sheet as mentioned by Mr. Raworth showed the liabilities and assets in balance sheet form for the first time this year. This was decided upon in consultation with Mr. Webb and the auditors last year, and, of course, twelve months had necessarily to elapse before it could possibly be done. Having largely helped to prepare this balance sheet, he had not found much difficulty in understanding it. Gentlemen who were unacquainted with accounts might possibly find some little difficulty in understanding an ordinary balance sheet; but if they took the assets they would find on the right-hand side that the investments of the Institution were there set forward in full detail, and they amounted to £10,500. With regard to the item "furniture as per last balance sheet," he was afraid that was a slip, a mistake of the secretary or the printer, because this was the first time that the balance sheet was issued in that form. As to the £14 depreciation, Mr. Webb, in consultation with the auditors, had decided that to be quite sufficient; that reduced the furniture to £200, and Mr. Webb said there would be no necessity for any further depreciation. That represented the value of the furniture now, and would probably still represent it in 10 years time. The overdue subscriptions were estimated to realise £228. A considerable amount of care and attention had been paid to the list; it had been gone through carefully, and he was advised that £228 was a very fair figure to put it at. To the stock in hand of Institution Journals and Ronald's catalogues, the same remark applied to the books and pictures. The books in Ronald's library had been mainly acquired by gift; they were not purchased, and if any half-dozen gentlemen would like to value those books they would probably each bring out a different value. It was quite sufficient for the purposes of the Institution to put that at £1,093. Those were the assets. On the other side the different funds to which the assets belonged were set forth. There was the premium fund, the life compositions, and he might remark that with regard to the life compositions they must be shown separately under the Articles of Association, which provided that they must be so shown—the Salomons Scholarship Fund, which also was shown separately because the income was shown separately, and was applicable to a certain purpose. The Institution could not divert the assets, nor could they divert the income. The building fund and the general fund comprised together £6,700, and the distinction between the two funds was a distinction made by the Council, and for which they were solely and entirely responsible. They formed the capital account of the Institution, so that the balance sheet, boiled down, as it were, to nothing, showed that the assets of the Institution amounted to over £12,000. He did not know that he could give any other explanation. It seemed to him that, on the face of it, the balance sheet gave all the information that was necessary. Mr. Raworth, as he understood it, said it was a sound balance sheet [Mr. Raworth: No, no.]. He thought it was a very sound balance sheet himself. He thought any institution which could show £10,000 of assets which could be realised to-morrow against any liabilities to creditors of any sort whatever could not be said to be otherwise than in a flourishing condition. As regarded the donation of four guineas to the library fund, he did not know the name of the donor, nor did it form part of his business to acquire the knowledge; but the four guineas had entered into the funds of the Institution, and that for all purposes seemed to him to be sufficient. With regard to the memorandum on the balance sheet as to the donations from Sir David Salomons towards the scholarship fund, it seemed to him that the balance sheet was not the place where they should make any remarks as to the gratitude they owed to anybody with regard to any particular donation. In all probability in this case, as in most other cases, the record of the donation was entered upon the minutes, and the gratitude of the Institution was expressed there. It seemed to him that the balance sheet had nothing to do with the gratitude of the Institution towards the donor of any particular donation.

The PRESIDENT: I won't waste any more of your time, but at once put to you Mr. Raworth's amendment to my resolution.

Mr. RAWORTH: I would like to point out that the last speaker has not replied to any of my remarks with regard to the balance sheet, but has left my criticism entirely untouched.

The PRESIDENT: I will put Mr. Raworth's amendment that the balance sheet be referred back to the Council for amendment.

Twenty-seven votes were recorded for the amendment and 16 against it. The President declared the amendment carried, and immediately called upon Mr. Dane Sinclair to read his Paper on "Telephone Exchanges and their Working." At the conclusion of the reading of the Paper the meeting was adjourned until April 16th.

THE TELEGRAPH AND THE BOAT RACE.

A remarkably successful experiment has been made in connection with the transmission of the result of the Oxford and Cambridge boat race over the cables of the Eastern, Brazilian Submarine, and Western and Brazilian Telegraph Companies, and the land lines of the Pacific and European Company across the Andes. On Saturday last the lines were cleared and particulars relating to the crews and other matters concerning the race were first of all sent through, and everything made ready for the result to be dispatched to Argentina, Chili, and Peru, the precautions taken including the careful checking of the clocks *en route* by Greenwich mean time just before 12:40 p.m. when London cleared. Immediately the winning boat passed the judge at Mortlake the message was received through the Exchange Telegraph Company at the Eastern station in Old Broad-street, London, by means of the Unigraph, a useful instrument invented by Mr. T. A. Bullock and Mr. A. C. Brown. From London the message started on its way *viâ* Porthcurno (Land's End) to Carcavellos (Portugal), thence to St. Vincent, on to Pernambuco, thence to Buenos Ayres, finally reaching Valparaiso 45sec. only after the result of the race reached London. In obtaining this result, no less than nine transmissions were required. The following particulars lend additional interest to the achievement:—

As previously stated, London cleared the line at 12:40 p.m. One minute later the first message went through that Cambridge had won the toss. Subsequent messages described the state of the weather, the position of the boats before starting, the start (at two minutes past one), the relative position of the boats at various points on the river. In brief but clear terms the chances of the competitors were rapidly conveyed to the other end of the world, until finally, at 1h. 22¼min., the ninth message was dispatched that Oxford had won by a third of a length.

In order that every care should be taken to verify the accuracy of the times taken, the stations *en route* were requested to answer inquiries relative to the receipt and dispatch of the messages, and these replies show conclusively that the ninth message, which left London 1h. 22¼min., occupied only 45 seconds in transit to Valparaiso, which was thus in a position, by the aid of consecutive messages, to take a connected interest in the race from start to finish—in fact, to take a closer part in the whole proceedings than we who were within a mile or two of the race were able to do

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It is needless to add that such an achievement would be impossible without preconcerted action and intelligent co-operation on the part of the intermediate stations. This co-operation was most conspicuous and laudable, each entering into the work with an earnestness which ensured success, rendering the long sections of cable and landline between London and Chili practically one length. The result of the experiment certainly reflects credit upon all concerned, and the companies over whose cables and landlines the messages passed may compliment themselves upon the activity and zeal of their staffs, and, under the conditions prevailing, the accomplishment of a feat unparalleled in the history of telegraphy.

The Direct United States Cable Company forward us the following:—"The result of the Oxford and Cambridge Boat Race was handed in at the office of the Direct Cable Company in London at 1:23½p.m., Greenwich time, and was received at their offices in New York and Boston, and in Montreal, practically at the same instant."

CORRESPONDENCE.

THE BALANCE SHEET OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is with much satisfaction that I observe that in your opinion the balance sheet of the Institution of Electrical Engineers is, or ought to be, a matter of interest to the members and associates generally.

Your leaderette of the 27th inst. on the accounts of the Institute supplies an apt illustration of one of the points which I brought up at the meeting last Thursday, viz., that no one could get a clear idea of the meaning of the balance sheet presented without very considerable trouble. I have no doubt, Sir, that you took more trouble over this matter than most ordinary members took, and that you possess for the purpose a critical mind more than ordinarily well trained; nevertheless, you have given the receipts as £4,533, which is £659 too high, against an expenditure of £2,641, leaving a balance of £1,892, whereas the balance for the year is actually £1,233. This result is, of course, a sufficient proof of our solvency, and as such I duly appreciate it.—Yours, &c., JOHN S. RAWORTH.

March 31, 1896.

[We are obliged to Mr. Raworth for calling attention to a slip in one of the five figures quoted in our Note of last week. The sum of £659 is made up of two balances on the "Receipts" side of the accounts, which should not, of course, be included in the 1895 receipts.—ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As I have not had any reason to look for dividends from the Institution, I fear I have been somewhat remiss in my perusal of the annual statement of accounts. Since, however, Mr. Raworth has called our attention to the subject, I have, as a matter of interest, looked over the statements of accounts for 1893, 1894 and 1895. If there is any object in issuing these accounts, I certainly think they should be submitted in a satisfactory form, although, for my own part, I am quite satisfied that the Council should keep the accounts in whatever way they think fit. I do not consider that the form of accounts as now presented can be regarded as satisfactory.

To take one item—that of "life compositions." The Articles of Association provide that "all such compositions shall be invested, and the interest alone shall be appropriated to the current expenditure." In 1893 the amount received under this head was £206, the amount invested during the year was £204. 10s., and the total investment on this account was £2,497. In 1894 the amount received was £362. 10s. and the amount invested during the year only £204. 16s. 6d., and the total amount invested £2,701. 16s. 6d., leaving a balance on the two years to be invested of £159. 3s. 6d. Now, in 1895 the amount received was £277. 10s., but as much as £552. 5s. 4d. was invested, bringing up the total amount invested to £3,254. 1s. 10d. According to this, it would appear that the sum of over £100 must have been in suspense from some period prior to 1893. I have no wish whatever to complain of this if the Council think fit to deal with the fund in this way, but it is not a satisfactory way of making up accounts that the balance of the life compositions not invested was not shown. The total amount of the life compositions is this year shown for the first time since 1893 at £3,272, of which only £3,254. 1s. 10d. is shown to be invested. Is the balance in the general fund? Would it not be more correct to show a separate account of the life compositions?

The same kind of thing appears in connection with the Salomons' Scholarship Fund. The amount received for interest in 1893 was £51. 1s. 8d., and the amount spent in awards was £70, but nothing is said of any balance on either side. In 1894 the amount received was £50. 17s. 3d., and the amount expended was £50, and the statement shows a balance of £32. 5s. 2d. How this balance is made up does not appear.

There are other items I might refer to, but I do not wish to take up too much of your space; I would, however, like to point out the extraordinary discrepancy between the statements in the annual report presented on December 12th, and the statement of accounts. In the report it is stated: "The following investments have been made during the year, viz., £554. 17s. 8d. on account of life compositions and £1,099 19s. 6d. on account of General Investment Fund." No such figures can be traced in the accounts, which show only £552. 5s. 4d. invested during the year on account of life compositions, but as much as £1,300. 12s. 8d. on account of general investment.

The report also says: "The annual accounts, when made up to the end of the year, will in all probability show a surplus equal to that of last year." Now, the surplus at the end of 1894 was £10,712. 8s. 1d. At the end of 1895, however, no surplus whatever is shown, and in place of it there is a general fund balance of £3,279. 18s. 9d., whatever that may be. The disparity between these figures arises out of the Premium Fund, the Life Compositions Fund, the Telegraphic Jubilee Fund, the Salomon's Scholarship Fund, and the Building Fund being this year regarded as liabilities, while in previous years the Council, according to the accounts, regarded these items as assets.

Now that the Council have by these accounts raised a doubt in my mind, I should certainly be very much interested to learn from someone able to enlighten us what these items really are. I have no doubt, as the Council say that the surplus this year is equal to that of last year, but it certainly is not correct to say that the accounts show it.—Yours, &c.,

1 and 2, Great Winchester-street, E.C., E. GARCKE.

March 31, 1896.

LEGAL INTELLIGENCE.

Lazare Weiller and Co. v. Bolton and Sons.

In the Appeal Court, last week, before the Master of the Rolls and Lords Justices Lopes and Rigby, the plaintiffs in this action appealed from a decision of Mr. Justice Mathew, who had decided that there had been a breach of contract on the part of the defendants, that there had also been a breach by the plaintiffs of a collateral agreement, and that the defendants were entitled to counterclaim in respect of it. Full particulars of this case were given in our issues of February 7th, 14th, and 28th.

Mr. Bigham, Q.C., Mr. J. Walton, Q.C., and Mr. Rufus Isaacs appeared in support of the appeal, and contended that there had only been one contract, and that the alleged collateral agreement was not a contract at all. On the other hand, the defendants, who were represented by Sir E. Clarke, Q.C., M.P., Mr. Lawson Walton, Q.C., and Mr. Wills, urged that the collateral agreement went to the root of the entire question, and further pleaded, by way of cross appeal, that they had been induced to enter into the original contract by misrepresentation.

In delivering judgment, the MASTER of the ROLLS said that the learned judge at the trial had, in his opinion, been quite justified in coming to the conclusion that no misrepresentation had been made by the plaintiffs, and that if any misrepresentation had been made the defendants had not relied upon it. As to the letter which the defendants contended amounted to, and which the learned judge held was, a collateral contract, in his opinion, when the terms of this letter were looked at, and when all the facts were taken into consideration, it could not be rightly said it was intended to contain a binding promise. It might be described as an agreement to enter into a further agreement, and, if so, it was not a promise which could be sued upon. Even if it were a promise, it was an independent promise, and could not be regarded as a condition precedent to the original contract. The plaintiffs were therefore entitled to succeed on all points. The appeal would therefore be allowed, and the defendants' counter appeal dismissed.

Lords Justices LOPES and RIGBY concurred.

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Walter v. The Central News (Limited).

This was an action before Mr. Justice Hawkins and a special jury, brought by the proprietors of *The Times* newspaper against the Central News (Limited), in which the plaintiffs allege that the News Agency had during the late war between China and Japan supplied them with telegrams purporting to have been sent by special correspondents, but which were, it was alleged, in many cases entirely fabricated and concocted by the Central News, and in other cases were unduly altered and expanded; and further that, whereas many of these telegrams were stated to have come from persons on the spot where the events recorded had happened, they, in fact, had not come from eye witnesses. For the defence, these allegations were denied, except that if any alterations or expansion had taken place, this had only been done in accordance with the custom and practice of the news agency business. A large array of forensic talent is engaged in the case, which is still proceeding, and is creating considerable public interest, especially when the originals of the telegrams are produced and are read in conjunction with the elaborated accounts which appeared in *The Times* during the period of the war.

Sir FRANK LOCKWOOD, Q.C., M.P., for the plaintiffs, pointed out that telegraphic communication between Japan and this country was expensive, being at the rate of about 8s. a word, but if news could be sent *viâ* Shanghai the cost was only 3s. 7d. a word. During the progress of the war, and after many of the telegrams had appeared, a letter was received by the proprietors of *The Times* from a gentleman of great experience in Chinese matters throwing doubt upon the accuracy of the telegrams, and an attempt was made to obtain possession of the original despatches, but in vain, the representative of the News Agency giving the assurance that the telegrams were in almost identical terms to those received from their correspondents. It was not until May, 1895, that attention was especially called by the *Kobé Chronicle* to the matter, and in an article in that journal a long telegram appearing in *The Times* was stated to be simply an expansion of a telegram published in the *Shanghai Mercury*, where it consisted of 216 words, but in the London journals became a blown-out despatch of 665 words. This telegram was considered by *The Times* to have been a trifle too bulky, and an explanatory note was published stating that more than two-thirds of the telegram had been manufactured in London. Mr. Moore, of the defendant Company, then wrote to *The Times*, stating that the allegations of the Shanghai paper were a tissue of fabrications. Some of the telegrams read by Sir F. Lockwood, both from the original despatches and their full-bodied successors in the columns of *The Times*, were certainly marvels of creative journalism. A more serious complaint, however, was that, according to the contention of the plaintiffs, the telegram of 216 words came from Shanghai, whereas the elaborated telegram of 665 words was stated to have come from Wei-hai-wei, where the engagement described in the telegram was alleged to have taken place. This method of amplification had not been confined to one telegram, but had been systematic, and the jury would be surprised to hear that the entire number of telegrams received by the Central News Agency contained only 7,413 words, whereas there was sent to and published in *The Times* no less than 36,599, including 3,487 words, representing 17 telegrams for which the defendants appeared to have no original dispatches at all. The plaintiffs (counsel concluded) had not brought this action to recover heavy damages, but it was claimed that the money which had been paid for these fabricated telegrams ought to be refunded.

On Monday, Mr Charles Frederick Moberley Bell, assistant manager of *The Times*, was examined, cross-examined, and re-examined. The evidence was extremely interesting and instructive, especially as to the light thrown upon the methods adopted by the news agencies to render foreign telegrams "readable and complete" and suitable for up-to-date journalism. The art of amplification was not the only journalistic peculiarity which the evidence disclosed, and the readers of the daily journals will probably in future discount somewhat the large measure of praise hitherto freely bestowed upon the "enterprise" of some of our leading dailies and their "own correspondents" and "special commissioners."

Mr. Bell's examination was concluded on Tuesday, and the case adjourned to April 14th.

The Electric Installation Company (Limited) v. Lord Stratheden and Campbell.

This case came before Justices Day and Wright, being the appeal of the plantiffs from the decision of the Official Referee (Mr. Ridley), who had given judgment for the defendant both on the claim and counter-claim. The plaintiffs sought to recover £1,300 for work done in connection with the fitting up of an electric light installation at Lord Stratheden's house, known as Hartrigg, near Jedburgh. The defendant alleged that the installation was deficient, as the water-power which had been utilised was not at times sufficient to produce the necessary light, and further that he had incurred a very heavy expenditure over and above the work the plaintiffs had indicated would be necessary in order to make use of a brook of water to supply the necessary power for generating purposes. In the result it was announced that the parties had come to terms, and that the appeal would be dismissed on the defendant paying to the plaintiffs £750 without costs.

Fowler and others v. the Chelsea Electricity Supply Company (Limited) and Sandon and others v. Same.

In this case, in which, it will be remembered, the plaintiffs obtained an injunction restraining the defendants from creating a nuisance by the noise from their works, counsel for the defendants on Friday last mentioned to Mr. Justice North in the Chancery Division that his clients abandoned their application for an extension of time during which the injunction was suspended on the terms of paying the costs of the plaintiffs. The injunction therefore, takes effect accordingly.

Gulcher (New) Electric Light and Power Company (Limited) v. Murray.

In *The Electrician* for January 24th, on page 423, reference was made to an action brought by the liquidator of the Gülcher Company against a Mr. James Murray to show cause why he should not be liable to pay calls upon 300 Preference shares alleged to have been duly allotted to him in the Company. Mr. Murray's contention was that he agreed to take the shares, but only upon certain conditions, which he maintained had not been carried out.

In the previous action the Court found that Mr. Murray had no knowledge of his name being on the register of shareholders, and decided that he was not liable. Hence the present appeal.

After hearing the arguments on behalf of the liquidator, and without calling upon counsel for Mr. Murray, the appeal was dismissed with costs.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations

NEW BOOKS AND EDITIONS.

The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices:—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell, with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

TENDERS INVITED.—The Electric Lighting Committee of the Derby Corporation require tenders for the supply and laying of low-tension cables and junction boxes in the borough. Tenders to Mr. H. F. Gadsby, Town Clerk, at the Town Hall, not later than 12 (noon) of Monday, April 13th.

——— The Commissioners of the township of Rathmines and Rathgar, Ireland, require tenders for the electric lighting of the new Town Hall and offices, for which about 250 lights with the necessary generating plant will be required; also for an installation of telephones and electric bells. Some further particulars will be found in our advertisement columns, and tenders must be sent in to Mr. F. P. Fawcett, Town Hall, Rathmines, by 10 a.m. of Monday, the 20th inst.

——— The Edinburgh Corporation invite tenders for the wiring of the police cells for the electric light. Tenders by 10 a.m. on April 11th, to the Town Clerk, Mr. Thomas Hunter, W.S., Town Hall, Edinburgh.

——— The Willenhall District Council require tenders for the establishment of an electric call system between the fire station and 14 firemen's houses. Tenders to the Clerk, Mr. Rowland Tildesley, 65, Walsall-street, Willenhall, by 10th inst.

TENDERS ACCEPTED.—Messrs. G. Ewing Johnston and Rea, of Liverpool, have secured the contract for the installation of the electric light at the new West Kirby Hydropathic. The plant will include gas engine, a battery of accumulators, &c.

——— The Gas and Electric Lighting Sub-Committee of the Aberdeen Town Council have accepted the tender of Messrs. Crompton and Co. for a new 300 H.P. engine and dynamo for £2,600. Messrs. Siemens Bros. and Co.'s tender for additions to the switchboard at £130 was also accepted.

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TENDERS ACCEPTED.—The Gas and Electric Lighting Committee of the Burnley Town Council have accepted the tender of Messrs. S. Z. de Ferranti (Limited) for the supply of 50 electricity meters at £262. 10s.

——— The Bedford Urban Sanitary Authority have accepted the tenders of Messrs. Siemens Bros. and Co. for the supply of a switchboard for £400, and of Mr. W. Bradley for the supply of 150 additional cast-iron lamp standards and fittings at £374. 5s.

——— At Tuesday's meeting of the London County Council the Fire Brigade Committee reported that the following tenders had been received for wiring and fitting up the fire brigade station in Tabernacle-street, Shoreditch, for the electric light:—

Russell and Lennard (*accepted*)	£173	15	0
A. W. Jackson	248	10	0
Pritchetts and Gold	228	0	0
Crompton and Co. (Limited)	219	0	0
Drake and Gorham	186	5	6

APPOINTMENTS VACANT.—The Council of the County Borough of West Ham invite applications for the post of electrical engineer, with a commencing salary of £300 per annum. Our advertisement columns furnish some further particulars in regard to the experience, &c., required, and applications must be sent to Mr. Fred. E. Hilleary, Town Clerk, Town Hall, West Ham, by 5 p.m. of Wednesday, April 8th.

——— An engineer and electrician is required for the Hackney public baths, salary £156 per annum. Applications to the Clerk, Mr. Geo. Grocott, Town Hall, Hackney, by noon of Thursday, the 16th inst.

LIQUIDATIONS.—At a meeting on the 21st inst. it was decided to wind up Roger Dawson (Limited) voluntarily. Mr. H. B. Johnson, 29, Gloucester-road, Regent's Park, London, N.W., has been appointed liquidator.

——— A meeting will be held on May 1st, at 27A, Sackville-street, for the purpose of receiving an account of the winding-up of the Foreign Electric Date and Time Stamp Company (Limited).

——— Notice is given of the release of the liquidator, Mr. C. J. Stewart (late senior Official Receiver), in the liquidation of Newington, Priddle and Co. (Limited).

AGENCY.—Mr. C. F. Quicke, M.I.E.E., of 72, Finsbury-pavement, E.C., has been appointed London agent to the old-established engineering firm of John Turner and Sons, of Denton, Manchester, who have recently added an electrical branch to their business.

ADDITIONAL PREMISES.—Owing to increase of business, Messrs. Ward and Goldstone, electrical engineers, of Gorton, have taken additional premises at Charles-street, C.-on-M., Manchester.

CATALOGUE.—We have received a copy of a catalogue, issued by the Campbell Gas Engine Company (Limited), describing the "Campbell" oil engine. This engine is built in sizes from 1¼ to 30 B.H.P., and is designed to work with ordinary lighting oils of from 120deg. to 150deg. flash point. The engine has been extensively used as a small motor in mills and factories and for electric lighting plants. The consumption of oil appears to be quite up to the average in economy; and from the system of governing used a high economy at reduced loads might be expected. The governor acts by missing explosions when the speed is too high. The prices of the engine are not printed in the catalogue, but may be had on application to the offices of the Company at Halifax.

THE "JANDUS" ARC LAMP.—Messrs. Drake and Gorham inform us that these lamps have been adopted by the Royal Arsenal at Woolwich and by the Army and Navy Stores, as well as by a number of electric supply companies; and that the alternating lamp, which will, we understand, contain features not to be found in other types of arc lamps, is to be ready for delivery in about a month.

NATIONAL TELEPHONE COMPANY'S SUBSCRIBERS' LIST.—It is notified by the National Telephone Company that a new and complete list of the names, professions or trades, and addresses of every subscriber to the Company's exchange system in the United Kingdom will be issued on or before July 1st next. It is important that subscribers who intend removing from their present premises before that date should communicate with the Company's manager in their district, in order that the list may be made as complete as possible by the necessary corrections being made. It will be impossible to guarantee any insertion in the list received after April 30th.

RECENT DEVELOPMENTS IN PHOTOGRAPHY.—Prof. Röntgen's recent discovery has caused a considerable demand to arise for vacuum tubes, induction coils, &c., and medical men especially will be interested to learn that the Vacuum Tube Company, of Albany-buildings, 39, Victoria-street, London, S.W., have made special arrangements for supplying these requirements. The Company owns patents in connection with the manufacture of special high-exhaustion tubes (electro-chemically exhausted) and vacuum tubes of all kinds. For the convenience of medical practitioners and others requiring to take photographs by means of X-rays, the Company have fitted up a room with a complete set of all requisite apparatus, which can be loaned at a small cost, technical advice being at the disposal of those who may require it.

THE "ENGINEERING MAGAZINE."—The contents of the April number of this excellent magazine include:—"Industrial Conditions and the Money Market," by Maurice L. Muhleman; "Railroad Corporations and Practical Politics," by Cy Warman; "Pump Irrigation on the Great Plains," by H. V. Hinckley; "Future of the Elevated Railway," by Eugene Klapp; "The Relative Value of Different Coals," by H. M. Chance; "The Present Status of Aerial Navigation," by Octave Chanute; "Modern Machine Shop Economics," by Horace L. Arnold; "Pure Water for Drinking and Cooking," by S. P. Axtell; "The Architecture of Modern Bank Buildings," by R. W. Gibson; "Determining the Value of an Iron Mine," by Nelson P. Hulst; together with the usual exhaustive Review of the World's Press. This number, as well as all the back numbers, may be obtained at the offices of the European edition, 1, 2 and 3, Salisbury-court, Fleet-street, London, E.C.

ABERDEEN.—The question of the proposed extension of the electricity supply station was considered by the Gas Committee at their last meeting, and it was decided that the electrical engineer (Mr. A. S. Blackman) should present a report on the subject. The Finance Committee were also instructed to present a report on the financial position of the electricity department.

ACQUITTAL.—At the Liverpool Assizes last week Peter Bradley, aged 26, an electrician, was charged with embezzling certain sums of money alleged to have been received by him on account of his employers, Messrs. Sharp and Kent, of Connaught-mansions, Victoria-street, London. Bradley pleaded not guilty, and the jury after hearing the evidence upheld the plea, and discharged the accused. The defence in the case was that Bradley had paid over the money or part of it, and that the balance was paid by him to Sharp and Kent's servants, whom he employed for the purpose of their business in Blackpool. Mr. McKeard, for the defence, commented on the peculiar system of book-keeping of the prosecutors' agent, and contended that the charge against Bradley, who he asserted was an honest man, arose from the lax system adopted by the prosecutors.

ASYLUM LIGHTING.—We referred in our last issue to the electric lighting of the Purdysburn Asylum at Belfast, the plant for which was installed by Mr. W. H. Drennan, of Belfast. The plant consists of two 9-kilowatt E.C.C. dynamos (90 amperes × 100 volts) coupled direct to Bumsted and Chandler high-speed engines running at 460 revolutions. The dynamos are arranged to work up to 130 volts for battery charging by varying the resistance in the shunt. A battery of 56 K17 type E.P.S. cells, having a capacity of 275 ampere hours, provides for day load and motors. Two Penman Cornish boilers are provided, and two Worthington feed pumps are arranged to feed either boiler. The main switchboard has been supplied by Messrs. Crompton and Co., and all arrangements have been made for running the plant in parallel. The washing machinery at the Asylum is worked by electric motors. The work has been carried out to the plans and specifications of the City Electrical Engineer, Mr. Victor A. H. McCowen, who acted as consulting engineer to the Board, Mr. John March acting as clerk of works.

BEDFORD.—At the last meeting of the Urban Sanitary Authority the statement of accounts of the electric light undertaking to December 31st was submitted. The capital expenditure to date amounted to £17,336. Revenue from the sale of current realised £1,114. 18s. 4d., and rental of meters £28. 0s. 6d., a total of £1,142. 18s. 10d. The up-keep, &c., amounted to £1,052. 9s. 10d., leaving a gross profit of £90. 9s. Sinking fund and interest came to £870, leaving a net deficiency of £779. 10s. Mr. Richards, in moving that the accounts be passed, said that the statement, which was the first annual one, was satisfactory. The demand for current continued to increase in a very encouraging manner. The accounts were adopted.

BELFAST.—At the last meeting of the Electric Light Committee it was stated that there had been a profit of £300 on the past year's working of the electricity supply station.——The report of the deputation recently appointed by the City Council to visit various towns where electricity was employed for traction purposes recommend the Council to adopt the overhead system of electric traction as being the most suitable for the city.

BRISTOL.—The question of electric lighting extensions was considered by the Electric Light Committee at its sitting on Saturday last, and it was decided to recommend the Town Council to borrow an additional sum of £75,000 for the purpose of extending the buildings and putting down additional plant and machinery. This report will be considered by the Council on the 14th inst. At the same sitting the Finance Sub-Committee presented the estimate of receipts and expenditure for the coming six months. It was stated that the revenue from the undertaking would be more than sufficient to defray the working expenses and to meet the interest

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on loans, sinking fund charges, &c. Various applications for extensions of the mains were received, and it was decided to carry them out. At the present time there is an equivalent of 28,134 8 c.p. lamps connected, and the Committee have applications in hand for over 2,700 more.——Major-General H. S. Crozier held a Local Government Board inquiry on Friday last into the application of the Town Council for sanction to borrow £25,000 for electric lighting purposes.

CHURCH LIGHTING.—The parish church of Rottingdean, Sussex, is now lighted electrically.——St. Barnabas Church, Sheffield, is being wired for the electric light.

CALCUTTA.—The contract for lighting the Sibpur College by electricity has been placed with Messrs. Martin and Co.

CARDIFF.—Mr. G. W. Willocks, M.I.C.E., held a Local Government Board inquiry on the 26th ult. at Cardiff into the application of the Corporation for sanction to borrow a further sum of £12,500 for extensions to the electricity works. The Town Clerk explained that the sum of £45,385 had already been borrowed for electric lighting purposes, and that the present loan required was for additional engines, boilers and other plant, additions to the station, and extension of the mains. The Borough Engineer said that the demand for current had been in excess of their anticipations. At present there was an equivalent of 10,000 8 c.p. lamps connected, and applications had been received for 2,500 more, which they could not supply until they had put down additional machinery, and the proposed outlay would provide for an additional 10,000 8 c.p. lamps. There was no opposition to the application.

DARJEELING (BENGAL).—The Darjeeling Municipality have decided to install the electric light at several large buildings under their control at a cost of 95,000 rupees, the estimated annual upkeep being 9,000 rupees. They will obtain a loan from the Government for the necessary funds. The contractors for the work are Messrs. Kilburn and Co., of Calcutta.

DERBY.—Under the presidency of the new Chairman, Councillor J. P. Thompson, the Electric Lighting Committee of the Corporation last week discussed a report by the resident electrical engineer, Mr. Christie, containing statistics as to the working of the electric lighting scheme during the past four months. Subsidiary schemes which have recently been completed, relating to the electric lighting at the Guildhall and the cattle pens, have entailed an outlay of £190 and £154 respectively.

ELECTRIC TRANSMISSION OF POWER IN MINES.—Continuing the correspondence in the *Financial News* which is referred to on p. 740 of our last issue, Mr. H. K. Baynes, a Director of Messrs. Easton, Anderson and Goolden (Limited), writes as follows :—

"As the successors in business of Messrs. W. T. Goolden and Co. (the contractors for the electrical transmission plant at Moodie's Gold Mining Company), we have read with interest the letter from Mr. W. B. Esson, and cordially endorse his views as to the reliability of electricity as a motive power in mining and other districts. Having supplied electrical plants to many mines, both at home and abroad, including, in Africa alone, the Champ O'Or Deep Level Gold Mining Company, the Cassell Colliery Company, Village Main Reef Gold Mining Company, the Goldfields Deep, Metropolitan Gold Mining Company, Meyer and Charlton Gold Mining Company, Roodepoort Deep Level Gold Mining Company, May Consolidated Gold Mining Company, George Goch Gold Mining Company, Salisbury-Jubilee Joint Mill, Witwatersrand Gold Mining Company, Ferreira Gold Mining Company, Nigel Gold Mining Company, &c., all of which have given the fullest satisfaction, we feel that we are in a position to speak with authority on the subject. To supply, however, any plant, whether the motive power be electricity, steam or anything else, it is necessary to know beforehand the conditions under which it is to work and the amount of power required. Neither of these factors were known in the case of Moodie's. The calculations as to the quantity of power required were prepared at Barberton, and embodied in a specification, and the plant supplied by Messrs. Goolden and Co. was designed to produce, and, in fact (as certified by Moodie's consulting engineer), produces the quantity specified. It now turns out that these calculations were quite incorrect, and that the quantity specified is altogether insufficient for the work required. Thereupon the uninitiated hasten to fall foul of electricity as a motive power, forgetting that as they cannot expect 50 H.P. out of a 5 H.P. steam engine, so they cannot hope to extract from a dynamo or motor more current than it is constructed to supply. They should address their complaints to the gentlemen who are responsible for the miscalculations in question, and not to the contractors who supplied exactly that which they were asked to supply."

EXHIBITION.—The Leicestershire Trades and Industrial Exhibition, which was formally opened on Saturday last by Sir Thomas Wright, is lighted electrically. The electrical section is well filled with, exhibits of electric light fittings and machinery, telegraph and telephone, and electric heating and cooking apparatus being shown.

FULHAM (LONDON).—A report on the proposed electric lighting and refuse destructor scheme has been prepared for the Vestry by Mr. F. H. Medhurst.

HALIFAX.—The Finance Committee decided on Friday last to recommend the Town Council to wire the Town Hall for the electric light, at a cost of £370.

HAMPSTEAD (LONDON).—The Vestry have decided, on the recommendation of the Lighting Committee, to put down an additional 300-kilowatt dynamo at the electricity supply station. It has also been decided to lay mains in Lambolle-road, Downshire Hill and Spaniard's-road.

INFIRMARY LIGHTING.—Messrs. Drake and Gorham's Manchester house have recently completed the electrical equipment of the new infirmary at Lancaster. In addition to the electric lighting installation of about 300 lights, the firm supplied and fixed medical switchboards, telephones, electric bells, &c. The County Infirmary, Stafford, has also been fitted for the electric light.

KIDDERMINSTER AND STOURPORT ELECTRIC TRAMWAY.—The Bill authorising the construction of an electric tramway between Kidderminster and Stourport has already passed the second reading in the House of Lords, but, owing to the extensive nature of the modifications introduced in Committee, it is stated that the promoters intend to drop the measure.

LONDON CHAMBER OF COMMERCE.—At the annual meeting on Monday it was reported that at the request of the Netherlands Chamber of Commerce in London inquiries had been made in the City as to the opinions of persons likely to be interested in the establishment of a telephonic service between London and Holland. Sufficient support could not, however, be obtained.

MARITZBURG (SOUTH AFRICA).—According to the *African Review* the electric light is becoming very popular in this town, and many business and private houses, as well as the Legislative Assembly, are being wired.

MERSEY RAILWAY COMPANY.—The Birkenhead Town Council have decided to withdraw their opposition to this Company's Bill, a clause in which relates to the adoption of electricity as the motive power.

SCHOOL LIGHTING.—The new technical schools at Salford have been fitted for the electric light by Messrs. Drake and Gorham's branch at Manchester. 1,300 incandescents and a number of arc lamps and alternating motors for driving fans, &c., are included in the installation. Current is taken from the Corporation mains. The County Technical Schools at Stafford have also been fitted for the electric light by the same firm.

SOUTH AFRICA.—Those interested in South African matters will find a recent publication, the "*Argus* Annual and South African Gazetteer," a useful reference book. This is the 29th year of publication, and the work, which is published at 6s., can be obtained of the Argus Company at Johannesburg, Cape Town and Pretoria, or at the London offices, 164, Fenchurch-street, E.C. The information includes all the usual items of a year-book of this character, in addition to much other useful information not to be found in any similar publication.

LECTURES.—An interesting lecture on "Practical Electricity and Electric Lighting" was delivered on Saturday evening last at Ashton by Mr. Herbert Wooler, A.I.E.E., of the firm of Messrs. F. H. Royce and Co., Hulme.——Mr. E. Manville lectured before a crowded audience on Saturday last, at the lecture hall of the Free Library, Swansea, on "Municipal Electric Lighting and Motive Power."——Mr. Mathew Buchan lectured on "Electric Light *v.* Gas Light" at Dunfermline last week.

MILL LIGHTING.—The electric light has been introduced into the Avon Paper Mills, Linlithgow. Incandescents are employed for lighting the interior and two 1,000 c.p. arcs illuminate the approaches to the mills. The installation was carried out by Messrs. Lowdon Bros., Dundee.

NEWCASTLE.—The new telephone exchange of the National Company was formally opened on Tuesday by the Mayor, Mr. Riley Lord. Conversation was conducted between Newcastle, Leeds, and Sheffield.

NEWINGTON (LONDON).—Major Philip Cardew, R.E., held a Board of Trade inquiry on Monday last into the application of the Vestry for a Provisional Order for the parish. The London Electric Supply Corporation opposed the application on the ground that they were authorised in 1889 to supply electric current to the parish, and that they had since executed the necessary works and made arrangements for supplying the parish with electrical energy. The County of London and Brush Provincial Company and an association styling itself the "Newington and Walworth Ratepayers' Association" also objected to the granting of the Order.

NORTON.—A project is on foot for the construction of a system of electric tramways to connect this town with Stockton, Thornaby, and Middlesbrough. It is proposed to acquire the existing lines of the Imperial Tramway Company in the latter town, and the Thornaby, Stockton and Norton interests of the Darlington and Stockton Company. It is stated that the District Fund Committee of the Stockton Town Council object to the use of the over-

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head system, and if that Corporation will not give its permission then the promoters intend to confine their attention to Thornaby and Middlesbrough.

SHIP LIGHTING.—The latest addition to the British Navy, the Mars," which was launched from Messrs. Laird's yard at Birkenhead on Monday, has a complete electrical installation, the lighting of the ship being effected by about 900 lights. There are six search-lights of 30,000 c.p., each of which is capable of being worked by dynamos under protection. The wiring work has been carried out by Messrs. Laird Bros.——The new Japanese battleship, the "Fuji," which was launched from the yard of the Thames Ironworks and Shipbuilding Company on Tuesday, is also lighted electrically. The vessel is to be supplied with five powerful search-lights. All the electrical apparatus and the wiring work has been supplied and executed by the electrical department of the Thames Company.

SOUTH AFRICAN EXPORTS.—Under the classification "Electrical," goods to the value of £4,202 were exported to South Africa for the week ended March 21st, made up as follows :—Cape Town £832, Algoa Bay £302, East London £2,013, Natal £170, Delagoa Bay £885. All the above are British goods.

THEATRE LIGHTING.—The Parkhurst Theatre, Holloway, London, which is to be considerably enlarged, is to be lighted electrically.

WORKS LIGHTING.—The Triumph Cycle Company, of Coventry, have decided to light the whole of their premises electrically. Current is to be taken from the Corporation mains.

——— Messrs. Oliver and Son, the contractors for the Rugby section of the Manchester, Sheffield and Lincolnshire Railway have decided to substitute the electric light for the oil lamps used at night in the cutting near Spring-hill.

YARMOUTH.—Messrs. Lacon and Co.'s new brewery stores on the North Quay are being wired for the electric light by Messrs. W. J. Crampton and Co. Arc lamps are to be employed, and current is to be taken from the Corporation mains.

CONCERTS.—The concluding concert of the season of the Electro-Harmonic Society was given on Friday last, and proved a great success.—The staff of the City of London Electric Lighting Company held their fourth annual Bohemian concert on Tuesday last at the Cannon-street Hotel, under the presidency of Mr. Frank Bailey, chief engineer to the Company. An excellent programme was furnished, and a large attendance supported the organisers of the concert.—Messrs. S. Smith and Son, of 9, Strand, London, the well known non-magnetisable watch makers, gave their eighth annual concert at the Freemason's Tavern on Saturday last, under the presidency of Mr. Samuel Smith. A programme of more than usual length was provided, in which the names of several prominent public favourites figured.—The members of the Electrical Trades' Union held a concert in the New Clerkenwell Town Hall on Saturday evening, under the auspices of the London Central Branch, at which Mr. G. W. Montague occupied the chair. A large company were agreeably entertained.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

March 16, 1896.

779. D. MCNAMARA. Dublin. An improved automatic telephone switchboard specially adapted for private installations.

5,794. P. R. DE F. D'HUMY. Liverpool. A new or improved manufacture of insulating material for underground electric wires, cables or the like.

March 17, 1896.

5,872. J. MCLAREN. Dersingham. An improved electric lift.

5,874. T. C. HEPWORTH. London. Improvements in carbon pencils for the electric arc light.

5,884. R. BRYMER. Manchester. Improvements in electrical switches.

5,948. G. J. CARSON. London. Improvements in insulating joints. (Date applied for under Patents, &c., Act, 1883, sec. 103, September 23, 1895, being date of application in United States.)*

5,951. J. DEVONSHIRE. London. Improvements in the suspension of motors for electric or other cars. (N. C. Bassett, United States.)*

5,980. A. J. BONNELIA. London. Improvements in electric switches.

March 18, 1896.

6,048. J. DEVONSHIRE. London. Improvements in controllers for electric motors. (W. B. Potter, United States.)*

6,053. THE MORRIS TUBE AMMUNITION AND SAFETY RANGE COMPANY (LIMITED), C. CUTHBERTSON and W. H. STENTIFORD, London. An improvement in electric primers for firing guns.*

6,058. G. BAMBERG. London. Improvements in moderating electric incandescent lamps and apparatus for that purpose.

6,069. W. S. RAWSON. London. Improvements in the method of electrically coating wire and apparatus therefor.

6,071. W. ROWBOTHAM. London. Improvements in primary electric batteries.

March 19, 1896.

6,113. A. G. BURRELL. Sheffield. Improved apparatus for adapting telephone line wires for fire-alarm signals and similar purposes.

6,148. H. LEA. Birmingham. Improvements in fittings for electric lighting.

March 20, 1896.

6,197. T. E. DOYLE and J. MCKENNY. Dublin. A new or improved underground system of electric traction.

6,208 A. BALLANCE and E. H. HEWSON. London. Improvements in automatic electric switches.*

6,216. C. H. PARKER and J. PULLMAN. London. Improvements in and relating to the treatment of sodium and potassium chlorides by electrolysis.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price 8d. each.

1894.

25,312. HEWITT and CASEY. Arc Lamps.

1895.

4,065. DE FERRANTI. Electric tramways and lifts.

5,137. DE FERRANTI. Electric transformers.

5,984. BENTLEY. Telephony.

6,035. ROSSITER. Electric conductors.

8,167. LABRE and COUSSINET. Electrically heated ironing, &c., appliances.

8,222. KINGSBURYS (Western Electric Co.) Telephonic systems.

8 564. DUCEUX. Electric alarms.

20,626. BRANSON. Arc lamps.

22,143. BLAKE. Culvert or duct for wires, pipes, &c.

1896.

880. EWART and VAUGHAN-SHERRIN. Electric heaters.

1,575. SIEMENS BROS. & CO., LIMITED (Siemens & Halske). Electrolytic production of zinc.

1,611. MCGEOCH. Incandescent electric lamp holders.

COMPANIES' MEETINGS AND REPORTS.

Metropolitan Electric Supply Company (Limited).

The ninth ordinary general meeting of this Company was held on Tuesday at Winchester House, Old Broad-street, under the presidency of Sir Eyre M. Shaw, K.C.B.

The SECRETARY (Mr. E. Cunliffe Owen, C.M.G.) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, before proceeding to the business which has brought us together I have to express the very sincere regret of the Board—a regret in which I am sure that all who are present will share—that in consequence of severe illness our honoured Chairman is unable to preside over this meeting. Sir John Pender has guided and superintended the operations of this Company from its commencement, and has brought to bear on it the skill and experience of a long life combined with the energy and indomitable courage specially characteristic of our countrymen, but seldom found so conspicuous or so permanently elastic as in his case. Indeed, I need not hesitate to affirm most distinctly and emphatically that the present condition of this Company—a condition which I trust before the end of this meeting you will be able to pronounce satisfactory—is in the main due to the commercial ability and indefatigable exertions of Sir John Pender. In temporarily occupying his place, as I do to-day at the desire of my colleagues, I feel more than anyone else how much we lose by Sir John Pender's absence. In bringing before you the usual motion for the adoption of the report you will, of course, expect that I should make some remarks upon the accounts for the past year. Dealing first with that portion which shows the capital receipts and expenditure, you will notice that the expenditure has been practically confined to five items, viz., buildings £5,467, machinery £5,016, mains £18,026, transformers and connections £12,884, and meters £3,038. The expenditure on buildings has almost entirely arisen from the work of extension now in course of completion at our Sardinia-street station, where provision has been or is being made for a large increase of generating plant to enable us to cope with the increasing demand for current, not only in the district in which that station is situated, but also by means of our trunk main system in any other district where the demand may exceed the local supply. There has also been construction work at our other stations, for the purpose of completing and developing them, but this has only involved a small amount of expenditure. The next item—machinery—is due to the same causes as the expenditure on buildings, and is a part of the provision which is being made for a considerable increase in

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our power of supply. The expenditure on mains, transformers and meters makes, as usual, a large item, and is about £4,000 more than was spent in 1894 under the same heads. It does not seem to require explanation, as the mains have to be continually growing to meet the statutory requirements of our large districts, and the transformers and meters have to keep pace with the increase of customers. For the purpose of meeting this expenditure it has been necessary to draw on the debenture stock authorised in 1894, of which a further sum of £31,640 has been issued, making a total of £181,640 out of the authorised issue of £250,000. We have been able to issue this amount at a considerable premium, being an average, after allowing for expenses and accrued interest, of just over 16 per cent. You will remember that in 1894 we carried the premium upon the debenture stock to the depreciation fund, but acting upon the opinion of the Company's auditors it has been decided to place the amount obtained in 1895 to the credit of the capital account. But the accounts which will have most interest for you as shareholders are the revenue accounts, and the Directors are glad to record a very large increase in income. The revenue from customers has increased by no less than £21,101 against the increase in 1894 of £16,150, and this growth has come mainly from the additional customers who have been taken on during the year, and to a small extent from the fact that the weather in the Christmas quarter was duller than in the corresponding quarter of 1894, and that consequently more artificial light was required. The total cost of manufacture during the year has been £52,536, or 49½ per cent. of the income, against £42,365 or 50 per cent. in 1894. At first sight this appears to be about the same ratio, but it really represents a decided reduction, as the cost includes a sum of £4,874 for purchase of current from other companies, rendered necessary by the fire at Sardinia-street on June 24, 1895, to which I shall have to refer later on. The fire also had an effect on the item of maintenance of engines, &c., as opportunity was taken of the closing of the station to effect a complete overhauling of the boilers and furnaces, in view of the necessities which would arise in connection with the extension of plant, the whole of which repair has been borne by revenue. The maintenance of mains has cost very little during the year, a fact due not only to the high quality of our mains, but principally to what is known as the looped ring system adopted by this Company, by which the number of joints, always the weakest part of mains, is reduced to a minimum. The item of £1,273 for parliamentary charges consists of absolutely necessary expenditure incurred in the struggle which is always going on against those who would like to take advantage of our pioneer work, and enter our districts in competition with us. The result of the revenue account is that we have made a profit of £39,154 0s. 7d., which, after adding the balance from last year, and allowing for the interest on debentures and other charges, becomes a net amount of £34,082. 4s. 3d. Taking the depreciation at the sum written off in 1894, this would have given a 5 per cent. dividend, but the Board, after careful consideration, are of opinion that in view of the future of this Company a strong reserve for depreciation is of the utmost importance, and they are sure that the shareholders will agree with them that the dividend now recommended of 4 per cent. for the year is a satisfactory one, the more especially as a very small increase in the current year should place the Company for the future on a sound and strong 5 per cent. basis. The fire at our Sardinia-street works, to which reference is made in the report, was the one misfortune of an otherwise prosperous year. That its effects were no worse are due, first, to its having taken place in the middle of summer, when our loads are lightest; secondly, to the system of trunk mains which connect our various stations; and, thirdly, to the assistance so kindly and promptly rendered to us by the London and City of London companies. Within a very short time the necessary arrangements were made, and connections completed to the assisting companies, and large use was made of the supply from these companies to supplement our own. This was necessary, as, although our trunk mains worked admirably, the increasing demand in the autumn compelled us to avail ourselves of the very cordial assistance of these companies. No time was lost in pressing forward the manufacture of plant to replace the machinery destroyed in the fire, and we are now again supplying our own requirements; but the connections will remain, and I need not point out the advantage of such an arrangement, both for ourselves and from the public point of view, as an additional security for an uninterrupted supply. I think it right to inform you that, although the fire took place between 6.30 and 7 in the evening, all the theatres but one supplied from these works were lighted as usual, and the greatest credit is due to our engineering staff for the zeal and energy they displayed on this most trying occasion. I need hardly add that the most careful preparations have been taken at all our works to render impossible the recurrence of such a catastrophe. The settlements we effected with the insurance companies were perfectly satisfactory, but as at the close of the year the reinstatement works had not been fully completed, you will observe that a suspense account appears on our general balance sheet. You will be pleased to find that it has not been found necessary to allude further in the report to the vibration difficulties which gave us so much trouble and anxiety for many years past. The steps we took under our engineer's advice to remove all cause for complaint in this direction have proved completely successful. The competition with which we have for some time past been threatened in the Strand area has quite recently become practically a fact, owing to the decision of the House of Commons Committee to recommend the confirmation of the Provisional Order obtained by the Charing Cross and Strand Electricity Company. It is needless for me to say that we felt it our duty to oppose this application to the best of our abilities in both Houses, and we are still of opinion that the granting of these powers to a rival company is an injustice to us and is detrimental to the true interests of the public. I ought to remind you that this competition has always existed in the St. Martin's district, but as we both commenced operations practically at the same time we had no legitimate cause for complaint. In the present case, however, the competition comes unfairly, as we think, after we have succeeded in building up a large and important business through our unaided exertions. I need not assure you that we shall take all necessary steps to protect your interests in this district, and that if we are forced to fight we shall do so with a determination to succeed. The steady and remarkable increase in our lamp connection is extremely satisfactory. We can observe no indication whatever of any falling off in new customers, and of course this continually increasing demand implies an increase in our capital outlay. I may here mention that to encourage a larger use of current, particularly during the lighter hours of the day, and to still further increase our business, we have decided to reduce our rates of charge to those of our customers whose consumption assists our output, and who thereby enable us to reduce our working cost. The whole question of our present and future extensions has been most carefully considered, and I may tell you that our chief engineer, Mr. Frank Bailey, laid before us some months ago his estimates of our probable requirements up to the year 1900. In addition to the works necessary for this growth of custom, the estimates provide for important re-arrangements of our system of supply, which will have the effect of a very considerable saving in our cost of distribution. I allude to the formation of transformer sub-stations which the lighting density in some of our districts will shortly warrant. These estimates have been carefully examined by the Company's auditors as well as by the Directors, and the results of the increased expenditure as foreshadowed by Mr. Bailey, in whose judgment we have the greatest confidence, point to a most successful future, and to steady increase of earnings. We have not yet arrived at any definite decision as to what form the new capital will take, but you will be called together to approve our scheme when determined upon, and I need scarcely say that the shareholders' interests will be be fully considered in making the issue. He concluded by moving the adoption of the report and the payment of the dividend therein recommended.

Admiral of the Fleet Lord JOHN HAY, G.C.B., seconded the motion.

Mr. HARRISON CRIPPS said he was very pleased to see their progress, but he regarded the dividend of 4 per cent. as a poor one in view of the limited period for which they held their concessions. He found that the cost of producing electricity in the case of this company was much greater than in the case of the Westminster, the St. James's, or the City of London Companies, and that their coal bill was also far greater than that of those Companies.

Mr. GEIBEL said he thought that the loop system adopted by the Company was the cause of their excessive coal bill, and he desired to know whether the Directors contemplated altering their system so as to bring it in accordance with modern practice.

The CHAIRMAN, in reply, said the coal consumption for the year was undoubtedly large, but the difficulties with which we had to contend, owing to the fire, made it impossible for us to arrange our supply on the most economical lines. We had to give our whole attention to supplying our customers under most difficult and trying circumstances, and naturally the methods which had to be adopted on such an emergency were not of a normal character.

Mr. CRIPPS said he thought that while the fire was going on they bought their electricity.

The CHAIRMAN: This was not the case. The current was not taken from other Companies until some considerable time after the fire. The question of mains is one which, if necessary, will be answered by our engineer; but I may state in general terms that we have a system of mains which has cost us comparatively little, and our coal consumption is high, whereas other companies have paid a great deal more for their mains and their coal consumption is lighter. But the principal point in connection with Mr. Cripps' question is the area of the different districts. Some of the districts are very compact, and can be worked more economically than ours. Our district is very large indeed, and we have a great many mains running where the inhabitants have not yet drawn upon us, as I hope they will do in the next year or two. In answer to Mr. Geibel, the chairman pointed out that in his opening remarks he had referred to the estimate of their probable requirements up to 1900, and had stated that important rearrangements of their system of supply would cause a considerable saving in the cost of distribution. He trusted that that explanation was satisfactory.

Mr. GEIBEL said he had not heard the Chairman's former statement on this point, and he was much obliged for the explanation.

The CHAIRMAN then put the resolution, and it was carried unanimously.

On the motion of Admiral Sir G. H. RICHARDS, seconded by Mr. J. B. VERITY, the retiring Directors (Sir J. Pender, M.P., Admiral Lord John Hay and Mr. J. C. Parkinson) were re-elected, as were also the auditors (Messrs. Deloitte, Dever, Griffiths and Co.).

The CHAIRMAN, in acknowledging the cordial vote of thanks to the Chairman and Directors, expressed a hope that the vote applied to the staff as well. They had the greatest confidence in their Secretary and their Engineer, and the staffs under those gentlemen, to whom they owed a great debt of gratitude for their services in the past year.

The proceedings then terminated.

Willans and Robinson (Limited).

The fourth half-yearly report of the Directors of this Company, to be submitted to the general meeting to be held at the Cannon-street Hotel, London, on Wednesday next, at 3 p.m, states that the Company's business continues to develop in a thoroughly satisfactory manner. Although, for reasons explained in previous reports, new business has been little sought for, the horse-power of Willans' engines ordered in 1895 was 27,883, against 26,624 in 1894; these figures comparing with 18,950 horse-power in 1893, the last and best year of the old Company. Even more significant is the fact that in less than three months of 1896, the horse-power ordered has reached 22,200, a development which, if more or less exceptional, yet

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indicates the probability of a rapid growth of business in the future. After writing off as depreciation from plant, patents, &c, the sum of £3,769. 13s. 4d., the balance to the credit of profit and loss for the half-year (including £319. 10s. 2d. brought forward) is £11,832. 14s., out of which the Directors propose that distributions be made of 6 per cent. per annum on the Preference shares, and 7 per cent. per annum (as before) on the Ordinary shares, amounting together to £7,224. 19s. 5d. £2,500 is carried to reserve, and the balance (£821. 5s. 3d.) is carried forward. The reserve fund, as the result of the first two years' working, will now reach £7,646. 9s. 11d.

The new works at Rugby are not yet in a position to assist in the production of engines, partly from the necessity which has already arisen for extending the new buildings, and for commencing others which it had been originally intended to defer, the Directors having judged it advisable to prepare for manufacturing operations at Rugby on a larger scale than was originally contemplated.

The necessary authorisation for the contemplated issue of debenture stock should now be given, and a resolution will be submitted to the meeting to that effect. In view of the remarkable expansion of the business, and of the necessity which may arise for even further extensions at Rugby, the Directors think it will be prudent to take powers to borrow up to the full limit of £112,500, but so far as they can forsee at present an actual issue of £75,000 may suffice. The mortgages upon the Thames Ditton freeholds have been paid off.

NEW COMPANIES, STATUTORY RETURNS, &c.

ALUMINIUM PRODUCTS SYNDICATE (LIMITED).—This Company has been registered with a capital of £6,000 in £1 shares, to manufacture and deal in alumina, aluminium, ferro-aluminium, brass, &c. The first Directors are R. Starke, A. C. Jeffery, and G. Mahaffy.

BRITANNIA MOTOR CARRIAGE COMPANY (LIMITED).—This company was registered on March 24th with a nominal capital of £100,000 in £1 shares, to acquire, work, develop, grant licenses in respect of and turn to account any patents, patent rights, inventions, &c., and to carry on the business of electricians, manufacturers of and dealers in motor carriages, and parts and fittings for the same, mechanical engineers, metallurgists, &c.

NEW GENERAL TRACTION COMPANY (LIMITED).—This company was registered on March 24th with a nominal capital of £170,000 divided into 10,000 £6 per cent. Preference and 24,000 Ordinary shares of £5 each, to enter into an agreement with Edwin A. King, to carry on the business of contractors for the construction and equipment of tramways and railways with electrical and other mechanical power, and to enter into, acquire and carry out contracts, concessions or other grants for making, purchasing, or working railways, tramways, telegraph and telephone lines, electric lighting, hydraulic and other works, &c. The first subscribers are :—E. A. Hopkins (1,000 shares), and A. Jones, H. Spinks, E. A. King, E. T. Church, J. Alexander, and G. A. J. Smallman (one share each).

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return to March 6th has been filed. The nominal capital is £800,000, in 40,000 Preference and 40,000 Ordinary shares of £10 each. All the shares have been taken up and paid for in full.

CHARING CROSS AND STRAND ELECTRICITY SUPPLY CORPORATION (LIMITED).—The annual return to March 9th has been filed. Out of a capital of £250,000, in £5 shares, 30,000 shares have been taken up, and the full amount thereon has been called and paid.

NOTTING HILL ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return to March 10th has been filed. The nominal capital is £100,000, divided into 6,452 Ordinary, 550 Founders' and 2,998 Preference shares, all of £10 each. All the Ordinary and Founders' and 1,860 of the Preference have been taken up, and the full amount has been called and paid.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LTD.).—The annual return of this Company to March 17th has been filed. The whole nominal capital of £448,200, divided into 37,350 shares of £12 each, has been subscribed for, and the full amount called and paid.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31½d. per oz. (April 1st). Consols (2¾ per cent.) 109⅝—109¾ for money, 109 1/16—109 1/16 for account; 2½ per cent. 105¼—105¾ (April 1st). Stock Exchange Settling Days: Consols, May 4th; Stocks and Shares Continuation Day, April 13th; Ticket Day, April 14th; Pay Day, April 15th; Mining Share Carry-over Day, April 11th.

ALUMINIUM COMPANY (LIMITED).—This Company announce that they intend to pay off the whole of the £100,000 debentures on October 1st next.

BARCELONA TRAMWAYS COMPANY (LIMITED).—This Company invite applications for 3,000 £10 Five per Cent. Cumulative Preference shares at par. An extraordinary general meeting of the Company was held on Friday last, when the resolutions passed on the 11th inst., increasing the capital to £300,000 by the addition of 15,000 shares of £10, and making certain alterations in the articles of association, were confirmed.

BLACKMAN VENTILATING COMPANY (LIMITED).—This Company has presented a petition for confirming a special resolution reducing the capital of the Company from £75,000 to £45,000, to be heard before Mr. Justice North on May 9th.

CALCUTTA TRAMWAYS COMPANY (LIMITED).—The ordinary general meeting of this Company was held at the Cannon-street Hotel on Monday. The Chairman (Mr. E. C. Morgan) referred to the difficulty of providing sufficient working capital, and the Directors hoped the position of the Company would be improved by the introduction of electric traction on the lines, respecting which negotiations were in progress. They felt that they had not exhausted the traffic to Calcutta, but they required more horses and rolling stock. The adoption of electricity would, he thought, enable them to get rid of many of their difficulties and to greatly increase the number of their passengers.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended March 29th were £918, against £932 in the corresponding week of 1895, a decrease of £14, The total receipts for the half-year amount to £12,656, against £12,648 for the corresponding period of 1895, an increase of £8.

CORK TRAMWAYS COMPANY (LIMITED).—An extraordinary general meeting of the shareholders of this Company was held on Saturday last for the purpose of approving a draft agreement between the Company and Mr. Wm. Murphy. The Chairman (Mr. J. Dwyer, J.P.) said the object of the agreement was to transfer to the Cork Electric Tramways Company (Limited) the powers granted to them for the construction of tramways in the city of Cork. The consideration for this transfer was the payment of £1,000 to meet the expenses incurred in obtaining the Order. The agreement was approved.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Directors of this Company have resolved upon the payment of an interim dividend of 2s. 6d. per share, free of income tax (being at the rate of 2½ per cent. per annum) for the quarter ended March 31st, payable on and after the 24th inst.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 29th inst. amounted to £1,133. The amount for the corresponding week last year was £1,002. Increase £131.

OSWESTRY ELECTRIC LIGHTING AND POWER COMPANY (LIMITED).—The annual meeting of the shareholders of this Company was held at Oswestry on the 20th inst. The Chairman (Mr. E. Bremner-Smith), in moving the adoption of the report and accounts, congratulated the shareholders upon their being able to show a balance of profit on what was practically only three months' working. They started with very few consumers, but there had been a very gradual, but a very steady and substantial, increase in the demand for current; and he was glad to say that so far that demand continued to grow in a very satisfactory manner. The Directors had determined to reduce the price, and personally he considered that the proper course to take, because, though the profit had been small at the present price, it was in the interest of the Company and the consumers that the price should be reduced, as he believed it would have the effect of greatly increasing and stimulating the demand. The Directors intended to put down such additional plant as would enable them to cope with any increased demand. Various applications from private houses had been received, and they had decided to extend their mains. Once private consumers had realised the many advantages of the electric light he thought there would be a considerable demand for current, and at present many of the churches and chapels of the town were considering the matter of adopting the light. The report and accounts were adopted.

ROBEY & CO. (LIMITED).—The Directors of this Company have decided to recommend the payment of a dividend of 8s. per share on both the Preference and Ordinary stock, £3,000 being placed to reserve, and £1,000 carried forward.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee has appointed April 14th for a settling day in 3,000,000 Ordinary shares (Nos. 1 to 3,000,000) of Sir W. G. Armstrong and Co. (Limited), and have ordered the said shares to be quoted in the official list.

TRAMWAYS ELECTRICAL TRACTION COMPANY (LIMITED).—The ordinary general meeting of the shareholders of this Company was held on Monday, at which the Chairman (Lord Richard H. Browne) said that those who were old shareholders in the Tramways Company of France would recollect that the Rouen Company was not in a very good financial position. The town was very hilly, and the number of horses that had to be employed was very large in proportion to the number required for tramways generally, and this caused great expense. The Rouen Company having decided to adopt electric traction, for the purpose of equipping their lines electrically they formed the Tramways Electrical Traction Company, whose articles of association, however, enabled it to do other similar work. The Company purchased all the shares and interest of the Tramways Company of France in the Rouen Company. They then entered into a contract with the French Thomson-Houston Company for the electrical equipment of the line, and the formal opening took place on the 22nd inst. with very great success. He believed they had conclusively proved the value of electric as compared with animal traction. The Directors of the Company had entered into an agreement for the disposal of all their shares and interest in the Rouen Company, and as a result of the sale there was a balance of profit which would enable them to pay the interest on the Preference shares and a dividend of £5 per share on the Ordinary shares, leaving £2,089 to be carried forward. They thought that the proposal to wind up the Company with a view to returning the whole of the paid-up capital was the best course to pursue, and a meeting to deal with this matter would be held next month. The adoption of the report and the payment of the interest and dividend mentioned was carried.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended March 27th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,338.

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COMPANIES' SHARE LIST.

Paid up Amount.	Amount of Share.	Last Dividend.	Name	Previous Week's Price, Mar. 18.	Price Tuesday, Mar. 31.	Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending Mar. 28. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,680	Stock	18/0	Anglo-American	47 49	47 49	5 2 0	Jan., Apr., July, Oct.	—	..
£2,993,560	Stock	36/0	Do. Preferred	89 90	90 91	5 9 11	" "	90	89
£2,993,560	Stock	5/0	Do. Deferred	7⅞ 8⅛	8 8⅛	..	..	8⅛	7⅞
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	100 104	100 104	3 17 8	January and July	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	10½ 11	10½ 11	..	..	..	..
150,000	£10	3/0	Brazilian Submarine xd	14½ 14⅝	14½ 14½	4 14 11	Mar., June, Oct., Dec.	14⅝	14½
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	112 116	113 116	4 7 2	June and December	..	—
10,000,000	£100	8⅛	Commercial Cable Capital Stock xd	160 170	160 170	4 2 4	Jan., Apr., July, Oct.	..	—
16,000	10	8/3	Cuba Submarine	14½ 15½	12½ 13½	5 14 4	February and August	13½	—
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 13 0	" "	20½	..
12,931	5	2/0	Direct Spanish (fully paid) x	4 5	4 5	4 0 0	April and October	..	—
6,000	5	10%	Do. Preference 10 per Cent. x	10 10½	10 10½	4 15 3	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	100⅞ 100⅞	103⅞ 100⅞	4 3 5	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877	9½ 9⅝	9½ 9⅝	4 4 1	Jan., Apr., July, Oct.	9½	9½
400,000	10	2/6	Eastern	17 17⅛	17 17⅛	3 14 4	" "	17⅛	17⅛
70,000	10	6%	Do. 6 per Cent. Preference	18 18½	18 18½	3 4 10	" "	18⅛	18⅛
£1,297,637	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	129 133	129 132	3 16 9	May and November	..	..
£102,160	100	5%	* Do. 5 per Cent. Debentures, 1899	105 108	105 108	4 13 3	February & August	..	..
250,000	10	2/6	Eastern Extension	17⅞ 18⅛	17⅞ 18⅛	3 16 9	Jan., Apr., July, Oct.	18⅛	17⅞
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128 131	128 131	3 1 5	February & August	128½	..
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	101 105	101 105	4 16 5	January and July	..	..
£80,690	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	101 105	101 103	4 18 5	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	106 108	105 103	3 14 7	February & August	—	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112⅞ 115⅞	112⅞ 115⅞	3 10 8	May and November	115⅛	..
180,227	10	1/6	Globe Telegraph and Trust	10½ 10⅝	10½ 10⅝	3 16 9	Jan., Apr., July, Oct.	10⅝	10⅝
180,042	10	6%	Do 6 per Cent. Preference	16⅛ 17⅛	16⅛ 17⅛	3 9 7	" "	17⅛	17
150,000	10	5/0	Great Northern	22½ 23½	22½ 23½	3 11 0	Jan., April, and July	23½	23⅛
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1933 Issue	103 106	104 107	4 13 11	March & September	..	..
17,000	25	12/6	Indo-European	47 50	48 51	4 18 0	May and November	..	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	..	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	107 1 0	107 110	5 9 7	" " March & September	107⅛	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1912	108 111	108 111	3 12 9	.. ..	..	..
11,839	8	4/0	Reuter's	5 6	5 6	..	April and October	..	..
2,881	£100 Cert.	25/0	*Submarine Cables Trust 6 per Cent.	132 137	134 139	4 6 4	" "	..	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	..	January and July	..	..
£238,300	100	5%	* Do. 5 per Cent. Debentures (red.)	101 104	101 103	4 11 7	March & September	..	..
30,000	10	2/0	West Coast of America	1 2	1 2	..	January and July	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	95 100	95 100	8 8 8	June and December	95	..
88,321	10	1/3	West India and Panama	1 1½	1 1½	..	..	1⅛	1⅛
34,568	10	6%	Do. 6 per Cent. 1st Preference	10½ 11½	10½ 11½	5 6 8	May and November	11⅛	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	103 111	103 111	4 11 1	June and December	..	..
64,248	15	3/0	Western and Brazilian	8½ 9	8½ 9	5 5 8	May and November	8⅞	8⅞
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6½ 6⅞	6½ 6⅞	..	—	6⅞	6⅞
33,129	7½	1/6	Do. Deferred Ordinary	2½ 2⅝	2½ 2⅝	..	—	..	..
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 12 2	February & August	—	..
£206,400	100	6%	* Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 12 2	" "	—	..
£1,177,000	£1,000	7%	*Western Union 7% 1st Mort. (Building) Bonds	113 118	113 118	6 1 9	May and November	..	..
£164,300	£100	6%	* Do. 6 per Cent. Sterling Bonds (red.)	102 105	102 105	5 14 10	March & September	..	—
			TELEPHONES.						
45,000	5	2/6	Chili Telephone (fully paid)	8 8½	8 8½	..	—	..	..
224,350	10/0	1½d.	Consolidated Telephone Const. & Maintenance	⅛ ¼	⅛ ¼	..	May and November	⅛	—
171,504	£1	8·215	Oriental Telephone and Electric (fully paid)	⅛ ⅛	⅛ ⅛	..	Yearly	—	..
484,597	5	3/0	National	6½ 7	6½ 7	3 18 7	June and December	7	6¼
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	17½	—
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	16½ 17½	16½ 17½	3 8 7	" "	16½	—
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6½ 6⅝	6½ 6½	3 12 9	—	6½	6⅝
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	105 108	106 100	3 4 8	January and July	107⅝	..
58,000	5	3/0	United River Plate	3½ 4	3½ 4	..	" "	—	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	97 102	93 101	5 0 8	" "	—	..
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	10/0	City of London Electric Lighting (fully paid)	14½ 15½	14½ 15½	3 4 6	—	15½	15
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	16 17	16 17	3 10 7	—	16⅛	16⅝
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	134 138	134 138	3 13 2	June and December	135½	—
19,900	£5	..	Electricity Supply Co. for Spain	.. ..	.. ..	..	—	..	..
£30,000	£5	3/0	Charing Cross & Strand Electricity Supply Corp.	7½ 7½	7½ 7½	..	—	7⅛	7½
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	— —	— —	..	—	..	..
24,175	£8	..	County of London & Brush Prov. Ord. (fully paid)	14½ 15½	8 9	..	—	8½	..
10,000	£10	9½d.	Do. Pref. (£9 paid)	16 17	12½ 13½	..	—	11	10½
8,322	£5	..	House-to-House Electric	.. ..	— —	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	.. ..	— —	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	— —	..	January and July	..	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅛ 7⅞	7⅛ 7⅞	3 16 2	—	..	..
111,000	5	..	London Electric Supply	.. ..	— —	..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	12½ 13⅝	13 13½	4 1 6	—	13⅞	13⅝
£150,000	Stock	4½%	* Do. 4½% Debs.	118 120	113 120	3 15 9	June and December	117	..
6,452	£10	4/0	Notting Hill Electric	8½ 9½	8⅞ 9½	..	—	..	..
..	..	..	Rand Electric	⅞ 1⅛ prem.	⅞ ⅛ prem.	..	—	..	..
19,990	£5	5/3	St. James and Pall Mall	9½ 10½	9½ 10½	..	—	9⅞	9⅞
20,000	£5	7%	Do. 7 per Cent. Preference	9½ 10	9½ 10½	6 8 4	—	9⅞	..
59,900	5	4/6	Westminster Electric Supply (fully paid)	9½ 10	9½ 10	3 10 0	—	9⅞	9⅞
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
96,000	2	1/3	Brush Electrical Engineering	1⅛ 1⅜	1⅛ 1⅜	5 8 8	—	1⅜	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅜ 1⅝	1⅜ 1⅝	3 4 0	—	1⅜	1⅜
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	110 113	110 113	3 19 10	March & September	—	..
25,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2½ 2⅝	2½ 2½	..	January and July	..	..
89,281	5	1/6	Edison and Swan United	1½ 1⅝	1½ 1⅝	..	..	1⅝	..
£103,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	103 106	101 107	4 5 0	..	—	..
£30,900	£5	..	Electric and General Invest. Ordinary (£1 paid)	— —	— —	..	—	—	..
110,000	2	..	Electric Construction	.. ..	1⅛ 1⅜	..	—	..	..
12,345	2	2 9⅛	Do. 7 per Cent. Cumulative Pref.	2½ 2⅝	2⅛ 2⅜	5 1 10	—	2⅜	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅝	⅜ ⅝	..	—	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	¼ ¼	¼ ¼	..	—	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	20 21	20 21	4 15 3	February & August	20½	20
£300,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	.. ..	.. ..	—	March & September	..	..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	.. ..	..	December and June	—	..
90,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	⅛ ¼	⅛ ¼	..	..	..	..
37,350	12	24/0	Telegraph Construction and Maintenance x	38 41	38 41	4 7 10	March and July	39½	38½
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	102 105	4 11 5	January and July	..	—
37,514	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	..	—	..	..
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	—	..	..
£100,000	10	10/0	W. T. Henley's Telegraph Works Ordinary x	16½ 17½	16½ 17½	3 8 7	—	17½	16½
£30,000	10	7/0	Do. 7 per Cent. Preference x	17 18	14½ 17½	4 0 0	—	..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock	107 112	107 113	4 0 6	—	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway Con. Ordy.	40 42	40 43	3 19 6	May and November	41½	41⅜
7,580	10	5%	Do. 5% Perpetual Preference	14½ 15	14½ 15	3 6 8	..	14½	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	132 134	132 134	3 0 3	May and November	..	..
£1,410	£10	3½%	Liverpool Overhead Railway	14 14½	14 14½	1 8 2	—	—	—
10,000	10	5%	Do. 5% Preference	16⅜ 16⅝	16⅜ 16⅝	2 1 3	—	—	—
146,000	Stock	4%	Do. 4% Debenture	114½ 116½	114½ 116½	3 10 2	January and July	—	—

* In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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THE ELECTRICIAN:

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NOTES.

THE staff of the Reichsanstalt have, with their customary good sense, taken time by the forelock, and made a practical test of the insulating and waterproofing properties of materials used in tramway road-bed construction, with the result that these properties may now be definitely considered as negligible quantities. The specific resistance of pure cement was found to be extremely low. On the addition of sand or gravel, the resistance rose, but so also did the porosity. The resistance of pure cement after a day's sojourn under water, fell, indeed, to one-third of its original value, but concrete behaved even worse; a subaqueous immersion of only two hours' duration sufficed to bring down its resistance to one-twentieth part of its initial value. Under ordinary conditions, ordinary road-bed materials may be expected to offer the magnificent resistance to earth of about half an ohm per mile of track.

So far as mere insulating and waterproofing properties are concerned, no heed being paid to cost or mechanical suitability, a complex compound consisting of 50 per cent. stone chippings, 20 per cent. gravel, 12 per cent. asphaltic-mastic, 8 per cent. pitch and 10 per cent. German tar appears to be a most excellent substance for fulfilling the Board of Trade desideratum of "separating the uninsulated return from the general mass of earth." It is, we believe, held in some quarters that it is a mistake to attempt to separate the rail-return from the general mass of the earth; doubtless this would be so were a comparatively high difference of potential such as 25 or 50 volts permitted to exist between the far and near ends of a return, but so long as the Board of Trade ideal of seven little volts is approximately lived up to no inconvenience need be apprehended.

INSTEAD of saying that his watch was ten minutes fast, Mr. MORDEY would appear to prefer to say that it was eleven hours and fifty minutes slow. At least, this would be a fair parallel to his objection to the common practice of saying that electrostatic capacity causes a *lead* of current. Mr. MORDEY would rather have it said that it causes such a very big lag that the current gets in front of the next wave behind, and appears to be in lead of it. "The capacity current lags so much behind the wave of E.M.F. producing it," he observed in the course of the admirable discussion on Messrs. COWAN and STILL's Paper, "that it is just in front of the succeeding E.M.F. wave." But this new idea of a lag produced by capacity involves us in the difficulty that to produce a genuine lag there must be an *opposing* electromotive force, whereas the electromotive force introduced into a circuit by capacity is essentially assisting the impressed electromotive force. There would be a curious discontinuity introduced, if we had to conceive that the slightest trace of capacity introduced into a non-inductive circuit would produce a lag of a whole period, whereas the slightest increment of that trace would cause only a small diminution in that enormous lag, and all the capacity it were possible to introduce would only reduce the lag to three-quarters of a period. It certainly seems more natural and logical to say that the lead of the current increases continuously from zero to a quarter of a period as the capacity is raised from zero to infinity.

IF alternate-current engineers want to run their steam engines at reduced speed on reduced loads, as proposed by Messrs. COWAN and STILL, there are two conceivable ways in which this might be done without reducing the frequency of the alternations. Variable speed gear has been suggested for this purpose, but it is an unfortunate fact that there does not exist an efficient or reliable gear of this sort, capable of taking more than a small amount of power. Another conceivable plan would be to keep the relative speed of the armature and field coils constant, while reducing the absolute speed of the armature to one-half at low load, by giving to the field coils a rotatory motion equal and opposite to that of the armature. Thus at full load the armature might run at 300 revolutions with the field at rest; while at half or lower loads the armature and field might rotate in opposite directions at 150 revolutions. The frequency would be constant. Of course the arrangement of machinery to produce this would depend on the type of plant; but where the alternator is coupled direct between two engines, one of these might be provided with reversing gear and suitable clutches for connecting or disconnecting the field or armature.

THE short abstract which we publish in another column of a Paper on "The Thermal Efficiency of Steam Engines," read by Capt. H. RIALL SANKEY before the Institution of Civil Engineers, conveys but an incomplete idea of the nature and consequences of the suggested standard of thermal efficiency for steam engines. It is not at all clear, in our opinion, that any standard is required for steam engines which cannot also be used for other heat engines; but,

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passing over this point, we may observe that such a standard is supplied with theoretical completeness by the ideal engine of CLAUSIUS. With this standard, however, Capt. SANKEY does not appear to be wholly satisfied; and we are so far in agreement with him as to say that the Clausius standard represents a size of engine, relative to its power, altogether out of agreement with practice. The difficulty, once having made up one's mind to have a standard peculiar to the steam engine, is to know how to devise one which shall have a strictly scientific basis, and yet be sufficiently near to practice to be useful. Without a sound scientific basis, a standard resolves itself into an arbitrary and empirical convention, and is exposed to the risk of being rejected by scientific experimenters. On this account we are inclined to think that Capt. SANKEY's ingeniously, yet nevertheless arbitrarily, modified Clausius standard will not meet with general acceptance among steam engine theorists.

IT may not be altogether unnatural in our mechanical engineering contemporaries that they have sometimes found a difficulty in understanding why steam practice in electric supply stations should differ from that in manufactories and mills. To the mechanical engineer an electric light station is nothing else than a factory; and he often fails to see why the mill engines and Lancashire boilers which have served so well in other factories should be discarded when it is a matter of "manufacturing electricity." This view has recently been expressed by our contemporary, the *Engineer*, in a leading article which we have reprinted. In this homily electrical engineers are chided for their neglect of the experience acquired by generations of mill engineers, and for having so little to do with the Lancashire boiler. "From the first," says our contemporary, "the Lancashire boiler has been almost absent from electric light installations. It is only recently that it begins to be used in a tentative fashion by electric light engineers," and it endeavours to prove this tentativeness by a reference to Islington, where Lancashire boilers and water-tube boilers have been put in "almost side by side."

REALLY our engineering contemporary has taken a very pessimistic view of the case, and does not appear to have fully acquainted itself with the facts. In an article which we published on August 16, 1895 (Vol. XXXV., p. 514), it was shown that no less than 60·5 per cent. of the boilers in the provincial electric supply stations are of the Lancashire type, while only 22·3 per cent. belong to the water-tube type. It is only in the metropolis, with its special conditions—absent, be it noted, from ordinary mill practice—that the compact, inexplosive water-tube boiler has a prominent place. We are glad to see that the experiment of working Lancashire and water-tube boilers together is to be tried at Islington. By varying the proportion and time of their respective duties, Mr. GAY will be able to elicit useful information as to their relative suitability. But we decline to accept this station as evidence of any tentativeness in electrical engineering practice. Some of the earliest provincial supply stations were provided with none other than Lancashire boilers; and at the present time such important stations as those at Manchester, Brighton, Bristol, and Liverpool, besides a host of minor stations, are wholly dependent for steam upon this type of steam generator.

SOME interesting researches have been made recently by Dr. A. LEBRET, on that influence of a magnetic field upon the distribution of electrostatic potential in a conductor carrying a current which is generally known as the Hall phenomenon. By means of an ingenious zero or balanced method, Dr. LEBRET has eliminated many of the disturbing influences which occur when the Hall effect is measured by deflection methods, and in consequence he has succeeded in obtaining a high degree of sensitiveness and accuracy in his apparatus. Our readers will find a full account of Dr. LEBRET's method in our columns this week, together with some account of his more recent researches on the Hall phenomenon in bismuth conductors. Of particular interest is the investigation into the dissymmetry of effect of a reversal of the magnetic field, Dr. LEBRET having detected and measured such a lack of symmetry in bismuth plates of considerable thickness. This curious feature of the Hall phenomenon, first observed by NERNST and VON ETTINGSHAUSEN, apparently has been explained by means of experiments on the zero and maximum values of the dissymmetry at various angles around a circular disc-shaped conductor of bismuth. An expression for the dissymmetry as a function of the angle was deduced, and revealed that a reversal of the magnetic field caused a change of algebraic sign in but one term in the expression. Hence the dissymmetrical values.

TO determine the hysteresis loss in a sample of iron, by means of a single observation of the "throw" of a spot of light along a scale, is the task which Mr. G. F. C. SEARLE has sought to accomplish, and the partial completion of which he has described in a Paper communicated to the Cambridge Philosophical Society. A reprint of this Paper will be found in our columns this week. The determination of hysteresis by a single direct reading is no doubt of great practical value, and it has already been accomplished in the hysteresis meters of Prof. EWING and others. These have the advantage of giving a steady reading instead of a transient "throw"; and the use of a pointer is generally preferable to a spot of light in practical work, as it does not involve using lamp or darkening the room. There is ingenuity and, so far as it is safe nowadays to say so, we believe there is also distinct novelty in Mr. SEARLE's method.

Royal Society.—The first of the two annual conversaziones of the Royal Society will take place on Wednesday, May 6th.

Verband Deutscher Elektrotechniker.—The fourth annual meeting of this Society will be held at Berlin from June 17th to 21st.

Society of Arts.—Mr. James Swinburne will deliver a course of Cantor Lectures on "Applied Electro-Chemistry," on Monday evenings, April 27th, May 4th, 11th and 18th.

Cable Interruptions and Repair :—

	Date of Interruption.	Date of Repair.
Santarem—Manaos	March 27, 1896. ...	March 28, 1896.
Puerto Plata—Martinique.	December 19, 1895. ...	—
Assab—Massowah	March 29, 1896. ...	

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King's College, London.—A special course of lectures and laboratory work on alternating currents is announced to commence on the 27th inst., of which particulars can be obtained of the secretary.

Lord Kelvin's Jubilee.—Sir Douglas Galton has been appointed to act as representative of University College, London, at the celebration, next June, of the jubilee of Lord Kelvin's professoriate in the University of Glasgow.

Electric Traction in Egypt.—Good progress is being made with the construction of the electric tramways at Cairo, the concession for which is held by a Belgian Company. A good portion of the material has already arrived, and it is expected that the first section of the line will be ready for operation in July.

South-West London Polytechnic.—From the 13th inst. the well-equipped chemical and physical laboratories of this Institute will be opened to day students on each working day except Saturday. Mr. Herbert Tomlinson, B.A., F.R.S., is principal of the Institute, which is situated in Manresa-road, Chelsea, S.W.

Congress of Chambers of Commerce.—It has now been definitely arranged that the third Congress of Chambers of Commerce of the empire, which has been in course of organisation by the London Chamber of Commerce since May, 1895, shall commence its sittings on June 8th, in the hall of one of the City companies—probably that of the Grocers' Company.

Professional Advice.—"Those who undertake to interpret natural law without proper professional advice are," says a Mr. H. V. Hinckley, in the March number of the *Engineering Magazine*, "as a natural consequence, fined for contempt in Nature's court."

Wanted, an Improved Accumulator.—A gold medal is being offered by the Société Industrielle de Rouen for an improved accumulator, having advantages in respect to efficiency, &c., over existing types. Full particulars of the competition, which closes on September 30th next, may be had from the Société Industrielle de Rouen, 2, Rue Ampère et Place de la Cathedrale.

Water-power Stations in the United States.—The *Electrical World*, of New York, has recently published a table of data of no less than 124 water-power electric supply stations in the United States, a list which covers the most important installations. Some 26 of these run electric tramways or railways, and 56 of the stations are equipped with steam plant for auxiliary power.

Electric Motors in Workshops.—On page 715 of our issue of March 27th we stated that Mr. Daniel Adamson had read a Paper entitled "Electric Driving," on March 21st, before the Manchester Association of Engineers, and had referred to the use of this method of driving at Messrs. Daniel Adamson and Co.'s engineering works at Hyde. We are requested to make two corrections, and hasten to do so:—1. The Paper was read on March 14th. 2. The electric plant referred to is in use in the works of Messrs. Joseph Adamson and Co.

Germanese American.—A copy of a little work has recently come into our hands, of which the following is a reprint of the title page. We have been at some loss to understand in what language it is written, but have come to the conclusion that it is an alloy of one part of German to two parts of American:—

"More than 2,000 questions relating to steam engineering which every engineer should be able to answer; systematically arranged for the practical tradesman to facilitate him the knowledge of his need, by giving chance for selfstudy; with argued answers, and over 500 illustrations."

Another gem, a footnote, reads as follows:—"If we speak in the future of the valve weight we consider the stem included."

Interior Conduit Wiring.—An extensive installation on the Bergmann interior conduit system has been put down at the new building of the Reichsgericht, the highest court of justice in Germany, at Leipzig. The installation comprises 3,000 glow lamps, 3 electric ventilators, 8 telephones, 50 electric bells, and 8 electric clocks. There were used 2·5 miles of lead-covered cables, 18·6 miles of paper conduits, 21·8 miles of copper conductors, and 120 switch boxes. All the conduits are sunk into the walls. The installation has been working since last September to the entire satisfaction of the authorities.

The Manchester Town Council and the Three-Wire Patent.—At the last meeting of the City Council the minutes of the Gas Committee were agreed to. They included a recommendation that £1,600 be paid to the Westinghouse Company in full discharge of all claims for royalty, present and future, in connection with the three-wire and five-wire systems in use in Manchester. The opinion was expressed that the arrangement with the Company—made subject to the condition that the Corporation should not oppose the application for an extension of the life of the Company's patents—would be advantageous to the Corporation.

Personal.—The title of Assistant-Professor has been conferred on Mr. G. U. Yule, assistant to the Professor of Applied Mathematics at University College, London, and a similar title has been conferred on Mr. A. W. Porter, assistant to the Professor of Physics at the same college.——Last week Mr. G. W. Monkhouse, who is about to commence business as consulting engineer in London, was the recipient of a presentation by the staff and workmen at the Edinburgh municipal electric supply station. The presentation took the form of a Fuller's drum slide calculator and a complete set of Crosby's steam indicators.——Mr. W. Bathurst, who has held the post of assistant engineer at the Hampstead Vestry electric lighting station since the date of its opening, was on Saturday last presented with a leather writing case subscribed for by the indoor staff as a token of their esteem. The presentation was, in the absence of Mr. Cottam, made by Mr. Egerton Sayer, engineer in charge of mains. Mr. Bathurst leaves for the Cape this week. Mr. C. O. Bastian has also, we learn tendered his resignation, and will be leaving the Hampstead station shortly.

Effects of Products of Combustion in a Gas-Engine Cylinder.—At a recent meeting of the Association of Yorkshire Students of the Institution of Civil Engineers, Mr. F. Grover, of the Yorkshire College, Leeds, read a Paper on the effects of products of combustion in a gas-engine cylinder. Dealing with the present greater economy of gas engines, the lecturer said this was chiefly due to the increased compression given to the explosive mixture before ignition. It was distinctly advantageous to expel the burnt gases. To investigate the effects of the presence of these gases upon the pressure obtained, Mr. Grover had carried out a series of experiments in the engineering laboratory of the College. He ignited pure mixtures of gas and air in the proportion of from 1 to 16 volumes up to 1 to 6 volumes, and to each pure mixture 5 per cent. (by volume) of products of combustion were added. The pressures obtained after the addition of each 5 per cent. were recorded by means of a Crosby indicator. Proceeding in this way, burnt gases were added by increments of 5 per cent. by volume until the mixture became inexplosive. The general conclusions deduced from these experiments were as follows:—(1) That the highest pressures are obtained when the volume of air present is only slightly in excess of the volume required for complete combustion; (2) that in some mixtures higher pressures are recorded when residual gases take the place of an excess of air; (3) that when the volume of products of combustion does not exceed 58 per cent. of the mixture, it is explosive, provided the volume of air is not less than 5·5 times the volume of coal gas; (4) that the time of an explosion is much reduced when excess of air is replaced by products of combustion.

Expiring Patents.—On Monday next, the 13th inst., will expire patent No. 1,769 of 1882, granted to M. Camille A. Faure, of Paris, for "IMPROVEMENTS IN SECONDARY BATTERIES." The invention relates to the manufacture of containing vessels "in such a manner that they are permanent, cheap and not easily breakable." The invention also relates to a method of suspending the "leaden sheets or electrodes" in the containing vessel. Each plate is provided with a strip of metal projecting upwards, and flat iron bars are laid across the vessel, the strips being folded over the bars, forming hooks, and secured in suitable manner.——On Friday next, the 17th inst., will expire patent No. 1,830 of 1882, granted to the late Prof. Fleeming Jenkin for "IMPROVEMENTS IN MECHANISM USED FOR

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TRANSPORTING GOODS AND PASSENGERS BY THE AID OF ELECTRICITY." The invention relates to a system of electric traction commonly known as "telpherage." The claims are as follows: "First, my system of telpherage, in which a single conductor divided into sections and with connections controlled by the passing trains drives a series of vehicles or of trains by electromotors upon them which are electrically connected in series through the conductor. Second, my system of telpherage, in which two conductors divided into sections, and with connections from one to the other controlled by the passing trains, drive a series of vehicles or of trains by electromotors upon them, which are electrically connected in series through the conductors. Third, the use in telpherage of insulated wires or ropes to sustain the vehicles, and simultaneously convey the electric current to electric motors upon the vehicles. Fourth, the use in telpherage of governing apparatus upon the vehicles, which cuts out the electromotor when a certain speed is reached, and at a higher speed applies a brake. Fifth, my system of electrical propulsion, in which the electromotors of the several trains or vehicle upon the line are caused to receive the current in series, each spanning a gap in an otherwise continuous conductor. Sixth, my system of automatically blocking trains or vehicles electrically propelled in series by maintaining continuity in that part of the conductor in which a gap is required to render the current effective in propelling the train or vehicle. Seventh, my combination of apparatus for propelling trains and vehicles in series by electricity, consisting in apparatus at a station maintaining a uniform current, a conducting system by which the said current passes to and through the trains or vehicles upon the line, in series, and governing apparatus upon each train or vehicle regulating according to speed the quantity of current taken from the conductor and passed through the propelling electromotor."

Röntgeniana.—The *Comptes Rendus* for March 30th contains numerous communications on the subject of X-rays, many of which are of unusual interest. MM. L. BENOIST and D. HURMUZESCU, in spite of repeated experiments, can find no trace of electrification by X-rays, but have alighted on a phenomenon analogous to that discovered by Prof. G. M. Minchin (see *The Electrician*, March 27th, p. 736). They find that the time taken for a given fall of potential to occur is different for different bodies. If we take the time for Pt as unity, then we have the following figures:—Zn (amalgamated), 0·96; Fe-Ni, 1·38; Zn and Ag (foil), 1·41; Cu (red), 1·48; Ag (sheet), 1·53; Al (beaten), 1·92; Al (sheet), 2·12; lampblack, 1·97. "Hence the aptitude with which the different metals utilise the energy of the X-rays to dissipate electricity clearly varies inversely as their transparency for these rays." The authors suggest the use of platinum salts for photographic purposes. The "conducting-dielectric" theory of Prof. J. J. Thomson does not explain the phenomenon, and experiments made with a view of discovering a similar property in dielectrics have so far yielded negative results.——M. G. SAGNAC has a long Paper entitled "On the Diffraction and Polarisation of Röntgen Rays"; he finds that the X-rays he experimented with "do not possess wave-lengths greater than four-hundredths of a micron," and can discover no signs of diffraction or polarisation.——M. CHARLES HENRY tries his hand at co-ordinating the various results attained up to date; the following is a summary of this paper: X-rays it is almost certain are transversely-vibrating ultra-violet rays. It is true they do present interference phenomena, but according to the Fresnel-Kirchoff theory this is exactly what should occur when λ approximates zero. They are not refracted; but then Wüllner has suggested a dispersion formula in which the refractive index is a function of the wave-length, hence $n=1$ when $\lambda=0$. X-rays give rise to phosphorescence; now according to Stokes' old law, phosphorescence is due to the absorption of short waves and their transformation into longer waves; hence X-rays are ultra-violet waves, a belief confirmed by their electro-discharging powers. M. Henry further gives cogent reasons for believing that cathode rays are merely X-rays complicated by material convection, that cathode-rays become converted into X-rays on entering dense media and *vice versâ*, that all sources of light emit X-rays, though feebly as compared to Crookes' tubes. Phosphorescent bodies excited by the solar radiation emit rays which will, as has been shown, traverse optically opaque bodies, but which, on the other hand, are refracted (*vide* M. Henri Becquerel), as they ought to be, λ in this case, differing as they do sensibly from zero. Phosphorescent bodies exposed to electrical radiation emit Röntgen rays, *i.e.*, waves of much shorter wave-length which traverse optically opaque bodies, but are *not* refracted. *Voilà tout!*—We have received a collection of very excellent X-ray "graphs," the results of experiments at University College, Nottingham. The "graphs" were taken by Mr. A. H. Simpson, and are published by the Electric Photo-Printing Company, Short Hill, Nottingham.

The Ford-Washburn Storage Cell.—On page 216 of our issue of December 13th last we made a few remarks on the storage-battery-traction trials initiated by the New York and Harlem Railway Company, in the course of which we said that the "electrical industry has yet to produce a battery commercially adapted to the conditions of traffic on common roads and tramways." With this dictum the Ohio Storage Battery Company of Cleveland (U.S.A.), manufacturers of the Ford-Washburn cell, join issue. We have great pleasure in giving their side of the question as fully as our space permits. In a letter dated April, 1894, the President of the Cleveland and Berea Street Railway Company writes as follows to Capt. G. A. Ford:—

DEAR SIR: In relation to the storage battery car used upon our Cleveland and Berea line, will say the car came on our road in September, having made a number of trips on the city roads before coming, and started making six trips per day between Cleveland and Berea from October 1st to February, and making a total of about 6,000 miles, and carried about 12,000 passengers. On special occasions the motor car successfully pulled a trailer, there being upwards of 150 passengers on board the train on one trip counted. Our facilities for charging the batteries were insufficient and of a temporary order. We had no facilities for inspecting the cells, and during the entire time they were used but one set was in service, consequently making it impossible to withdraw one set from the car for charging and inspection while another was in service. One feature of the service was the placing of the car and its cells entirely in our hands for housing the car, &c., without restriction or rigid continuous inspection of our actions and treatment of the equipment, while under our care overnight and between trips, by yourself or engineer; in consequence we can unqualifiedly say the equipment of cells in the car when its service was discontinued was the same as when the initial trip was made. The reason we were obliged to surrender the use of the car and the further entire equipment of our line with your system, was due to the fact that your system in the opinion of bond-purchasing investors was not wholly removed from its formative business stages; on account of this condition existing we were deprived of the possibility of placing in service an ideal system for electric suburban traction, and you as well were deprived of the opportunity of showing in long continued use of several equipments the entire practicability of your system. The cells in the car were sold to Prof. Langley for the use of Case School of Applied Science and Adelbert College. We learn they have been found, after careful inspection, to be in as good order electrically as when first used, which certainly speaks volumes for the practicability and indestructibility of your cells, since the same cells were subjected to hard usage in service on our road.

In addition to this testimonial we have before us a long report by Profs. J. W. Langley and C. F. Mabery, of the Case School of Applied Science. The Ford-Washburn cell, we may say, has "a flat bar of lead for the positive pole, placed within a perforated conductor of sheet lead which is filled with lead dioxide. This lead conductor is placed within a porous earthenware cell. . . . The space between the internal lead conductor and the porous cell is filled with lead dioxide. This earthenware cell is placed within another perforated sheet lead conductor, and the space between the outside surface of the earthenware cell and the external lead conductor is filled with litharge. These two lead conductors, with the porous earthenware cell, constitute a single element." The cells were tested in a thoroughly practical manner over a period of two months, one test consisting in subjecting a cell to 9,000,000 jogs spread over 422 hours, during which time it was charged, discharged, short-circuited, and allowed to remain on open circuit. Generally speaking, it was shown that the internal resistance remained remarkably constant, that "sulphating" was almost entirely absent, notwithstanding the severe conditions imposed, that the plates and porous pot were in no way deteriorated, and that the ampere-hour efficiency varied from 73 to 86 per cent, and the watt efficiency from 55 to 72 per cent. We sincerely trust that the future performances of the Ford-Washburn cell wil enable us to withdraw the statement objected to.

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FURTHER PROGRESS IN RADIOGRAPHY.

BY PROF. OLIVER LODGE, F.R.S.

The applications to surgery and anatomy are growing so important and interesting that they have some tendency to delay progress in the direction of a better understanding of the physical nature of the Röntgen rays. The focus-tubes now in the market are able to stand as much power as can be applied to them by an induction coil with make-and-break. Alternating currents as exciter are unsuitable; a quick sharp break is much the best. Leyden jars are quite unnecessary. A low-resistance primary, excited by two or by three storage cells and a break under alcohol, acting on a large secondary coil, are the means which I have found best for exciting the tubes. A well-exhausted tube can stand for hours discharges which are on the verge of leaping across its terminals outside the glass, and can keep quite cool all the time, although the primary contact-breaker may get partly melted. The vacuum improves in action and ultimately gets too good, so that the discharge occurs altogether outside the bulb. In that case the flame of a Bunsen suffices to liberate condensed gases from the glass and give the bulb a new period of activity. Rays so obtained are very penetrating, and make such bodies as potassium-platino-cyanide and calcium-tungstate fluoresce powerfully. These two substances are the best I have yet seen, and the second is much the cheaper, even if the former is the better, as I incline to think it is. Neither should be powdered, but should be thrown down in minute crystals, and these, when dry, should be spread on a layer of clear varnish painted over either tracing-cloth or glass. Several such layers of crystals superposed give a good screen, which, mounted as the base of a box with two eyeholes at the distance of distinct vision in dim light, enables the effect of even feeble Röntgen rays to be readily seen. Of course actual light is to be excluded by two or three thicknesses of photographic black paper or otherwise. Armed with such a spy tube, and having accustomed the eye to a dark room for some time, the screen can be seen to fluoresce under the action of rays which have penetrated considerably more than a foot thickness of solid pitch-pine. The rays which have penetrated a person's chest also have the power of exciting vivid fluorescence. Indeed, under favourable conditions, the rays which have been through one person can be sent through another, and their effect can still be seen after that. Of course clothes make no practical difference. It is rather less easy to see through a head than through a chest, but it is quite easy enough to see through every part of the body when things are working well, but in no case have I as yet been able satisfactorily to perceive any detail by this method of viewing. Whether it be merely that the light is too dim for discrimination, though apparently rather bright, or whether it be that these very penetrating rays make less distinction than ordinary rays between bone and other less dense material, I am not sure. Possibly there is truth in both these obvious suggestions. It would not be easy to read a page no more strongly illuminated than is the fluorescent screen after the rays exciting it have penetrated the trunk, and perhaps the absence of detail is thus sufficiently explained; but I have been several times forced to surmise that just as the original Lenard rays are easily stopped by a few inches of air and have feeble penetrating power, so Röntgen rays may be of two or more kinds, perhaps differing in something of the fashion that violet light differs from red; and that, whereas close to the source we get Röntgen and Lenard rays mixed, and a little further off Röntgen rays only, *i.e.*, those which discriminate most clearly and throw therefore the most instructive shadows, so after great obstruction, like a human body, only the most penetrating quality of ray gets through. And under these circumstances the interposition of the palm of one's hand scarcely adds to the shadow, nor do the bones of the palm make their appearance in so prominent a manner as one might expect from the general brightness. Against this, however, is to be recorded the fact that I have taken a photograph of a spine to discover the nature of the damage to a vertebra in a patient, and the details of the processes of the vertebræ come out well. Also I have taken a hand with rays which have come through 6in. of pitch-pine, and the bones, though a little blurred, are not bad.

Naturally the body radiographs are not easy to read, except by a skilled anatomist after some practice, because the aspect of bones which are semi-transparent, and are all projected together upon a flat surface, is by no means a usual aspect, indeed is a quite novel one, and requires to be learnt. A study of the skeleton, and some skill in drawing, is necessary in order to disentangle the superposed impressions. But the impressions themselves are not indistinct. The internal organs also appear. Comparing this method of investigation with the stethoscopic method it cannot be thought that the stethoscope is the easier. To a novice both would seem equally puzzling, and both require skill and experience.

Foreign metallic bodies in the trunk, such as a Murphy button used by surgeons for joining cut intestines, are, of course, easily radiographed. The other day I got a good impression of one of these in an adult, with only ten minutes' exposure of the plate.

But here again some evidence of possible physical interest occurs. The outline of the button, naturally at some distance from the flat, is not sharp. Its shape is quite visible, but its outline is blurred. Of course it is enlarged by the cone of rays, and its position between plate and source could be estimated exactly by its size, if only its outline were sharp. Possibly the blurring is only due to internal movements in the body, the intestines are known to be very movable; but if, as Lenard said, opacity is the nature of turbidity, the whole body glowing as it were like faintly ground glass under the action of the rays, which is just what it looks like through the described spy-tube, then this slight haziness of outline may be considered as physically explained.

A coin laid upon each plate serves as a handy label and a guide in developing. It may be worth remarking that a threepenny bit placed on top of a shilling comes out readily on a plate, and that one can "see" through several thicknesses of sheet iron such as tinplate.

As to the photographic plates used, I have found that only plates by the best makers are of any use. A cheap packet, in which some of the plates may have been already partially fogged, is utterly unsatisfactory. Hitherto Edwards' isochromatic plates have done best for me, though Marion's rapid, and probably any thoroughly good maker's, are equally good; and I do not now fancy that the isochromatic property is an essential help. Either the hydroquinone or the pyrogallate developers are perfectly satisfactory, but my assistant usually prefers the hydroquinone. In developing the plates it must be remembered that the penetrating power of the rays has enabled them to operate equally right through the film, and not chiefly on the surface; hence development may be safely pushed pretty far. This fact may have given rise to the opinion that the films are acted on from the glass outwards, instead of from the surface of the film inwards, as in the case of light. At present I am not by any means convinced of the truth of this opinion.

It would, however, be very remarkable if that interesting experiment of Prof. J. J. Thomson's should be confirmed—viz., that the cathode rays themselves inside a vacuum had no power of exciting a photographic plate. From their violent action on glass it would seem more likely that their action, though admittedly indirect, must nevertheless be strong, perhaps strong enough to undo and mask their initial effect. At any rate the experiment needs repeating.

As to the source of the rays, I, like others, have made many experiments, and the results are definite enough. When the rays from the cathode, inside the vacuum, impinge first on a glass surface, then that surface is the source. It is not as if the cathode rays penetrated the glass and proceeded on their path; it is not as if the glass surface were a wave front, from every point of which a ray proceeded normally; the glass radiates X-rays just as a red hot surface radiates light. From every point a cone of rays starts in all directions, and there is no mutual interference in the lateral directions, as there would be between a number of similar sources all in the same phase. Every point of the glass radiates independently,—like a hot

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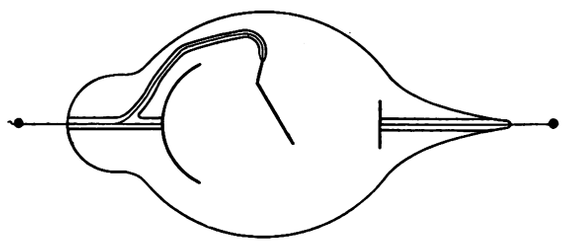
surface, in fact. The best experiments of this kind were those in which I used a magnet to deflect the cathode rays on to any chosen spot or patch of the glass, and then took shadow photographs through slits and holes placed at a measured distance. The shadows of wires at a distance from the plates, taken through a narrow slit at some distance from the wire, show that if the X-radiation consists of waves at all those waves must be very small. There has been nothing, as yet, to discriminate between longitudinal and transverse oscillations. Transverse must be considered as the most probable at present; but then it is not certain that they are waves at all. If waves they must be very small ones; and the question whether they are transverse or longitudinal is almost a minor consideration if it should turn out that the wave-length is comparable to the size of molecules. The interest and importance of such an instrument of investigation as radiation with that size of wave, whereby indirectly molecules themselves would hereafter be rendered diffractionally visible, are immense.

When the cathode rays do not first strike the glass, but first strike a piece of metal enclosed in the bulb, then its behaviour depends largely on what it is connected to. My experiments on this point are not complete, but this much is certain, that if the bombarded piece of metal is attached to the cathode, so that it is unable to receive any electrical charges from the cathode stream, then it either declines to act as a source of rays at all, or else emits a radiation of the most feeble kind, which can without difficulty be attributed to a secondary cause. But on the other hand, if the bombarded disc be connected to the anode, so as to be able to receive the negative charges of the cathode stream, then it acts as a most vigorous source. In a low state of vacuum it will indeed get hot and radiate light, but in a high vacuum every part of the bulb keeps perfectly cool, and the whole energy supplied seems to pass off in X-rays.

The following experiment is worth quoting at greater length.



A bulb like this with concave electrode, having at its centre a rather thick aluminium plate connected to it metallically (wires protected by glass), and beyond in its shadow the other electrode, was excited either with the cup as cathode or with the cup as anode, and pinhole photographs were taken simultaneously from various points of view, and at measured distances. A glass plate was subsequently put in the position of each of the sensitive plates, and the appearance of the tube as seen through the "pinholes" (which were ¼in. diameter), by an eye roving about, were drawn in ink upon the glass. The eye-picture thus obtained was afterwards compared with the developed images, and the sources of the radiation thus clearly observed.

When the small flat disc was cathode, every part of the complicated anode appeared strongly and quickly on the plate, especially the tilted and first bombarded portion on a plate placed above the tube. The cathode disc itself did not show at all. On a plate placed below the bulb the anode cup appeared strong, but the tilted disc did not appear. On the other hand it threw a sharp faint shadow *of the hole*, showing that its focus spot acted as a feeble point source, by reason of a few rays reflected back on to it from the cup.

When the current was *reversed*, the small disc anode showed faintly, being excited by rays which had penetrated the interposed tilted disc, but again the cathode hardly showed at all, not even the tilted portion on a plate placed below the bulb. By giving a very long exposure (two hours) some impression was obtained, about equal to that from the shaded anode disc; but, of course, if the tilted plate had been under these circumstances an anode, it is well known that a few minutes would have sufficed to show it strong upon the plate beneath.

Hence undoubtedly the X-rays do not start from cathode or from anything attached to the cathode, but do start from a surface upon which the cathode rays strike; whether it be an actual anode or only an "anti-cathodic" surface. Best, however, if it be an actual anode. I suggested the term "anode-rays," therefore, while Prof. S. P. Thompson prefers the term "anti-cathodic rays"; but probably the term used by Röntgen is still the best at present.

When the glass walls, instead of receiving cathode rays, are pierced only by the true Röntgen rays from the disc in the middle, no evidence is afforded by my photographs that the glass under these circumstances acts as a source. It is well that it does not, for its only effect would be a blurring one. With focus tubes the glass phosphoresces under the action of the anode or X-rays, as anything else would phosphoresce, but its phosphorescence is not of the least use. It is a sign that the tube is working well, and that the rays are powerful, but if by reason of fatigue the glass ceases to phosphoresce strongly, the fact constitutes not the slightest detriment. Not even when the glass itself is the first bombarded thing, and therefore itself the source of the Röntgen rays, does its fatigue make any difference. The fatigued portion of glass *looks* dim and unsatisfactory, while if by means of a magnet the rays are drawn aside from the fatigued patch on to a fresh portion of glass, the fresh portion *looks* bright and active; but the only radiographic result is that the source has shifted in *position*, as can be seen well enough by the shadow-parallax of suitably-disposed objects on a fluorescent screen; but no difference in *brightness* occurs. The fresh piece of glass glows brightly, and emits much more *light*; but it emits no more X-rays than the fatigued portion. I emphasise this statement because the contrary has several times been asserted.

The phosphorescence of the glass bulb is handy as an index, but it has no further advantage. The quality of the glass is doubtless of some importance, the lighter and thinner the better, one would suppose; and I doubt if *very much* advantage will be gained by replacing it with aluminium. I must say, however, that tungstate of calcium seems to me notably opaque to X-rays, and hence a non-fluorescent substance, or a less fluorescent substance than glass, may be really better for the walls of the tube. I anticipate that the use of uranium or other such glass would be a step in the wrong direction.

All the observations of the Discoverer have been confirmed by subsequent experiment, and the only additions that I am aware of to the list given by him are:—

1. The focus-tube: which is an old pattern of Mr. Crookes' merely more highly exhausted. I first saw it at work in Prof. Carey Foster's laboratory at University College, London, last January, and that particular tube still gives about the best defined results possible.

2. The use of potassium- instead of barium-platino-cyanide, or more recently the use of calcium-tungstate, as the fluorescent screen. Mr. Sydney Jackson, of King's College, seems to have done excellent and most useful work in this entire subject of fluorescence, as well as in helping everyone to acquire good and well-made focus-tubes by getting them put upon the market in a thoroughly well-exhausted condition.

3. The discovery of J. J. Thomson that the rays make insulators conduct.

It is sometimes spoken of as new that the rays discharge electrified bodies, but Lenard observed that in 1894. What had not been previously discovered was the reason why they do this. Many observations, more or less fanciful as I think, have been made as to whether positively or negatively charged bodies are discharged most rapidly; any such observation, to be dependable, requires extreme precaution, even if there were not the complication that nothing can be depended on to insulate when exposed to the stream of rays.

There is here evidently a large field for investigation, but any new results should be received with extreme caution, inasmuch as experiments on electrostatic discharge are open to such a variety of disturbing causes at the best of times.

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It may be of interest to state that Prof. J. J. Thomson's discovery that the known discharging power of these rays for both positive and negative electricity is to be explained by the fact that they render insulators conductive, has been verified in my laboratory for one or two substances; but any differences between positive and negative discharge, and any difference between one kind of metal and another, remain in my judgment seriously open to doubt.

Another fact may as well be noted, viz., that platinum foil kept white hot by an electric current has practically the same degree of opacity as a cold piece. Five pieces cut from the same sheet were compared simultaneously; they were of different breadths and had the same current flowing through most of them, so that one was white-hot and one was cold, and the others were at intermediate temperatures, but there was no appreciable difference in their transparency. This, of course, tends in the usual direction of emphasing the importance of mere density; for hot and cold platinum must be considered as of appreciably the same density for the purposes of this experiment.

The crop of assertions about the detection of X-rays from all manner of absurd sources has somewhat dwindled of late, and the loss is a bearable one. A serious attempt must be made to observe if the sun emits them by exposing suitable objects, such as bullets imbedded in cork, in front of protected plates on mountain tops this summer. The atmosphere, being equivalent to over two feet of mercury, must entirely screen these rays from lower levels; but Alpine tourists have often reported a strange fogging of plates, which they have been disposed to attribute to the warmth of a guide's back!

The production of the rays has now reached a considerable pitch of perfection; there remains much good work to be done in the direction of their better detection, especially in their more rapid photographic fixing. It is true that a few flashes will now give a radiograph of a hand, but nothing comparable to the snapshot exposure which has been achieved in the case of light can yet be predicated of the X-rays. Their fluorescing power seems to show that they possess plenty of energy, and, of course, many attempts have been made to utilise this property directly, so as to make films more sensitive.

If the films themselves can be made to fluoresce, without otherwise being damaged, it *may* be a step in the right direction; but, so far as my experience goes, which is not far, a coating of fluorescent material near the film tends rather towards a scattering and diffusion of light—a poor exchange for the straightforward penetrating property of the X-rays themselves.

Nothing better than Röntgen radiation has ever been got for throwing clear sharp shadows and giving a dense clear image. Rays which cannot be refracted, nor apparently diffracted, nor even reflected to any appreciable extent, are splendid for bringing out sharp details, and any exchange of them for the diffuse glow of any kind of phosphorescent light may be a step backwards. Nevertheless, it is improbable that the present plates, put into the market for one purpose, are the best that can be devised for an altogether different, though allied, purpose, and much work of a somewhat empirical kind remains to be done by photographic manufacturers or amateurs before the most suitable kind of film is discovered.

EXPERIMENTS ON THE HALL PHENOMENON IN BISMUTH.

BY DR. A. LEBRET.

The Hall phenomenon, as we know, can be described as follows:—If we send an electric current (called the primary) through a thin plate of any metal, then it will be possible to find out on the edges of the plate any two points of the same potential. Joining these points in series with a galvanometer, then, of course, no current will be shown. After, however, exciting a magnetic field near the plate, the galvanometer does show a deflection indicating an electric current (called the secondary), and therefore a potential difference must have arisen by the influence of the magnetic field. The potential difference is due in no respect to any induction effect, as it does not disappear as long as the field remains magnetized. It is proportional to the strength of the primary current and to the magnetic force (to the latter only approximately), and, further, it depends a great deal on the metal used, being the strongest in bismuth and tellurium. Finally, it is inversely proportional to the thickness of the plate.

Hence the mathematical expression for the resulting potential difference is

$$e = \frac{M T C}{d},$$

and for the current passing through the galvanometer

$$i = \frac{M T C}{d r}.$$

M is the magnetic force, T the primary current, d the thickness of the plate, r the resistance of the secondary circuit, C the constant of the metal used. C, however, has been found to vary with temperature.

I performed an investigation on the Hall phenomenon in bismuth at the physical laboratory of Leyden under Prof. Kamerlingh Onnes' guidance. First, I examined the variation of C with temperature; secondly, I made some experiments on the dissymmetry of the Hall phenomenon for the opposite directions of the magnetic force.

The method of observation (Fig. 1) is somewhat different from the methods used by others, and the idea of it may be of use as well for other electrical investigations, especially

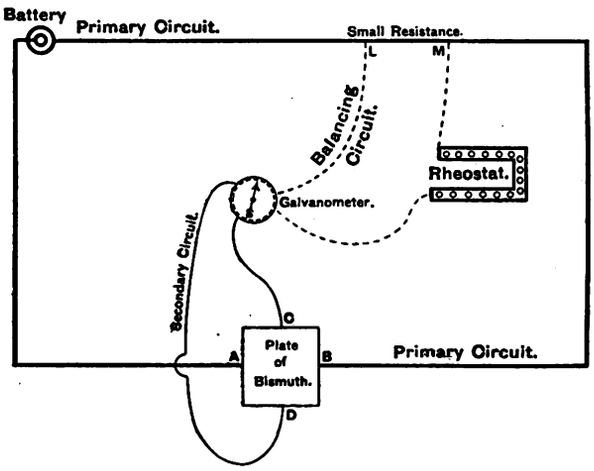

FIG. 1.—Plan of Method of Observation.

for relative measurements, as, for instance, variation with temperature. It consists chiefly in this—that the effect of the secondary current on the galvanometer needle is balanced by that of another electric current, which I shall call the "balancing" current, passing through a second coil of the same galvanometer. The two coils do not touch in any point, as do the coils of an ordinary differential galvanometer. The leads of the "balancing" circuit connect the ends of a small invariable resistance, joined into the primary circuit, in series with the second galvanometer coil and a resistance box, which allows the current to be adjusted. The strength of the balancing current is

$$i^1 = T \frac{r^1}{R},$$

supposing that the resistance r^1 joined into the primary circuit is very small (say 0·02 ohm), compared with the resistance R of the "balancing" circuit (say 100 ohms).

If the coils are in quite the same condition with respect to the needle (assuming which the explanation is a little simpler), then a balance obtained means that the currents are of equal strength; hence

$$i = i' = C \frac{M T}{d r} = T \frac{r^1}{R},$$

and

$$C = \frac{1}{R} \frac{r r^1 d}{M}.$$

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The falling out of the strength of the primary current is not a small advantage of this method over the usual one, in which this current ought to be kept constant, and measured carefully. Besides, as mine is a zero method, the primary current has to be closed only for one moment in order to see if the exact balancing has been obtained or not, so that all heating and other disturbing effects, which require some time before becoming fully developed, fall away. All these are developed to their full extent in the usual deflection method.

For measuring the variation of C with temperature the magnetic field is kept constant. At another temperature the value of it (call it C_1) is given by the same formula:

$$C_1 = \frac{1}{R_1} \frac{r r^1 d}{M}.$$

We introduce only another value for the resistance (R_1) in the "balancing" circuit, the other quantities being quite or nearly constant.

Hence $$\frac{C}{C_1} = \frac{R_1}{R}.$$

So the constant of Hall is inversely proportional to the resistances to be introduced into the "balancing" circuit, and the variation of C is thus measured by the variation of $\frac{1}{R}$ only.

The results of the experiments on two samples of bismuth plates of different origin were not the same. The first (Fig. 2) was of very pure bismuth, in which no traces of other metals

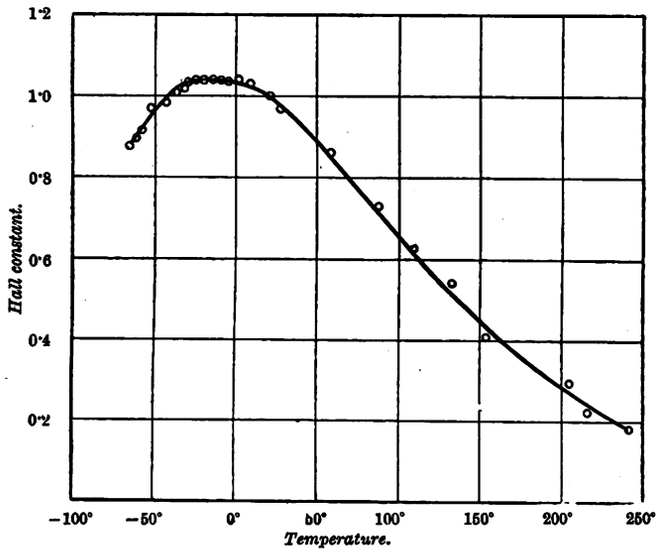

Fig. 2.—Variation of the Hall Effect with Temperature, in Pure Bismuth.

were to be found. The value of C at 21°C. was about 13 (C.G.S.) higher than ever was found before. This may be attributed partly to the purity of the metal used, and partly to the falling away, in our method of observation, of the disturbing effects which tend to reduce the potential difference.

The curve (Fig. 2) shows the variation with temperature. The most remarkable values of C, expressed in proportion to the value of C at 21deg., are, firstly, 0·175, the lowest one for 242·5deg., the highest temperature at which an observation was made; secondly, 1·040, the maximum value of C found at −12deg.; and, thirdly, 0·866 for −69deg., the lowest temperature attained.

Another sample of bismuth examined (Fig. 3) contained small traces of iron. The value of C at 21deg. was 7, as to show once more that the smallest impurity throws down the value of C to a much smaller magnitude. As concerns the variation with temperature, the lowest value observed was found at 246·5deg. to be 0·280 in proportion to the value of C at 21deg., and the highest 1·256 at −74deg., the lowest temperature at which I succeeded to make an observation. The form of the curve (Fig. 3) shows that this temperature cannot be far off from the maximum value of C which may be obtained.

A very important point connected with the Hall effect in bismuth is that the potential difference seems to rise to different values for opposite directions of the magnetic field. Von Ettingshausen and Nernst (see *Wiedemann Beiblätter* 11, p. 357, 1887) were the first who observed this; Hall (see *Sillim Journal* 36, p. 282, 1888) found this to be true, but hardly to be detected if the field does not rise above 8,000 (C.G.S.); and finally Van Aubel (see *Arch. des Sciences Nat. et Phys. de Genève* 33, March 15th, 1895) confirmed it, even for weak magnetic fields, but he supposed that the "dissymmetry" found was not a really existing physical quantity, but only the effect of an inaccuracy in the method of observation.

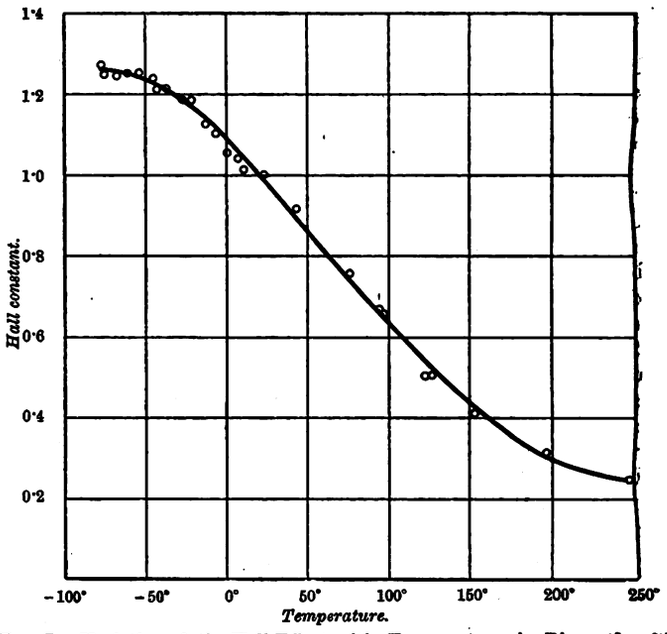

Fig. 3.—Variation of the Hall Effect with Temperature, in Bismuth with small traces of Iron.

The inaccuracy consists in the following:—The two points on the edges of the plate, to which the secondary leads are fastened, are not easily chosen as not to show a slight potential difference in a zero-magnetic field. Practice has given various means to redress this inconvenience. I myself used a wire joining a point of the positive side of the primary circuit through an adjustable resistance to the secondary lead of the lower potential (Fig. 4). So we can get the two points on the edge quite equipotential in the zero-magnetic field. Van Aubel makes an objection against this. The magnetic

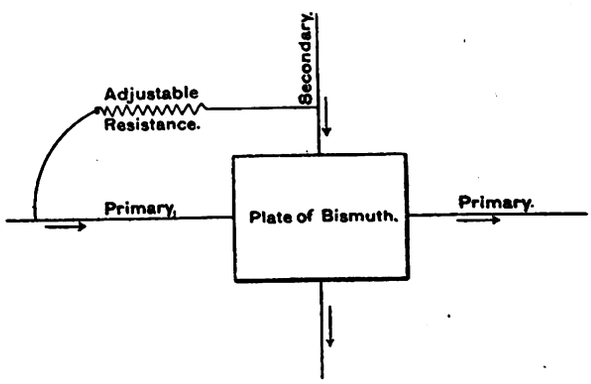

Fig. 4.

field, as we know, increases the resistance of the plate of bismuth. So only for this reason the equipotentiality shall fail to exist after the exciting of the magnetic field, and we should see a deflection of the galvanometer needle, even if the Hall phenomenon did not exist at all. This deflection would show itself always on the same side, not depending on the direction of the magnetic field. The deflection of the Hall phenomenon comes in addition to the former, and as it changes sign on reversing the magnetic field the resulting value is different for the opposite directions.

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Van Aubel relied on this explanation, because he had found that after reversing front and back of the plate the greater deflection is shown by that direction of the field which had shown the smaller before. This really agrees with the explanation given. He expected that the dissymmetry should not be found in thick plates, as the increase of the small resistance of those would not disturb much the equipotentiality acquired before. The plate Van Aubel used was only some hundredths of a millimetre thick, and so of great resistance.

Although using very thick plates (3·5mm.), I observed the dissymmetry as well. Besides which, I found that in the plate of bismuth I used then, Van Aubel's explanation could not be right—for this reason, that according to it the potential difference ought to be the stronger for the direction of the field, which, in fact, showed the smaller. Finally, in order to be quite sure that no error could come in, I left out the wires with the adjustable resistance, the small potential difference existing in a zero-magnetic field being brought into account after the experiment was finished. The dissymmetry was observed again, and the ratio of the corrected readings found the same.

I examined carefully if any other error of observation or the influence of any thermomagnetic effect could account for the observed dissymmetry, but I did not succeed. Finally the following two experiments showed me in which direction the explanation was to be found.

First I changed mutually the primary and secondary leads, so that the primary current was sent through the plate in a direction perpendicular to the direction it went through before. I now observed that the potential difference arising by the magnetic field was the greater for that direction which gave the smaller effect before. We could say: the dissymmetry had changed sign without changing the absolute value.

Secondly, as the turning of the primary current direction at an angle of 90deg. makes the dissymmetry change sign, what should be the effect of turning it at another angle? Should the dissymmetry for any angle get a zero value? In order to examine this point I made a round plate of bismuth, which enabled me to fasten and unfasten the four leads at any points of the circumference where I liked. And after some trials I found out in which direction the primary current had to pass in order not to show any dissymmetry. This direction, which can be marked on the plate, we call an axis of symmetry. Another axis of symmetry is found perpendicular to the first. Directions between the axes show a dissymmetry, the sign of this being different in the first and third quadrants from that in the second and fourth. The dissymmetry gets to the maximum value for the direction which makes angles of 45deg. with the axes.

These results enable us to put the dissymmetry of the Hal phenomenon into a mathematical form. The Hall phenomenon itself is expressed by the formulæ:—

$$\frac{dp}{dx} = -ku - hv,$$

$$\frac{dp}{dy} = hu - kv,$$

in which p is the electrical potential, u and v the flow of electricity along the x and y axes, calculated per square unit; k is a resistance coefficient, and h a quantity depending on the material used and on the magnetic force, changing sign if the latter does, and having a zero value in a zero-magnetic field.

Suppose the primary current to flow in the direction of the x axis, then the potential difference of Hall arising by the magnetic force can be calculated to be $= h\frac{T}{d}$, where T means the strength of the current passing through the section of the plate, and d means the thickness. Reversing the magnetic field we have to give the negative sign to h, thus no dissymmetry is taken into account by the equations.

We have to vary the equations so that they do show the dissymmetry. We may best start with the axes of symmetry, for which the equations do not fail. Transferring to other axes would keep them in the same form unless there is a difference between the value of k in the first equation (call this k_1) and the value of k in the second (call this k_2). If there is then the calculated difference of potential for the axes of symmetry remains the same $= h\frac{T}{d}$.

Transferring now to other axes making an angle (say α) with the former, the equations become

$$\frac{dp}{dx'} = (-k_1\cos^2\alpha - k_2\sin^2\alpha)\,u' + \{-h + \tfrac{1}{2}\sin 2\alpha\,(-k_2 + k_1)\}\,v'$$

$$\frac{dp}{dy'} = \{+h + \tfrac{1}{2}\sin 2\alpha\,(-k_2 + k_1)\}\,u' + (-k_1\sin^2\alpha - k_2\cos^2\alpha)\,v'$$

and the calculated potential difference, if the current flows in the direction of the x' axis, becomes

$$e' = \frac{h + \tfrac{1}{2}\sin 2\alpha\,(-k_2 + k_1)}{d}\,T.$$

Reversing the magnetic field, we have to change the sign of h only. So we do not get the same value for the opposite directions of the magnetic field, and the dissymmetry results from the new equations.

The above-mentioned experiments agree with the values of the potential difference deducted from the equations. For if we turn the co-ordinates to an angle of 90deg. from the new position, then the dissymmetry changes sign. And the maximum dissymmetry results for $\sin 2\alpha = 1$, hence $\alpha = 45$deg., which is the angle found experimentally between the axis of symmetry and the direction in which we have to send the primary current in order to get the maximum dissymmetry.

So we are induced to assume that the magnetic field increases the resistance of the plate of bismuth in different rates for different directions (which can be marked on the plate). The directions of the maximum and of the minimum increase cut each other at right angles, and are axes of symmetry for the Hall phenomenon.

In connection with this I might remark that my plate, after the experiments were finished, was broken into pieces, and the cutting planes were found to be parallel for the majority. So the crystals of bismuth must have been parallel as well. It should be important to find out whether there is any relation between the crystallographic axes and the axes of symmetry for the Hall-phenomenon.

Experiments on the amount of the dissymmetry in different plates, or with different strengths of magnetic field, should be made after the direction in the plate being found for which the dissymmetry has the greatest value. I have made a few experiments on one plate with different strengths of the magnetic field:—

Strength of magnetic field.	Relation of the currents for the opposite directions of the field.
1,500	31 : 69
2,160	22 : 78
2,740	14 : 86
3,480	3 : 97

So the dissymmetry is quite distinct, and increases greatly if the magnetic field does. Experiments are going on at the Leyden University in order to get still higher values of the dissymmetry.

It has been proposed to measure the strengths of magnetic fields by the amount of the Hall current they should excite in a bismuth plate, standardised for the purpose. As yet this method has never been used in practice. More chance there will be, I think, that the strength of alternating magnetic fields might be measured by the amount of the dissymmetry effect which the alternating field excites. The plate of bismuth must be carefully standardised before use, with the aid of continuous magnetic fields, and, of course, the primary current is sent through in such a direction that the maximum value of the dissymmetry is shown.

Electric Traction in Germany.—The municipality of Darmstadt has just voted £32,500 for the construction of two electric tramlines on the overhead system, giving the contract to Messrs. Siemens and Halske.

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COMMERCIAL ELECTROLYTIC ANTIMONY.

We learn from the pages of the *Zeitschrift für Elektrochemie* that Siemens and Halske are now preparing antimony by electrolysis, of considerable purity and in a convenient form. The samples which have been exhibited consist of dense grey plates of the metal, about 2mm. in thickness, and having the rugose and warty surface characteristic of antimony deposited from a thioantimonite solution, *i.e.*, a solution of antimony trisulphide in an alkaline sulphide. The side of the plates which has been next the cathode is smooth and bright, and the fracture of the metal is crystalline and brilliant. The plates are slightly curved and are very brittle, so that they can be readily powdered. As is evident from the following analyses, this electrolytic product is almost pure, and may be put on the market for most purposes without further refining, although it may also be fused into the customary ingots and slightly improved if desired.

—	Electrolytic antimony direct from cathode.	Cast metal prepared from electrolytic antimony.	Refined antimony prepared in the dry way.
Arsenic	...	...	Trace.
Sulphur.....	0·288	0·0001	0·1000
Iron	0·008	0·0046	0·0100
Lead and copper.	Trace.	0·0084	0·0303
Sodium	0·014	...	...
Antimony	99·690	99·9869	99·8587

Hitherto antimony has generally been sold as "regulus," *i.e.*, as cakes of the cast metal about 4in. thick, having the trade mark of the manufacturer on one side and the well-known "star" on the other. The crystalline appearance of the upper surface of an ingot of antimony is definitely stellar, and is taken by dealers as an index of purity, much as the "cry" of tin is accepted by traders in that metal. The value of these simple phenomena as a guide to the quality of the material is much overrated. A similar superstition exists in the galvanised iron trade, in which a crystalline appearance on the surface of the zinced plates is much esteemed, and is obligingly provided by the maker, irrespective of the quality of his wares. It may, therefore, take some little time to make buyers understand that antimony may be pure and yet destitute of a "star"; ultimately they may even be led to accept the crinkled surface of electrolytic antimony as a proof of quality, after which a natural step on the part of some enterprising person will be the preparation of thin plates of ordinary antimony, having their surfaces artistically roughened, which have never been in the neighbourhood of a cathode.

ON THE ELECTRIC CONDUCTIVITY OF CEMENT AND CONCRETE.*

BY DR. ST. LINDECK.

The disturbances caused by the leakage currents from the rail-return of electric tramways have of late been the subject of much discussion. Of the remedies proposed those should be preferred which not only overcome disturbances of a certain kind and at a certain place, but which attack the evil at the root, that is to say, diminish the leakage from the rails and consequently remove all kinds of disturbances at the same time. Prof. Ulbricht in a recent communication has given it as his view that even if we retain the rail-return system there are a number of ways of reducing the disturbances to a permissible amount. The most effective method, he considers, would be to increase the resistances between rail and earth. The amount of the earth currents is mainly conditioned by the relation of w_e/w_s, where w_e means the resistance between a unit of length of rail and earth and w_s the resistance of the rail itself for this unit of length. The knowledge of the electric conductivity of materials used for the foundation of electric tramlines is, therefore, of great practical interest.

Cement and Cement-Concrete.—The materials examined at the Reichsanstalt were parallelopiped blocks (Fig. 1) of 10cm. × 10cm. section and 40cm. length. About 3cm. from either end the electrodes E E', consisting of perforated sheet iron 8cm. × 8cm., with holes of 1 sq. cm., were embedded. In the middle, at e_3 and e_4, and also 10cm. on either side, pairs of strips (e_1, e_2 and e_5, e_6) of perforated sheet-iron 2·5cm. wide were arranged as secondary electrodes. This arrangement permitted an investigation of the uniformity of the material and of the distribution of the current. At least two blocks of each of the following materials were tested:—

1. Pure cement (Rüdersdorfer).
2. 1 part cement, 3 parts sand.
3. 1 ,, ,, 5 ,, gravel.
4. 1 ,, ,, 7 ,, gravel.

The resistance tests were generally made in such way (*see* Fig. 2) that a plug resistance box, W, a battery, B_1, consisting generally

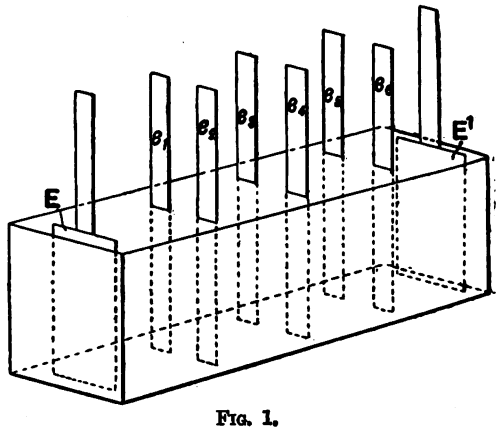

FIG. 1.

of 10 small accumulator cells, and the block X formed a circuit. The connections were made to the electrodes E E'. A Hallwachs electrometer, H, was employed for measuring the potential difference on the secondary electrodes of the block, and comparing the same with the fall of potential along a selected resistance of the testing set by means of the switch U_1. The needle of the electrometer was charged from the battery B_2 to a potential of from 50 to 90 volts. One pair of quadrants was earthed, the other was brought to the required potential. At each

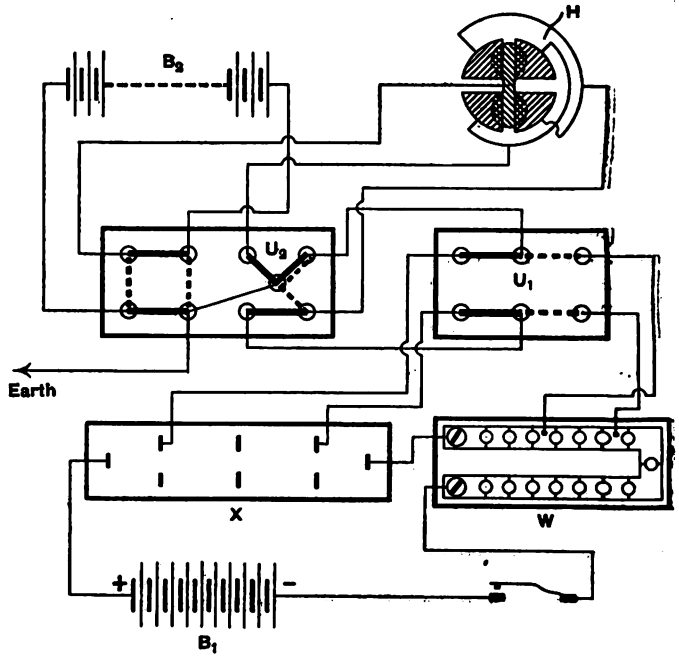

FIG. 2.

test the two pairs of quadrants were interchanged by means of the switch U_2. For the purpose of checking the numerous tests made with the electrometer, a galvanometer was employed having in series a resistance of 20 megohms. The results so obtained were identical with those obtained with the electrometer (*see* Tables).

The figures in the following tables give the results of tests made on blocks of the composition mentioned above. The blocks were made on July 8 and 10, 1895, and were allowed to thoroughly dry in the open, and it was only after 2½ months that the first tests were made. Two blocks (I. and II.) of each kind of material were examined, and on nearly all blocks the resistances between e_1 and e_5, and also e_2 and e_6 (*see* Fig. 1) were taken. For this reason there are provided in

* Abstract from the *Elektrotechnische Zeitschrift* of March 19th. Communication from the Reichsanstalt.

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—	Date.	Block No. I. Resistance in ohms for $1\frac{dm}{dm^2}$. a	b	Block No. I. Temperature in deg. C. t=	Block No. II. Resistance in ohms for $1\frac{dm}{dm^2}$. a	b	Block No. II. Temperature in deg. C. t=	Remarks
PURE CEMENT.	Sept. 28...	445	445	17·0	465	460	16·3	Taken with the electrometer.
		435	435	17·2	450	450	17·2	Taken with the galvanometer.
		435	435	17·2	...	...	..	Taken with the electrometer.
	Sept. 30...	460	460	15·7	...	...	...	Taken with the electrometer.
		460	460	15·9	...	...	...	Taken with the galvanometer.
		Both blocks for one hour under water (electrometer used only).						
		225	225	16·5	240	230	16·5	Quarter hour after being taken out.
		230	230	...	...	...	...	1½ hour after being taken out.
	Oct. 1...	305	...	15·9	305	305	15·9	—
	Oct. 2...	340	335	16 0	345	345	16·0	...
		Both blocks for about 22 hours under water.						
	Oct. 3...	130	130	15·5	155	145	15·6	Three hours after being taken out.
	Oct. 9...	260	260	18·2	295	290	18·1	The blocks dried in the open air.
	Oct. 28...	464	460	17·5	505	490	17·2	...
	Oct. 29...	480	475	16·9	520	510	16·6	...
		On November 2nd the blocks were heated for 5½ hours at over 100°C.						
	Nov. 4...	935	940	18·6	1,330	1,270	18·8	...
	Nov. 6...	1,080	1,090	17·2	1,510	1,520	18·4	...
	Nov. 11...	1,330	1,360	18·7	1,800	1,850	19·1	...
	Dec. 3...	2,160	2,220	17·0	1,850	2,000	17·0	...
	Dec. 4...	2,120	2,500	17·7	...	...	...	...
ONE PART CEMENT, THREE PARTS SAND.	Sept. 30...	1,395	1,405	17·0	1,555	1,480	16·7	Taken with the electrometer.
		1,345	1,380	16·9	1,480	1,455	16·4	Taken with the galvanometer.
	Oct. 1...	1,420	..	16·3	1,480	1,455	16·5	Taken with the electrometer.
		Block No. I. for 2 hours under water (electrometer used only).						
		140	...	16·8	...	...	...	Shortly after being taken out.
	Oct. 2...	175	175	15·7	1,480	1,455	...	...
					Block No. II. for 2 hours under water.			
		...	...	...	140	135	...	1 hour after being taken out.
	Oct. 3...	260	230	16·0	165	168	16·4	...
	Oct. 4...	285	280	17·0	...	...	...	Blocks dried in the open air.
	Oct. 5...	355	350	17·6	280	285	...	...
	Oct. 9...	515	525	18·2	485	480	18·0	...
	Oct. 28 ..	1,220	1,205	17·0	1,205	1,165	17·0	...
	Oct. 29...	1,270	1,305	16·8	1,305	1,260	17·1	...
		On November 2nd the blocks were heated for 5 hours at over 100°C.						
	Nov. 5...	740,000	725,000	18·0	109,000	155,000	...	.
	Nov. 6...	605,000	565,000	18·3	108,000	155,000	19·1	...
	Dec. 4...	580,000	580,000	17·1	180,000	165,000	...	...
ONE PART CEMENT, FIVE PARTS GRAVEL.	Oct. 3...	3,710	3,880	17·5	4,250	4,360	...	All readings taken with electrometer.
	Oct. 4...	3,680	3,850	18·5	4,150	4,310	18·8	...
	Oct. 7...	3,890	4,060	19·0	4,460	4,620	18·9	...
		Both blocks for 2 hours under water.						[taken out.
	...	210	220	17·5	215	415	17·0	Three-quarters of an hour after being
	Oct. 9...	570	585	18·1	520	510	17·9	...
	Oct. 11...	940	975	18·2	1,025	1,055	18·1	The blocks dried in open air.
	Oct. 28...	2,580	2,730	18·0	3,330	3,450	18·0	...
	Oct. 29...	2,740	2,890	17·9	3,590	3,755	17·6	...
		On October 31st heated for 4½ hours at over 100°C.						
	Nov. 1...	5,650,000	5,850,000	17·8	4,950,000	4 900,000	17·7	...
	Nov. 5 ..	2,250,000	2,350,000	17·8	2,050,000	2,050,000	17·8	...
	Dec. 5...	1,500,000	1,600,000	18·0	1,500,000	1,500,000	17·3	..
ONE PART CEMENT, SEVEN PARTS GRAVEL.	Oct. 3...	5,120	4,610	17·3	...	...	..	All readings taken with electrometer.
	Oct. 4...	5,020	4,560	18·5	4,820	5,220	18·4	...
	Oct. 7...	5,500	4,820	18·9	4,970	5,370	19·0	...
		2 hours under water.			45 hours under water.			
	Oct. 9...	615	575	17·9	220	220	17·9	Block No. I. was tested 45·5 hours, and No. II. two hours after being taken out of the water.
	Oct. 11...	1,275	1,165	18·3	560	600	17·0	
	Oct. 29...	3,930	3,570	...	3,800	4,110	18·0	...
	Oct. 30...	4,130	3,730	18·3	4,010	4,310	18·1	The blocks dried in the open air.
		On October 31st heated for 4½ hours at over 100°C.						
	Nov. 1...	6,950,000	7,150,000	18·2	6,200,000	6,450,000	17·4	...
	Nov. 5...	3,150,000	3,150,000	17·5	2,350,000	2,600,000	...	...
	Dec. 12...	1,800,000	1,850,000	17·3	1,670,000	1,750,000	17·1	...

the tables two columns headed *a* and *b*. The middle electrodes were only used for the purpose of checking, and it was found that the sum of the resistances between e_1 and e_3, and e_3 and e_5 approached very near the resistance between e_1 and e_5. For the reduction of the observed resistances to the resistance of a decimetre length of the material 1 decimetre in cross-section, the actual distances of the secondary electrodes were, of course, remeasured in each case. No special care was taken with regard to the temperature of the blocks; the readings given in the tables were taken with a thermometer, the bulb of which was in touch with the block.

From these tables it will be seen that the electric resistance of cement blocks and blocks made of cement and sand or gravel when in an air-dry condition is relatively small; it is lowest of all in the case of pure cement, and becomes higher as more sand or gravel is mixed with the cement. The porosity of the material increases, however, in the same proportion, as can be seen by the decrease in the resistance after the blocks have been put under water for some time. In this way the resistances of cement blocks fall, after being under water for about one day, to one-third of the resistance shown when in an air-dry condition. In blocks containing one part cement and three parts sand, a two-hours immersion

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is sufficient to bring the resistance down to one-tenth of the original. And in the two kinds of concrete the resistance of the blocks when moist drops to about one-twentieth.

On the basis of these tests one cannot but come to the conclusion that the arrangement of the roadbed of electric lines must be very favourable to leakage, especially where the concrete on which the rails rest is covered with a layer of asphalt, which latter prevents a good drying of the concrete. The extent to which concrete retains moisture can be seen from the tests made on the blocks after they had been heated to over 100°C. for several hours. For instance, the resistance of a 1-decimetre length (1 decimetre square) of the compound, consisting of one part cement and seven parts gravel, rose to 6 or 7 megohms while in an air-dry condition, and three months after the manufacture the resistance was only 5,000 ohms. Similar results were obtained with the other concretes, but after one month's exposure to air the resistance fell to one-third of this figure.

In the cement blocks the change of resistance due to heating was small compared with the compound blocks. The resistance rose at first to 1,000 ohms, and further after one month to about 2,000 ohms.

If for the purpose of an approximate calculation the resistance of concrete in dry air is taken at about 5,000 ohms per 1 dm./sq. dm., a tramline put down on concrete would have a resistance to earth of under 1 ohm per kilometre.

Asphalt-Concrete.—Prof. Ulbricht's communication directed the attention also to asphalt-concrete, a material used to some extent for building purposes in Dresden. The same form and arrangements as for the other materials were adopted for this material, and the tests were made together with the others. Asphalt-concrete consists of 50 per cent. of stone chippings, 20 per cent. of rough gravel free from loam or sand, 12 per cent. of asphaltic mastic, 8 per cent. of pitch and 10 per cent. of German tar. The composition of the material can however be varied as desired.

It would be of little use to record here all the tests of the different blocks, as there was always an extremely high resistance, and one could never be sure whether one was dealing with the conductivity of the material, or only with surface conduction. For instance, a block made with "Syenit" chippings gave in dry condition per 1dm./sq. dm. 280,000 megohms. The block was then placed under water for two hours, and after having been again in the air for 2½ hours, it still showed a resistance of 160,000 megohms. Even after the block had been continually under water for six weeks, it still gave an insulation resistance of 17,000 megohms. Similar results were obtained with other blocks of asphalt-concrete. *The material is, therefore, practically wateproof.*

Summing up it appears most probable that by using asphalt-concrete the rails could be permanently insulated from earth to such an extent that leakage currents of any importance could not occur. The asphalt-concrete should be laid in a thin layer over the cement-concrete, so that the cost of a line would not be appreciably increased.

PUBLIC LIGHTING BY ARC LAMPS.*

BY ANDRÉ BLONDEL.

(Continued from page 759.)

Quality of Carbons.—The quality of the carbon has a considerable influence both on the voltage, on the production of light, and on their own duration. Not only the composition of the paste,[15] but also the methods employed in manufacture, and the temperatures employed in baking play a most important part. The proportioning of all these elements is more an art than a science; it is, properly speaking, a sort of culinary art, which only the initiated know how to accomplish, and even they have many failures, "wasters" occurring from one reason or another. I can only, therefore, offer very vague suggestion on the subject.

According to Mr. Marks[16] and Mr. Stine[17] a soft carbon gives more light than a hard one for a given amount of energy. But this is only true for short arcs; and if we are to accept the experience of French lighthouses, the contrary appears to hold for long arcs[18]. This is only natural, for everything which facilitates the volatilisation or deflagration of the molecules, as a rule, reduces the efficiency. French makers no longer make the distinction between soft and hard pastes, and their carbons all have but one baking. A high temperature appears to have the good effect of expelling all the hydro-carbons (which cause flaming), and of increasing the conductivity of the carbon. Wishing to develop these advantages as far as possible MM. Street and Girard recently tried the effect of re-baking the carbons in an electric retort, where they were partially turned to graphite. Carbons thus treated have special properties which appear to make them specially useful *as negatives.*[19] They may be considerably reduced in diameter without the consumption being increased. Some are employed with success in the shops of the Louvre. Then we know that to obtain a steady arc it is necessary to use a cored carbon for the positive, that is to say, it is necessary to use a carbon, the axis of which consists of a "wick" of some conducting mixture easily vaporised; by this means we can lower the voltage as much as we please, independently of the main body of the carbon itself. But this is done at the expense of efficiency, for the intrinsic brilliancy is also perceptibly lowered. I found, for instance, in measuring the mean brilliancy of the crater, that it is lowered from 160 candles per square *millimetre* to 120, merely by a very slight increase in the conductivity of the core.[20] But it will be objected that all these details cannot be foreseen when an installation of arc lamps is undertaken. It is not possible for the engineer to study the manufacture of carbons. This is perfectly true, and I should never think of suggesting such a study, which only makers can undertake, and in which, moreover, chemical analysis is almost useless.[21] But there is a far simpler method, and that is to note the results. We see on one side that carbons last the stated time and burn regularly with a steady arc. From this we can form some idea of the value of the carbons, as we can also by measuring the range of play, that is to say, the variation of voltage, which is possible without causing either hissing or flaring. To this end we ascertain the voltage at which the arc hisses, and then the higher voltage at which the flame appears. A badly-baked carbon which hisses at 50 volts and flares at 55, may with better baking only hiss and flare at 42 and 60 volts respectively. A good cored carbon should not hiss with more than 35 volts or flare with less than 60. We can satisfy ourselves as to the homogeniety of the carbons by ascertaining by means of a recording apparatus that the variations of current or of the potential difference between the carbons do not exceed, say, 5 per cent. A photometric measurement should also be taken. Not a measurement at this or that angle, but a spherical measurement of the total luminous flux or of the lower hemispherical flux should be made by the aid of a *lumenmeter.* I am quite aware that I am now going contrary to practice, which is to define arcs by the energy they absorb. This may be a very easy method, but it is absolutely irrational, and calculated to hinder all progress. Is it just that we should impose no test on that part of our system which transforms energy into light, while we impose conditions of Draconian severity as to the efficiency of the machines which produce the energy? Is it not ludicrous to quarrel about 2 per cent. in dynamo efficiency, while we allow variations of from 100 to 200 per cent. in the lamp? From this point of view every saving in the cost of carbons which is effected at the expense of their quality is one of the most unfortunate we can possibly imagine. I will assume, then, in that which follows that we have first of all obtained a good efficiency in the production of light, for it is only on this condition that the improved equipments admit of the energy being well utilised.

Equipment.

Fittings for Public Arc Lamps.—Without troubling here as to the construction and form of the lamp-posts, I will consider the form of the envelope covering the lamp, the reflectors which may be fitted in it, and the optical equipment of the lamp generally. The arrangement of these fittings depends on many circumstances. The ease of handling, economy in up-keep, elegance—fashion even—play a great part in the choice of fittings. But for my present purpose I can easily single out a small number of appliances, such as the following:—

Polygonal Lantern.—The arc lamp is placed in a lantern similar to those used for gas. There are only a few examples of this fitting, for instance, on the Newsky Perspective in St. Petersburg

* From *La Révue Technique.* Translated by Mr. John Hesketh.

[15] The paste of European carbons consists of a mixture of retort coke, lampblack and tar; the core of a mixture of charcoal and alkaline silicates. In America petroleum coke is much used in the paste, but the quality of the carbon is inferior to ours. The proportion of these elements greatly modifies the conductivity and other properties of the carbon.

[16] "Life and Efficiency of Arc Light Carbons," *Trans.* American Inst.E.E., Vol. VII., 1890, Nos. 6 and 7. See also *The Electrician*, Vol. XXV., June 13 and 20, 1890.

[17] *Electrical World*, February 25, 1895, p. 223.

[18] See notice on the apparatus exhibited at Chicago in 1893 by the Service Central des Phares, and "The Electric Arc Light and Machinery of Lighthouses," by A. Blondel. International Maritime Congress, 1893, see *The Electrician*, Vol. XXXI., September 1, 1893, p. 428.

[19] For positives both the electrical and calorific conductivity are too great; the arc is too unstable, and too great a portion of the carbon gets red.

[20] *The Electrician*, Vol. XXXII., December, 1893, "On the Continuous-Current Arc."

[21] My friendly colleague Mr. Debray, professor and director of the Laboratoire d'Essais at l'Ecole des Ponts-et-Chaussées, has been good enough at my request to make an analysis of a series of samples of carbons of different makers, each presenting widely different practical properties. He found that the chemical composition of the pastes was almost the same for all the samples. To distinguish any difference it would be necessary to separate out the different kinds of carbons. This is a most delicate test, and one which can be undertaken by very few industrial laboratories. M. Girard has made a number of tests of this nature in his work on graphitic carbons.

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(Fig. 6) and in the City of London (Fig. 7). This type has many practical advantages, such as easy access to the carbons by opening the door of the lantern, perfect shelter for the lamp and ability to change each pane of glass in case of breakage. It is frequently used in lighting railway stations. Fig. 8 illustrates the lantern used by the Midland Railway Company.[22] The simple reason, in my opinion, why this lantern is not more used for public lighting is

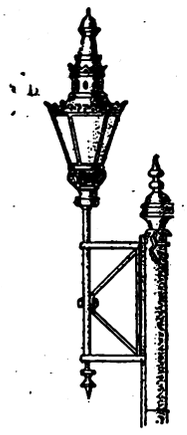

Fig. 6.—Newsky Perspective Lantern.

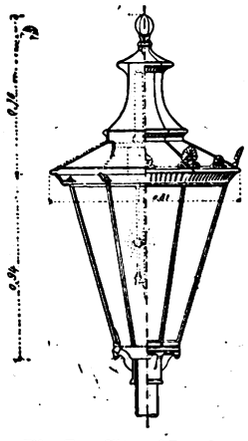

Fig. 7.—City of London.

because it is ugly. Certainly a lantern such as that used in the City of London, when it is fitted with opaline panes, is most inelegant. The type used in St. Petersburg is more acceptable, and the arrangement for sliding the lamp up and down the post is very ingenious. But it is easy to see that the polygonal lantern can never have the same elegance as our Parisian lyre. This type of

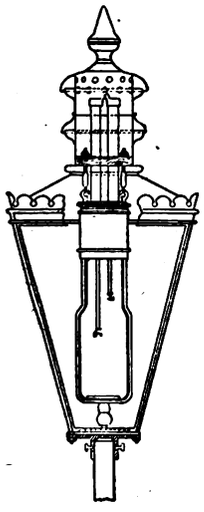

Fig. 8.—Midland Railway Company's Lantern with, fluted glass.

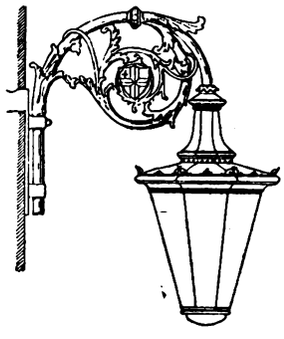

Fig. 9.—Wrought-iron Bracket and Suspended Lantern (City of London).

lantern is also open to the objection that it leaves a dark space at the foot of the post; an inconvenience observed in London. Such a lantern, if suspended (Fig. 9),* enables us to escape the shadow, and seems by far more elegant than if fixed on a pillar. Lanterns forming part of the lamp itself (Fig. 10) are out of the question

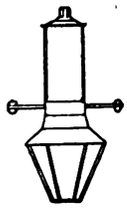

Fig. 10.—Lantern used in Docks, &c.

entirely, and should never be used except in yards, docks, &c. A metallic reflector is often placed inside lanterns when there is sufficient room; of these I will speak later.

* The figure is taken from Major-General Webbers' well-known paper on the lighting in the City.

[22] This last arrangement allows the lamp to be lowered through the bottom of the lantern in case of repairs, which is a far easier method than lifting it through the top.

Plain Globe.—Lamps fitted with a simple spherical or oval globe are suspended in the same manner as when used for interior lighting. The method of suspension may be either by a cable crossing the road to be lighted, by a bracket, or by a bishop's crook or crosier (Figs. 11 and 12), all of which arrangements avoid

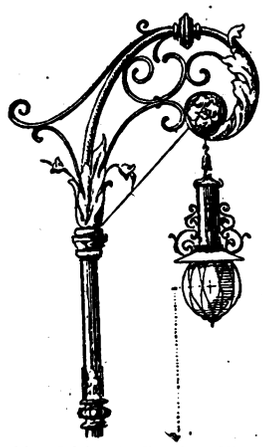

Fig. 11.—Bishop's Crook. Fixed at Ulm by Messrs. Schuckert.

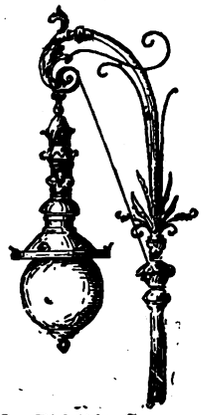

Fig. 12.—Bishop's Crook, with Removable Lamp. (Unter den Linden, Berlin.)

Fig. 13.—Nuremburg Lyre, with Flexible Lamp Fitting.

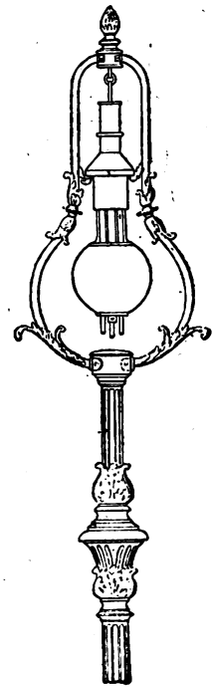

Fig. 14.—Milan Lyre.

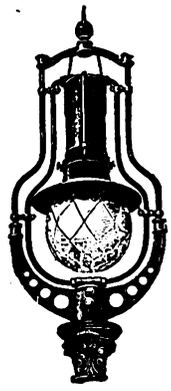

Fig. 14A.—Crompton Lyre.

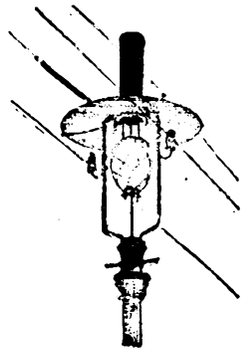

Fig. 15.—Marienbad Lyre, with Reflecting Shade.

shadows at the foot of the lamp post. Suspended lamps may also be fixed in a light lyre-shaped carrier, which does not detract from the beauty of the arrangement and hides no light (Figs. 13 and 14). The shadow at the foot of the lamp exists, however, unless the lamp is sufficiently raised (Fig. 14). The advantage of these arrangements is the economy, the lamp having no accessories, so to speak.

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Trimming is generally done by lowering the lamp, either by a winch or by tilting the post on a knuckle-joint and removing the globe, as is done in the interior of buildings. The æsthetic effect is not

FIG. 16.—Coire Oerlikon Lyre.

FIG. 17.—Zurich Lyre.

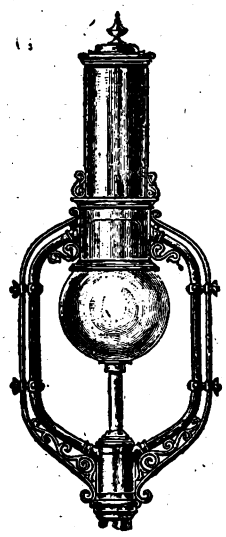

FIG. 18.—Johnson and Phillips Lyre. (St. Pancras, Dublin, Bristol, Londonderry.)

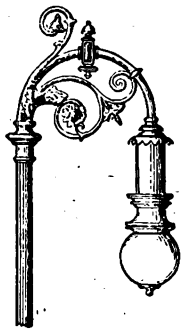

FIG. 18A.—Johnson and Phillips Bishop's Crook. (Aberdeen.)

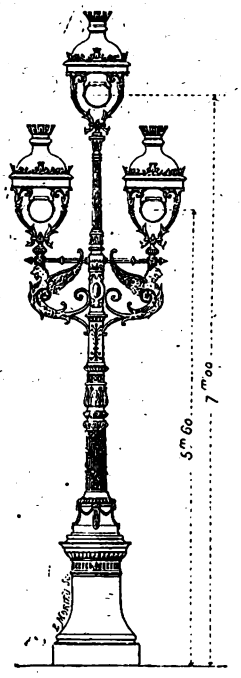

FIG. 19.—Post with three Cupolas at Toulouse.

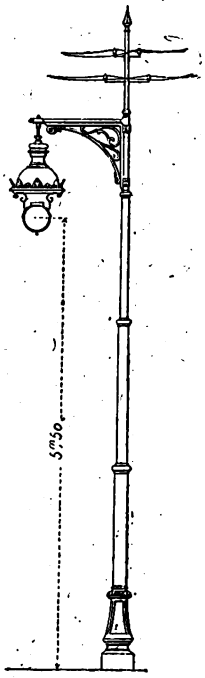

FIG. 20.—Post and Suspended Cupola.

bad, but the general appearance is rather skimpy. The chief objection is that the lamp and globe are poorly protected against wind, rain and snow[23]; a hood is therefore often added to shelter the globe (Figs. 12 and 15). The appearance then is much less graceful. These fittings are chiefly employed on the Continent, but very little in France. They are much in favour in Germany, Italy

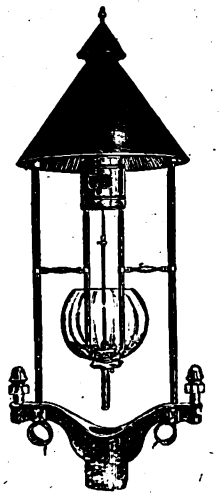

FIG. 21.—Thomson-Houston Lamp, with Hood.

FIG. 22.—Hood of Brush Lamp.

and Switzerland, where very light and graceful lyres are to be found (Figs. 16 and 17). In England, on the contrary, these patterns have been modified so as to make them more substantial,

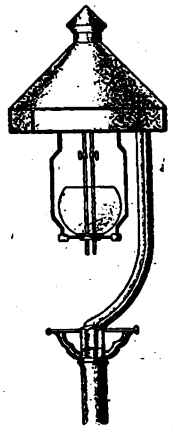

FIG. 23.—Chicago Hood.

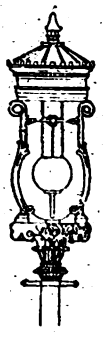

FIG. 24.—Lyre and Cupola at Chicago Exhibition.

but certainly at the expense of their artistic aspect, if we may judge from Figs. 14 and 18, which though very convenient, are not the most attractive examples of lanterns for use in an important city.

FIG. 26.—Lyre and Cupola at Blackpool (by Smith and Sons, from designs by J. Hesketh)

FIG. 27.—Three-armed Carrier at Brighton (Crompton).

Globes with a Cupola or Dome—This type is, from many points of view, the most practical. The globe is well shielded, the lamp may be perfectly hidden, and if necessary the dome may be fitted

[23] This arrangement is therefore without *raison d'être*, unless it is opted with a view to avoiding the use of a ladder.

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with a reflector. The dome and the lamp contained in it may be fixed on any kind of post, or suspended from a cable, or from a bracket by a hook (Figs. 19 and 20). The globe may also be spherical or oval. From the artistic point of view, very different

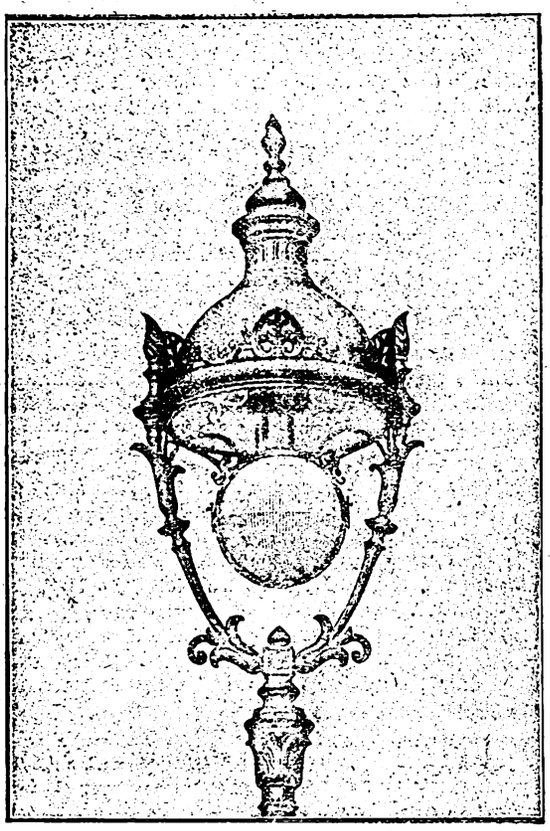

Fig. 25.—Lyre and Cupola as Used on the Paris Boulevards.

results may be given by this type of carrier according to the fancy of the makers. They are most ugly in America, as shown in Figs. 21 to 24; but in Europe, and particularly in France, where this type is used almost to the exclusion of all others, they are very elegant. The lyre and dome of the boulevards (Fig. 25) is

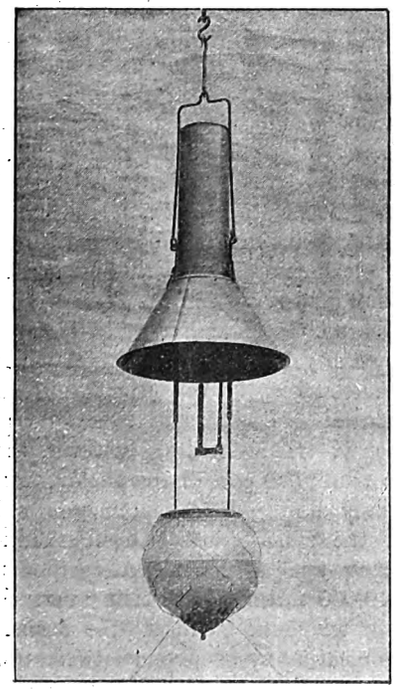

Fig. 28.—Lantern of the Port of Havre, showing Method of Moving the Globes.

now adopted in most French cities, and is sure to become the chief type for urban lighting. In Germany this type is little used; but it is beginning to be adopted in England. Figs. 26 and 27 show two recent examples, which are certainly very elegant and deserve high praises.

When this type of carrier is used,[24] the trimming is done in one or other of the following manners:—(*a*) The globe is cut vertically into two halves, and is opened like a lantern for cleaning and trimming (Fig. 25). This method is adopted in Paris and many French towns. (*b*) The globe is kept intact, but may be moved to give access to the carbons, either by suspending it from two chains, as shown in Fig. 28, or sliding it down a globe carrier, as in Fig. 26. (*c*) The globe is divided horizontally, and the lower half only can be moved.[25]

Almost all lyres carry enamelled reflectors, to which I will refer later. Care should be taken that the globe carrier is sufficiently long to reduce the shadow cast by it to a minimum, and for the same reason the thickness of the arms of the lyre should be reduced as far as possible. These are the principal types of fittings at present in use.

Problem to be solved in the Utilisation of Light.—The problem to be solved is simply: To diffuse the light in the best possible manner; that is to say, to soften the brilliancy so as to allow the eye to take in as great a part as possible; and distribute it in the most advantageous manner. Light sent above the horizontal plane of the lamps is generally lost. Neighbouring houses reflect it only in an imperfect manner, and besides, the occupants of the rooms above the lamps are generally anxious to be relieved of the annoyance of having the arcs constantly under their eyes[26]. We should then, in general, endeavour to send down all the light below the horizontal and distribute it according to a theoretical law, closely following that indicated in my "Theory of Public Lighting" (see *The Electrician* Vols. XXXV. and XXXVI., October and November, 1895). We may form an opinion of the comparative value of this or that type of fitting for lamps by calculating the luminous *efficiency* which it attains. This efficiency is the ratio of the *useful flux of light*, *i.e.*, the light which each lamp fitted with all its accessories sends out below the horizontal—to the *total flux* produced by the arc employed.

(To be continued).

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

MONDAY, April 13th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ENGINEERS.

7:30 p.m. Ordinary Meeting at the Royal United Service Institution, Whitehall.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting at the Palatine Hotel, Hunt's Bank, Manchester. "Lecture and Demonstration of the New Photography with Lantern Views," by C. M. Dorman. After the Lecture the Members of the Society will visit the Manchester Corporation Battery Station on the invitation of Mr. C. H. Wordingham.

TUESDAY, April 14th.

ROYAL METEOROLOGICAL SOCIETY.

7:30 p.m Ordinary Meeting at the Institution of Civil Engineers, Great George-street, Westminster,

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Papers to be read: (1) "The Thirlmere Works for the Water Supply of Manchester," by G. H. Hill; (2) "The Vyrnwy Works for the Water Supply of Liverpool," by G. F. Deacon. At this meeting the monthly Ballot for Members will be taken.

WEDNESDAY, April 15th.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Meeting at 20, Hanover-square, W.

THURSDAY, April 16th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Recent Chemical Progress," by Prof. Dewar, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Discussion on Mr. Dane Sinclair's Paper: "Telephone Exchanges and their Working."

FRIDAY, April 17th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Colour Photography," by M. G. Lippmann.

[24] That which follows applies more generally to all lamps fixed in lyres, even though without cupola or dome.

[25] Most of the lamp-posts used in France are made by Messrs. Durenne, of Auteuil, who have made a speciality of this class of fitting.

[26] This is still another reason for avoiding very high arcs in narrow streets.

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THE TELEPHONE AND THE POST OFFICE.

The transfer to the Post Office of the trunk line telephone wires, which took place on Monday last, has been described as the commencement of a new era in the history of telephony in this country. To us it seems rather only one stage further in a development which has been proceeding with singular slowness for many years past, and which at the same rate will take as many more to reach its culminating point. Except that the Post Office Department will now be in still closer relations—relations amounting almost to a partnership—with the National Telephone Company, there is really nothing new in the position of affairs. From the Company's point of view these relations are close enough already, seeing that they are represented by a royalty of over £70,000 per annum which the Company have to pay for the privilege of doing the telephone business of a Department which does nothing but pocket the money. Henceforward, however, the Post Office will work the trunk line part of the business itself, the wires of the Company having been purchased, and fresh ones erected, with the sums granted by Parliament for that purpose as long ago as 1892. Altogether there is said to be about 40,000 miles of trunk line wire now available for that kind of telephone business—the business, that is to say, of communicating by telephone between town and town, as distinguished from that of speaking from one part of a town to another part of the same. The town exchanges will continue to be under the management of the Company, the accumulated charges for conversations passing over the inter-urban lines being divided between the two partners, the Post

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Office, needless to say, taking the biggest share, based, no doubt, on the practice of the Company itself, which made a heavier charge for using the trunk wires than for the local service.

The National Telephone Company having already erected the larger portion of the wires now to be worked by the Post Office, it will be seen that nothing very startling has occurred. There has been a transfer of plant and a sectional change of management, the section appropriated by Government being the trunk lines. The public may feel assured that so far as these lines and those to be speedily taken over, or be erected hereafter are concerned, the service will be rendered with the same efficiency which characterises the telegraph service. But the service over these wires under the old management was not a ground of complaint—or at all events not by any means the most serious—against the Company; and it is rather hard to understand why Parliament or Post Office elected to take over that part of the business and to leave the other alone. There are no trustworthy statistics available on the subject; but we may safely assert that trunk wires are the least used and the most costly part of the telephone business; and that consequently the less remunerative part of it will be the reward of the Government for its timidity. It is a case of not cancelling the "charter," but assuming authority over a branch of the administration which involves greatest responsibility with smallest returns. Let us hope that the local exchanges may not prove to be Matabele for the Post Office. This danger, it seems to us, is by no means a fanciful one, for the satisfactory working of the trunk lines must necessarily depend largely upon the condition of the exchange systems with which they are connected, and every obstacle occasioned by the latter will be sure to be credited to the connecting links, the Post Office getting all the blame. If this should result in greater influence being exerted over the Company to the improvement of the local services the public will congratulate itself on the change. But it must not be forgotten that the Government have all along had the power to do this, but have never exercised it, and we are by no means sanguine that what has happened now will bring about any radical improvement. The *rôle* of sleeping partner does not lend itself to active interference, and we fail to see how that activity will be aroused by becoming a bed-fellow.

The false position in which the Post Office allowed itself to be landed at the outset is one from which it can never be extricated save by assuming absolute control over the telephone system in its entirety. Any lingering doubt as to the actual as well as legal identity of the telephone and the telegraph was dissipated when the Company began to construct trunk lines. From that moment it also became clear that the Government could not indefinitely refrain from taking over those lines, which would otherwise become a formidable rival to the older method of communication. Logically it would follow that the town exchanges, which are said to have injured the telegraph revenue very considerably, should also fall into the hands of the Government. But reasons outside the sphere of logic have so far protected the National Telephone Company in its local strongholds. We need not enumerate; the objections to acquisition by the State of an enterprise such as these exchanges represent are manifold, and for a long time to come will be potent. Mr. Goschen's allusion in 1892 to a vast army of State telephone officials is enough of itself to frighten Parliament for another decade at least. This being the case, we may dismiss for the present all thought of transferring to the State the remaining property of the National Telephone Company. And so far as we can see there is no desire for it on the part of the public, who would be perfectly content if the Company would, or could, provide a better and cheaper system for local purposes. We do not attach too much credence to the public complaints on this subject, and we gladly offer our testimony that things have lately improved somewhat. But when all allowances are made, the local telephone systems of this country are far from being what they should be, both as regards tariff and efficiency, compared with those of some other countries. We cannot boast of the telephone service as we do of the telegraph service; and we naturally ask why these two, so closely related with the government of the country, should continue so different in merit.

One reason may be that the Post Office is reluctant to interfere with or hamper a Company which yields a handsome revenue to the coffers of the State—a circumstance which, if true, illustrates very clearly the anomalous position of the State in its relation to the Company. The suggestion has been made that the right to issue fresh licences should be freely exercised by the authorities, and that at least this right might be advantageously exerted in favour of Local Authorities, some of whom, it is understood, would be only too glad to start business in competition with the existing company. A very good case would have to be made out for it, however, before any Postmaster-General could be induced to grant such licence even to an enterprising County Council. Failing the Local Authorities the next best thing to do would be for the Post Office to acquire absolute control over the plant, and *farm out* the working of it. The Department does this already on a large scale in respect of Post Office business, over which, nevertheless, it exercises complete administrative authority. The arrangement is profitable to both parties; and it seems to us not beyond the bounds of possibility that the same principle might be applied to the working of local telephone exchanges without vastly increasing the number of State paid officials. Not that they need cause any very serious alarm in a country like this where they have as yet no connection with political movements; but it is best not to take steps, which cannot be retraced, in a direction leading towards a grave public danger, and we cordially agree with Mr. Goschen as to the inadvisability of augmenting the army of civil servants when it can be avoided.

REVIEW.

Electric Wiring. By Russell Robb. (New York and London: Messrs. Macmillan and Co.)

This book is designed to put before architects, underwriters and the owners of large buildings the main principles of electric light and power supply, with especial reference to fire risks, and it is intended for use in America. The contents have appeared during the last two years in a series of articles in the *American Architect and Building News*. The first four chapters, which deal with generalities, have but a limited application to English practice, and the last chapter, which contains the National Code of Rules for Electric Wiring, with special comments and explanations by the author, is, of course, applicable solely to American practice. In the introduction there is a very readable comparison between electric and hydraulic power, which although not always scientifically true, serves to convey a fair idea of the main facts if not of the phenomena underlying them. Indeed, the author rightly assumes that there is no need for his readers to try to master the subject as experts. He says: "It is largely a matter of familiarity, and it is doubtful that our knowledge of the ultimate meaning of pounds and feet is much clearer than our knowledge of volts and amperes." We

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cordially agree with him. Generally the technical information is conveyed in concise and clear statements, without the not unusual confusion between power and energy, but there are some curious slips, which we mention only to ensure amendment in a second edition. On page 15, after a discussion upon the heating of conductors by an electric current, and a summary of the results as regards loss of pressure and waste of power, we are told "it is partly because of these facts that wires of inadequate sizes are so often used." The author's meaning may be clear enough from the context, but his language does not convey it, and we can imagine a non-technical reader's amazement at the literal statement. In several places, too, we find that volts are multiplied by amperes, with the results that watts are produced. Such arithmetic feats may be understood of the multitude, but they are a blot on a useful book. The author evidently feels the need of consulting engineers in America. On page 26 he says:—"In a large building there is opportunity for a good grade of engineering skill, and to have this work done by anyone except those who have studied this branch of engineering and who are familiar with its requirements is sure to result in loss." We echo this sentiment, if we do not quite agree with the terms in which it is couched.

To an English engineer the interesting part is that referring to the National Code of Rules in use in America. There appears to have been a revolution in wiring practice in the United States, unless the rules are more honoured in the breach than the observance, as, perhaps, our "Rules" are on this side. Some of the requirements are even more severe than those in practice here. For example, the use of flexible wire for "show windows" (presumably shop windows) is prohibited in America, while here there is probably not a shop served by electric light which has not one or more of such fittings. In connection with interior conduits, it is interesting to note that unarmoured conduits are not considered as insulation between conductors and earth, and that, therefore, the insulation of the conductor must be of the same grade as if wood casing were used, and only a single conductor is allowed in each conduit. It follows as a corollary to this rule that the use of twin conductors is prohibited for this class of work. If we mistake not, that form of cheap wiring was suggested as being quite efficient and safe at the recent wiring discussion at the Institution of Electrical Engineers. In connection with fuses and switches, it is noteworthy that the requirements of the Phœnix Fire Office are adhered to. Double-pole fuses and double-pole switches are required on all important sections of the installation.

In fact the general practice so strenuously advocated by Mr. Musgrave Heaphy is practically adopted *en bloc*, and new restrictions are added.

THERMAL EFFICIENCY OF STEAM ENGINES.

At the ordinary meeting of the Institution of Civil Engineers on Tuesday, the 24th inst., Sir Benjamin Baker, K.C.M.G., the President, in the chair, a Paper entitled "The Thermal Efficiency of Steam Engines" was read by Captain H. Riall Sankey, R.E. (retired), M.Inst.C.E. The question of the standard with which the results of steam-engine trials should be compared, had occupied considerable attention in several Papers on steam-engine economy which had, during the past 14 years, been read and discussed at the Institution. The matter was, nevertheless, in an undecided condition, and the author expressed the hope that discussion on this Paper might prepare the way for the adoption of some definite standard. He urged that in order to obtain full information of the thermal performance of an engine, two efficiencies had to be stated, namely, the absolute thermal efficiency, and the "standard" thermal efficiency, the latter denoting the comparison of the actual engine with an ideal steam engine working within the same temperature limits. In other words, the "standard" thermal efficiency was the absolute thermal efficiency of the actual engine divided by the absolute thermal efficiency of the ideal steam engine chosen as the standard. It was the choice of this standard which had caused so much discussion. Many views were held as to what should constitute the ideal engine required for this standard of comparison; but the author considered that the true object of such a standard was to provide ready indication as to how far the particular engine under consideration fell short of what was physically possible within the limits of temperature by which the engine was bound, having regard also to the varying temperature at which the heat was supplied to the feed water. It was shown that this requirement was met by the Clausius "perfect" steam engine, slightly modified, however, as regards the point to which the expansion was carried, for practical reasons which were universal and permanent.

To assist in a decision as to the standard to be adopted, other ideal engines which had been proposed or used as standards were considered; for instance, the Carnot cycle; the engine whose expansion line was the saturated steam line, and the engine the expansion line of which followed the law pv^n = constant; and in each case it was pointed out in what respects the requirements of the standard were not fulfilled. This comparison was also made by means of the $\theta\phi$ chart.

After considering certain points in connection with the various lines of the indicator diagram of the standard in greater detail, the author proposed the following as the standard of comparison:—

1. Admission line at the temperature of the steam at the stop-valve of the engine;
2. Expansion line adiabatic, and carried to within 0·15 atmosphere of the back-pressure;
3. Back-pressure: that in the exhaust immediately outside the engine;
4. Compression nil, and clearance nil.

The object of limiting the expansion, as suggested, by carrying it down to within 0·15 atmosphere of the actual back-pressure was to obtain a compromise between the two following conditions:—If the expansion were carried to the back-pressure, the standard would lead to the use of engines too large for their work; if, however, the expansion in the standard were only carried to a pressure equal to the back-pressure plus the mean pressure (referred to the low pressure) corresponding with the friction of the actual engine, a premium was, so to speak, awarded to a stiff engine, and the standard would be made to vary with the stiffness of the actual engine. To avoid the lengthy calculation of the absolute thermal efficiency of the proposed standard, curves had been prepared enabling the required result to be obtained by inspection, and numerical examples were given to show the method of application.

The author pointed out that in many cases a comparison of the actual engine with what he proposed to call the "type" standard was useful. The type standard was an ideal engine which took into account the clearance, compression, back-pressure, &c., necessary with the particular type of engine under consideration. For instance, the ideal engine with an expansion line following the saturation line was the type standard for a jacketed engine. The difference in the amount of heat utilised by the standard and the type standard showed the unavoidable loss normal to the particular type of engine, whereas the difference in the heat utilised by the type standard and the actual engine gave the more or less avoidable loss. The proposed standard was applied to the case in which super-heated instead of saturated steam was used, and the $\theta\phi$ diagram of this standard was given, and two numerical examples were worked out.

It was pointed out that the actual commercial criterion of a steam engine's economical performances, namely, the number of pounds of water per indicated horse-power, led to errors of about 1 per cent. as a maximum when using saturated steam; but that the error might be as much as 13 per cent. when superheated steam was used. This difficulty would be met by stating the amount of heat required per indicated horse-power, as proposed by Mr. Mair-Rumley in 1882.

The Paper was accompanied by appendixes demonstrating the use of the $\theta\phi$ chart for finding the absolute thermal efficiency of the proposed standard engines and an investigation of the efficiency of the fluid in heat engines in general.

BOILERS AT ELECTRIC LIGHT STATIONS.*

There is a cause for everything, if not a reason. It is not always easy to see what the cause may be, or to be satisfied with the reason. But the fact remains. In electricity manufactories or electric light stations, whichever they may be called, it is noteworthy that steam is generated on a system different from that which has for half a century at least satisfied millowners, and indeed manufacturers of almost all known commodities. For ordinary manufacturing purposes the Lancashire or the Cornish boiler is used almost to the exclusion of all other types. The former is no doubt an excellent example of the survival of the fittest, and its all but universal adoption is the result of a careful calculation based on commercial principles. From the first, however, the Lancashire boiler has been almost absent from electric light installations. It is only recently that it begins to be used in a tentative fashion by electric light engineers. In not only the United States, but this country

* From the *Engineer*.

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as well, we find that boilers of the water tube or locomotive type are nearly always employed to drive electrical machinery. There must be some reason for this. We do not think that it has ever been stated; but it does not seem to be far to seek, and when found it is instructive.

When electric light stations were first designed in this country the designers were in almost every case electricians, not mechanical engineers; or at least not mechanical engineers possessing any considerable commercial knowledge of the working of steam machinery. These gentlemen knew from books that high-pressure steam was more economical than low-pressure steam, in the sense, at least, that a smaller weight of the former than of the latter would give a horse-power, so it was determined that high-pressure steam must be used. But the Lancashire boiler was not deemed suitable for pressures over 100lb., so recourse was had to water-tube boilers; and to locomotive type boilers because it was a familiar fact that on our railways pressures of 150lb. and more were regularly carried. It is no disparagement of the water-tube boiler to say that the results of its adoption have not been uniformly satisfactory. It is, for one thing, peculiarly exigent in its demands for good water, and in the second it is very expensive to keep clean, and if not kept clean the tubes split and leak. The locomotive boiler, again, is a very admirable steam generator, but it, too, has its peculiarities. It is the full consciousness of these things that has induced mill-owners to resist all temptation to use any other than the double-flued or Lancashire boiler, which has been recently so proportioned that it will carry any pressure asked for. Indeed, it should be almost self-evident that if a marine boiler 15ft. or 16ft. in diameter can carry a pressure of 160lb., there ought to be no difficulty in making a Lancashire boiler of half the diameter equally strong. The mistake committed by the electrical engineers has been in assuming that the boiler which made steam most readily and was most economical in the consumption of coal must be the best. It is just the species of error into which the non-commercial engineer is likely to fall. The truth is that coal represents but one item in the cost of making steam, and it is not invariably the most important item. The price to be paid for water is not infrequently very large; and ever high-priced water may not suit either water-tube or locomotive boilers. Then there is the question of wear and tear, the quality of the steam produced, and many other matters which must all be considered before it is possible to say what is the best type of boiler to put down; and all this, be it noticed, has nothing whatever to do with the qualities of the boiler regarded from the theoretical point of view.

To make our meaning quite clear, let us suppose that a sum of £500 is available for the purchase and erection of a boiler. We may obtain with this a Lancashire boiler which will work well and give satisfaction for 10 years, with very moderate repairs, and be nearly as good and serviceable at the end of that time as it was at the beginning; or we may get a locomotive boiler which will need heavy repairs before half that period has elapsed, and will be good for very little at the end of the term. Or a water-tube boiler, which will last for half a century, simply because it has new tubes put in, a few at a time, all the year round, every year of its life. All three may be of equal evaporative efficiency, but even if they were not the millowner would keep to the Lancashire boiler, not only because it would, in the long run, be much the cheaper of the three, but because it would always be ready when wanted. It would seldom, if ever, be laid off for repairs. No doubt it may be urged, and urged with truth, that both the water-tube and locomotive boilers are excellent steam generators. This does not affect the question in any way. All the experience available goes to show that over a series of years the Lancashire boiler will be found less costly in upkeep, and more trustworthy than any other type of land boiler in the market; and that this truth is gradually coming home to electrical engineers is demonstrated by the circumstance that recourse is now being had to the Lancashire boiler in very important installations, to an extent, indeed, not dreamed of a few years ago—that at St. Pancras, for example, which we illustrate this week. It must be understood that in writing as we do, we are simply bringing before our readers certain considerations often overlooked, and endeavouring to find a cause, if not a reason, for the remarkable departure from normal practice which marked the advent of the electric light in this country. It can scarcely fail to strike any thoughtful man as remarkable that types of boilers scarcely known in Great Britain should have been used to the exclusion of all other types for supplying steam to electric light engines. Outside of railway shops no locomotive type boilers could be found driving stationary engines of more than a comparatively few horse-power. In factories they are practically unknown. The water-tube boiler fought for its life in Great Britain. All over the kingdom, in spinning and weaving mills, pumping stations, factories of all kinds, many rolling mills of the largest size, nothing was used but the Lancashire boiler. But with the new light all this was changed, and we had not only the electrical experiment, but the steam generating experiment as well, and it is not remarkable that the results were not always quite satisfactory.

It would not be fair, however, to attribute the adoption of the locomotive type or the water-tube boiler either to caprice or theoretical knowledge alone. No doubt installations were often constructed under circumstances that rendered it next to impossible to use anything but the water-tube boiler. There are places in the Andes where no part of a steam engine or boiler must weigh more than 200lb. Everything has to be carried on mule back. There are places in great cities into which it is equally impossible to convey any large structure. For such places the sectional boiler is simply invaluable. But this scarcely suffices to explain the favour which the locomotive type of boiler enjoys. It is not because only such a boiler can be forced, and other reasons must be found for its adoption. That it requires no brickwork, and is an excellent steam maker, are no doubt points very much indeed in its favour; but, when all this has been said and admitted, we have still to face the fact that for places were large demands are made for steam, day after day, nothing is so popular as the Lancashire boiler, or its modifications.

Those who can read the signs of the times know that the production of electricity on a small scale in numerous establishments will have to give way to its manufacture wholesale, on a great scale. That which has become possible at Beckton with gas may become equally possible with electricity. The question will then force itself on engineers, What is the best method of manufacturing steam? It is not wise to prophecy until after the event. Yet we are rash enough to say that probably the Lancashire boiler will be used in conjunction with mechanical stokers, the smallest possible amount of manual labour being employed. In settling this question it must not be forgotten that the demand for power becomes more and more uniform the larger the installation, and, consequently, the wider the district served. "The peak" does not occur, for instance, in all existing metropolitan installations at the same hour. This consideration will have an important influence on those who have to select the type of boiler to be used. Furthermore, the heat storage system introduced by Mr. Druitt Halpin may modify conditions of service very considerably. In saying this we do not wish, as we have said before, to be understood as finding fault with any particular type of boiler. Our object is to record what may be termed the drift of public opinion. It does not follow that we regard the water-tube boiler as inferior to the Lancashire if we state as a fact that mill-owners prefer the latter, and that electrical engineers in taking to the former have departed from precedent. The doubt and hesitation which exist are fairly well exemplified on a small scale at Islington, where Mr. Gay has put down both Lancashire and water-tube boilers almost side by side. It must, too, be borne in mind that nearly all the electric light stations in this country are comparatively young, and few opportunities have yet been afforded for testing the actual life of a boiler. Our purpose will have been served if we have succeeded in directing the attention of our readers interested in the manufacture of electricity to the fact that a considerable departure from normal manufacturing practice has marked the progress of the electrical engineer, and that many more things than the production of steam have to be thought of when ordering a boiler.

THE REGULATION OF PRESSURE AND THE REDUCTION OF LIGHT LOAD LOSSES IN ALTERNATING CURRENT SYSTEMS OF ELECTRIC SUPPLY.

The following is an abstract of the discussion which followed the reading of Messrs. E. W. Cowan and A. Still's Paper before the Northern Society of Electrical Engineers (see *The Electrician*, April 3, 1896, p. 762):—

DISCUSSION.

Mr. RIDER said he should, first of all, say that he had listened to that Paper and read it with deep interest. So far as the first part of the Paper was concerned, in dealing with the regulation of pressure, he was fully in accord with the authors. In the "Thomson" diagram the size of the feeder which worked out as most suitable for that particular current came up to 19/14. Taking the maximum current at 71 amperes, which was given in the Paper, that came to about a density of 750 amperes per square inch, which was a very safe working current for a feeder. He fully agreed with the statement that the size of the feeder should be determined by the current it had to carry, and that the drop should not be taken into account at all, as by the Thomson law the loss per mile due to the drop increased in the same ratio as the cost of the feeder. With regard to the regulation of the feeders, the method the authors had drawn their attention to was one which he (Mr. Rider) was at present using, and he could speak of it in the highest degree. He would like to point out that it was only applicable, and could only be used to keep the pressure at the feeding points absolutely constant when the different feeders and networks were distinct from each other. If they had one network and two feeders feeding at different points, they could not keep the pressure exact at

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those two feeding points under such conditions. They would have to cut the network, each feeder would have to serve its own network, and not be connected with any other. They then came to the second part of the Paper. He was afraid that there was a good deal of debatable matter in it. A scheme which he (Mr. Rider) was putting down had been mentioned, that was of using accumulators in connection with a motor-alternator. He was not at present able to give any figures, because they had not started, but the Society must get his successor to give them a Paper, and he would no doubt tell them more truth about it than he (Mr. Rider) would. The various points brought before them wanted very carefully thinking about. It was recommended that for a light day-load plant a separate steam pipe should be used. He presumed that it was meant that the main steam range should be cut off during the day. If they turned the steam on suddenly to a large steam ring they ran the risk of breaking the joints. He believed in having steam on right up to the stop-valves of the engines the whole of the time, otherwise they might have a big smash. The scheme which was brought before them for reducing light-load losses was no doubt very interesting, and the figures which were given were very plausible, but he could not altogether see through them. The authors mentioned that they found a saving of 17 per cent. in the horse-power when running through this augmentator, having the engine speed reduced two-thirds, that was 17 per cent. of saving; it was not 17 per cent. of the full horse-power of the engine. Supposing the engine was 100 H.P. it was a very bad plant if it took 20 H.P. to drive it at light load. If they took 17 per cent. of the 20 H.P. it only brought them to about 3·4 horse-power, which was not a very great saving. He thought the best way would be to put in a much more efficient plant, say an open coil alternator with no iron in the armature rather than using one with heavy losses. Surely if an alternator with no iron in the armature was awkward to run parallel with the iron cored machine which they had at heavy load, that difficulty would only come in at the time of paralleling to change over, as the small plant then could be stopped. It was suggested that the governors of the engines should be arranged so that they would give the variation of speed mentioned. He wished to see the governor which would enable them to alter the ratio one-third and still have a good range of governing. He thought if they had governors which would give an adjustable range of 5 per cent. they were good governors. This method of reducing losses only took into account the losses at the station, and did not affect the losses outside—in fact, they were going to increase the losses outside, and when their station became a large one, and the number of transformers very large, that method would be in a still worse place, because heavy losses would be going on all the time outside. With regard to the question of altering the frequency of arc lamps and meters. Last year at Bolton they reduced the speed of the whole of the plant 17 per cent., not on account of the alternators, but for reasons which were purely mechanical. They brought the periods down from 100 per second to 83 per second. They had a number of arc lamps in the town, and they had not to alter the regulation of a single one—in fact, they burnt better. With regard to the meters, some of the meters were made for 100 periods, and he thought that some of them would be reading a bit out at the reduced periods. He made careful tests, and put in series with these meters other meters specially made, and he found practically no difference at the end of the quarter, taking the ordinary working load on the meters. They were Chamberlain and Hookham and Shallenberger meters. The Paper said that as there were no alternating-current motors in use they need not be taken into consideration. He (Mr. Rider) said alternating-current motors were in use in many stations, and if a station had only one motor in use, the result of such a procedure as lowering the speed of the plant every day would be to damn the system.

Mr. MORDEY said before speaking on the Paper he wished to be allowed to say a word of explanation. In the report of their last meeting he read that the President had done him the honour to regret his absence, and that the author of the Paper, Mr. Hammond, did him a similar honour. The fault was scarcely his. He was not a member of the Institution, he had had no notice of the meeting nor copy of the Paper, either from the Society or from the author, nor had he been invited, so that he could hardly have been expected to be present. With regard to the matter before them, he wished to join in congratulating the authors on the Paper, which was an excellent one—he wished they had more such papers in London. A great many points were touched on, but he must confine himself to a few of them only. With regard to the first paragraph, he quite agreed with the plan the authors advocated, and which was shown in Fig. 4. It was a very good one, and one which in many cases had advantages. The Brush Company used it a great deal. He thought it was Mr. Dawbarn of his Company who first introduced it, and they found it convenient and simple. Ideas as to "banking" transformers had changed; they did not get very much advantage if they used transformers above a certain size. In a 12 or 15 kilowatt transformer they got a no-load loss of between 0·75 and 1 per cent., and no matter how large the transformer might be the loss did not go much below that, so that there was no advantage in efficiency in having very large ones. And as to the cost, the lower price per kilowatt of larger transformers had to be set against some extra cost in mains and inconvenience in handling. It might be hypercritical, but he wished to object to the capacity current being spoken of as being in advance of the E.M.F. He knew it was the universal way, but it was wrong; it gave a wrong impression. The ordinary, or he might say, the general explanation given of the difference between self-induction and capacity was that self-induction caused the current to lag behind the E.M.F., while capacity caused it to lead or be in advance of the E.M.F. He once heard an eminent Professor explain that self-induction was something that when the E.M.F. was applied delayed the flow of current, while capacity was something which sucked the current out before the E.M.F. was applied. This amounted to saying that the effect preceded the cause. In the interests of clearness of perception of the physics of the matter, he wished to protest against this way of speaking of the effect of capacity. What really happens is that the current is caused to lag still more by capacity than by self-induction—the capacity current lags so much behind the wave of the E.M.F. producing it that it is just in front of the succeeding E.M.F. wave. For mathematical purposes it may be convenient to consider it as in advance of the E.M.F., but it must be remembered that this does not correctly represent the fact. Instead of saying it was a quarter period in advance of the E.M.F. it would be physically more correct to say that it was three-quarters of a period behind the E.M.F. The authors alluded to an excellent method of regulating shown in the various diagrams 3 and 4. He thought that the arrangement of the Manchester Company or of Mr. Rider was an excellent one; it did not differ in principle from what had been seen before, but he thought it was the most practical way of applying the principle. With regard to the saving of power when the pressure was raised by apparatus of that sort, he might mention a fact from his own experience. In one station with which he was acquainted it was necessary to raise the volts. He found, on going into the question as to whether there would be a loss of power, that there was a saving of power. He found that by raising the volts by an augmentator the actual power absorbed by the alternator and the augmentator was less than by the alternator alone if worked up to the full E.M.F. He mentioned that as illustrating the effect of the apparatus which was called a "hitcher-up." There was another point in connection with "hitching-up" which was perhaps of some interest. There had been a good deal of discussion as to whether they ought to have self-induction or not in alternators. He had always thought the less they had of it the better. If for no other reason, for the very sufficient one that it spoiled the "characteristic" of a machine, and made regulation troublesome and difficult. When working normally there was no need for self-induction, but there were perhaps certain abnormal conditions under which self-induction might be of service, if the required effect would not otherwise be obtained. For sample, they had two alternators without self-induction, and put them in parallel when they were out of phase, causing a more or less violent shock under current. If they had attempted to lessen the shock by giving the machines a good amount of self-induction they would lessen the shock, but the machines would regulate badly; they would have a large drop in the E.M.F. when the load was increased. With an augmentator, however, with the fine wire across the mains, and the thick wire in series with the alternator, they had self-induction, but it was only self-induction when the machines were out of step. At other times it had no effect on the regulating qualities of the machine. This was a valuable feature in his opinion, in connection with the use of augmented alternators. An important matter was raised by the proposals to reduce the losses in alternators at light load. He rather agreed with Mr. Rider's criticisms on the proposals. He thought the whole point of the diagram No. 7 was that the machine was an unfortunate one for the purpose. He did not mean to say that it did not illustrate the proposal well, but he was quite sure that the authors would not put it forward as a machine that had other good qualities than that of showing the need for reducing its no-load losses. He was rather in favour of reducing the engine losses at light load than the alternator losses. Of course, engines could not be run with very small loads, but in cases where it was necessary he thought that the losses even of a large alternator were so small that the probability of using a small engine should be considered in connection with some clutching device by which the alternator would be driven in the day time by the small engine and at night by the large one. He might illustrate what was said about the careful lagging of the cylinders by referring to a recent experience he met when he was carrying out a test. As the people who built the engines were very anxious to get good results, they had every door and window closed. He was assured by the man in charge of the engine that if they had the doors and windows open there would be a very perceptible increase in the amount of fuel consumed. He suggested that they might put the engine into the feed water tank, so that the lost heat might be recovered. He thought it was a mistake to suppose that a machine without iron in the armature they got such a very large current on short circuit. As a matter of fact, the current on short circuit with an armature without iron in it was not or need not be more than with machines with iron cores. In his own machines they always short-circuited the terminals with full steam on, and the current usually did not rise above three times, and he had never yet seen it more than five times the full working current. They had learned by experience that they must make machines to stand short-circuiting, and had had no difficulty in doing so without losing the good regulating quality which he thought, next to safety, was of prime importance to central station engineers. The first thing to have, after safety, was a machine with the smallest possible fall of potential and self-induction. Just one word before he concluded on the subject of reducing speed. If the authors would consider that the light-load dynamo under most circumstances was running a large number of transformers, and was fairly heavily loaded, even with no lamps on, he thought that they would see that a reduction in the speed was not advisable, because the total transformer loss would increase more rapidly than the alternator loss would diminish. This would be the case at least in stations where the day-load dynamo and engine were fairly proportioned to their load.

Mr. STATTER said with regard to diagram No. 2 he would like the authors to tell him why they limit the money to be spent on the feeder to the copper. It seemed to him that they ought to be able to spend as much per annum on the losses in their feeder as they incurred by way of interest on the total sum expended in materials and in the labour for laying the same, plus an allowance for depreciation in getting the current from point to point. He supposed that in central station work it was a very difficult matter to fix upon the size of conductor, because they did not know what the requirements in the future would be. But if Thomson's law was used at all, then 10 per cent.) the authors' figures for interest and depreciation) of the total cost of the feeder and of laying it should be plotted,

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instead of 10 per cent. of the cost of the copper and insulation only, as plotted by the authors.

Mr. WORDINGHAM said the first point he wished to refer to was with regard to the fourth method of distribution described in the Paper. He thought the authors were certainly right in saying that it was the most convenient and best way of distributing; at the same time, in case of a short on the mains all the fuses might go, and it would be a terrible nuisance to get them back quickly, and there would be a very serious interruption in the supply, whereas if they had the transformers in sub-stations they could very rapidly get their fuses replaced. He thought the position the authors had taken up about the most economical size of feeder quite unassailable. The current density, which had been worked out in that diagram, was about what he believed to be the best density they could find; it was about 750 amperes per square inch, which agreed fairly well with his own practice. He generally used 600 amperes. With regard to the device for showing the potential at the end of a feeder, which the authors said was largely used in America, he believed that that was due to Dr. John Hopkinson; that method was introduced and patented by him many years ago. He thought that that might be of interest to mention, as they did not like to get their ideas from America. The same consideration that occurred to Mr. Rider about the steam pipe occurred to him also; he did not think it was really practicable to shut off the main steam range for any part of the day, unless they were sure to have ample time to have it on again. If they had a sudden demand, and the range was shut off, the the result would be disastrous. He might say a word with regard to the reliability of ejector condensers. At the Manchester station they had them on all their engines, and they had never had the slightest trouble with them, and they had given excellent results.

Mr. NISBETT said he would like to protest against diagram No. 2, which in his opinion was entirely misleading, owing to the fact that the cost of laying the mains, armouring, making good the pavement, &c., had not been included. It was obvious that because these were standing costs, whatever size of mains you lay, they should not be left out, for when the main is worn out the armouring is worn out, and the trench is also worn out, and therefore depreciation on these should be added to that on the cable. This allowance would make the economical current density very much higher than the authors supposed. Taking the same example as the authors had done, viz., an average current of 26 amperes, adding to the cost of the cable that of the armouring and trenching, the economical section of copper would be 0·03 of an inch instead of 0·1, so that at heavy load that cable would be working at a density of 2,500 amperes per square inch. The authors, on the other hand, had taken the cost of energy lost in the cables at 1½d. per unit, whereas they had taken the energy lost in driving the pumping and other plant at something like ¾d. per unit, because they said the standing costs were not in such case chargeable. Of course the same reasoning applies equally to the losses in the mains, it being only the coal bill which is increased. If now they add to the interest and depreciation on the cost of the cable the amount due to the trenching, armouring, &c., and reduce the cost per B.T. unit lost in the mains to ¾d. instead of 1½d., it was at once obvious why Thomson's law was not more generally adopted, at any rate, for high-tension mains, for the law shows that the economical section is such that if it were used the mains would be red hot at load time every evening. There were one or two points in connection with the system of distribution marked D. He could not altogether see that it had many advantages over the system C. Mr. Wordingham had raised a point about the difficulty of getting at fuses in transformer pits. That was a very important one. The contacts on transformers were very apt to get loose. He considered the scheme with sub-stations far preferable. All the contacts could be seen and examined periodically with ease, and the facilities for switching transformers in and out as the load varies were better. Both systems, however, had their uses. Then the authors laid too much stress altogether on the amount of capacity current. They calmly talked about a capacity current of 10 amperes on a feeder. That would mean that the feeder would have to consist of 25 miles of 19/18 cable. He thought that they had put down to cables that which belonged to the transformers. He agreed with the authors as to the necessity for regulation on feeders, and the apparatus designed by them seemed to answer its purpose admirably. With regard to the remark as to the cost of pressure wires, these were not so great as the authors seemed to think, as a pair of pressure wires can be put into a high-pressure cable for about £35 per mile, which is not a very serious item. He did not agree with the authors as to the economy of injectors. He thought that they had rather contradicted themselves as he read it. Apparently they had overlooked the losses due to the condensation of steam and the necessary re-evaporation of the water; the pulsometer pump was an instance of that, and, although a useful form, he did not think anyone would say it was a more economical form than a barrel pump. It seemed to him that a good pump of the ordinary type, driven by an electric motor, was far and away better than any injector.

Mr. HESKETH said he thought that engineers at last saw the futility of seeking for an absolutely uniform day load, and the authors were now attacking the question at the right end in seeking instead for high efficiencies at low load. Certainly any central station engineer who settled down to solid work after hunting the phantom of a day load, would find that those little economies were very difficult to obtain—even more difficult, perhaps, than the day load. With regard to the question of boiler efficiencies, the efficiency of a boiler increases as the duty is lowered. He obtained about 9·5lb. of water per pound of coal when evaporating 9,000lb. of water, but reducing the evaporation to 6,000lb. of water he got 10½lb. of water per pound of fuel, showing a great advantage from not pressing the boilers, or using rather large boilers for low duty. As to cutting off the steam range, he found that the losses in the steam ring were getting very considerable, and tried the natural expedient of cutting it off during light load time, but unfortunately the cost of repairing joints was double the cost of keeping steam up There is also a great deal of loss in the use of feed water heaters. It is a very common practice to put a large feed water heater in the main exhaust pipe, and expect that they were going to get the full advantage of the whole of the heat units in the exhaust steam. That was a great fallacy. The same economy would be obtained by using the exhaust steam from their pumps to heat the feed water and condensing the main exhaust. If they so used the exhaust of their steam pumps, the losses in driving feed pumps by steam were not so great as they would at first appear. The steam taken by the centrifugal pump mentioned by the authors would not be 1 per cent. of the total steam taken by the engine, although its power might be 1 per cent., but the steam would be something between 5 and 10 per cent. The method of reducing engine losses by reducing the speed was rather drastic, and he would rather use an alternator without iron in the armature. They had one or two motors at Blackpool, and to alter the periodicity every day would cause such trouble that they would have no peace at all. One of the greatest requirements in central station working was absolute confidence of the consumers in the supply; and if they were going to vary their speed every day, of course the consumers would never put up with it. As regards the low-tension distribution in scheme D, he said that they had experimented with short circuits recently at Blackpool to see the effect, and found that the fuses acted immediately, and cut out the faulty section.

Mr. LINDLEY said that on the question of the reduction of the speed he thought that, apart from the difficulty with the springs which Mr. Rider had foreshadowed, there was the difficulty that they would have to stop the engine to alter them again before it could be put in parallel with the other machines. He would like to suggest what might be done to meet that difficulty. It was not advisable to reduce the speed of the engine providing you could put up with having the alternator running at its full speed. The whole thing really centred on how much they could reduce the power of a compound engine without seriously falling off in the economy; this in a suitable engine should be one-fifth of full load, and then there would be no necessity to reduce the speed of one of the smaller units in order to operate the day load with economy. He might suggest to Mr. Mordey, who had been kind enough to offer to teach them something about putting engines into the feed water tank, that he, Mr. Mordey, might have put the steam pipes in also, so that they would get a higher efficiency still.

Mr. STILL said, in reply, that Mr. Cowan and he had been prepared to meet with a good deal of opposition, as there was no doubt they had laid themselves open to attack from various quarters. The way in which the Paper had been received was a very agreeable surprise, and he wished to thank those present, both on his own behalf and on Mr. Cowan's, for the kind way of which they had spoken of it. He proposed to reply to the points raised in the first part of the Paper, and Mr. Cowan would then deal with the second portion. He was glad to learn that Mr. Mordey had found the system of distribution shown at D in every way satisfactory; it certainly seemed to him very superior to the system of sub-stations with a heavy low-pressure network, which, neither from the point of view of economy or of regulation, made proper use of the many advantages of a high-tension supply. With regard to Mr. Wordingham's remarks, that in the case of a short circuit all the fuses might blow, this was only applicable to the case in which all the secondaries of the transformers are connected in parallel, by closing the switches marked S, which would most decidedly be the wrong thing to do. In reply to Mr. Statter, and notwithstanding Mr. Nisbett's great confidence in his own assertions on the subject of Thomson's law, it is quite evident that in working out the most economical cross-section of a feeder, the capital cost we have to consider is only that portion of the total capital outlay *which depends upon the amount of copper in the feeder.* Mr. Nisbett admitted that the laying of the mains, making good the pavement, &c., were standing costs, and did not depend upon the size of the cable, and this was the assumption which has been made in the Paper; but Mr. Nisbett still thought that the amount of these costs should determine the size of the feeder. Why then should he stop at the culverts and trenches and not include transformers and sub-stations, or even the cost of the generating station itself. The wearing out of the culverts or pipes and the cost of keeping these in order was a question of the choice of the system, not of the exact cross-section of the cable to be used. If the extra labour of drawing in a heavy cable is worth considering it should undoubtedly be taken into account, as also should the *increased* cost of the culverts, &c., if these have to be made larger in size as the cable increases in weight. The most convincing argument of all in support of their contention, that though capital costs which are constant cannot affect the economical size of the cable, was one which every mathematician would appreciate at once. In order to obtain the minimum value of any quantity which is a function of another variable quantity, he differentiates both sides of the equation, and since the differential coefficient of a constant is zero, there could be no trace of this constant left in the differential equation, and it was therefore quite impossible that it should influence the size of the feeder. Mr. Nisbett mentioned excessive temperature rise as a possible limit to the size of feeders worked out on Thomson's law, but in practice this was not found to be the case, and for that reason it had not been referred to in the Paper. If a dangerously high temperature were likely to occur at times of full load, two or more cables would have to be laid side by side, or the cross-section of the single cable increased, according to which method proved to be the most economical. Mr. Nisbett also spoke of feeders as being buried in the ground, but this was bad practice; they could always be drawn into pipes or laid in culverts, where they were easily accessible, and could be added to when required. With regard to the 10 amperes of capacity current referred to in the Paper, this was merely assumed in order to work out an example, but as a matter of fact a capacity current of 8 to 10 amperes, or even more, was by no means impossible or unheard of, and Mr. Nisbett seemed to forget the existence of rubber-insulated cables, which, with their

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thin dielectric of comparatively high specific inductive capacity, took far more capacity current than paper-insulated cables. The current due to the capacity of the cables was a totally different thing to the magnetising current of the transformers, and there could be no confusion between the two. Mr. Mordey, on the subject of capacity current, objected to its having been spoken of as a quarter-phase in advance of the E.M.F. This, however, was the usual way of expressing what was really the truth, and the question was, after all, only one of the choice of terms. There were, undoubtedly, two ways of expressing one and the same thing, and it was, of course, quite correct to speak of the current as lagging three-quarter phase behind the E.M.F., but when dealing with the phase differences between two periodically varying quantities, there was no beginning and no end to be considered, and the displacement of one of these quantities with regard to the other could surely be expressed with equal accuracy either by stating the amount by which it was in advance of the other, or by the amount by which it lagged behind.

Mr. COWAN, in reply, said that Mr. Rider, Mr. Wordingham and Mr. Nisbett had all criticised the suggestion that steam ought to be cut off the ring main during the hours of light load, as they did not believe it was practical on account of the failure of joints likely to arise. If that was the case, why was it that cylinder cover joints did not give similar trouble? He thought that if the joints were properly made and the steam pipes properly suspended, such trouble ought not to occur. Of course great care must be exercised in admitting steam to a comparatively cold range of pipes, in the matter of draining, &c. It could not be done in a hurry. There seemed to be considerable doubt in the minds of many of the speakers as to the advisability of reducing the speed of the engine. Mr. Mordey and Mr. Lindley seemed to think that the object was to save losses in the alternator. This was not so; the saving effected was only in the engine, nothing was saved in the alternator. A good deal was made of the increased losses in the transformers which would, of course, arise with the lower frequency. This point had been, he submitted, effectually answered in the Paper. When the time came, when the day load plant was loaded with a very large number of transformers, the only saving in the reduction of speed might be in "wear and tear," and it might not be considered worth while to continue the practice. He did not think there would be any great difficulty in designing a governor which could be adapted to control the engine at two different speeds. The tension of the springs should not be altered, but the leverage at which the weights acted; and the alteration must, of course, be made by hand without stopping the engine. Mr. Lindley preferred an engine which gave nearly equal economy at all loads, from one-fifth to full load. But the question was not one of thermodynamic efficiency only, but *brake horse-power* compared with steam consumed. An engine which gave nearly equal economy at from one-fifth I.H.P. to full load was the right kind of engine to install for light load, but the saving due to reduction of speed was effected with that engine as well as with any other. On the question of the results of the reduction of frequency from the consumer's point of view, the only point raised was the effect upon motors. In reply to that he would only say that he held the opinion, and always had held it, that motors were unfit for lighting circuits, especially alternating-current motors, with their large idle current. He prophesied that if motors became popular the electric light would become unpopular. It was impossible to regulate properly with alternating-current motors on the circuits. Having come now to the proposed method of reducing the alternator losses, viz., by halving the induction, he was glad to have Mr. Mordey's support as to the saving being an undoubted fact. At the same time, Mr. Mordey had misunderstood Diagram No. 7, the curves on which were drawn to show that the losses in alternators varied nearly with the square of the induction. The plotted experiments were made with an iron-cored alternator, but experiments with Mr. Mordey's own alternator would follow the same curves; indeed they would approximate more nearly to the true parabolas drawn, because the hysteresis loss peculiar to an iron-cored alternator did not vary quite as the square of the induction. The objection to Mr. Rider's suggestion of putting an alternator down for light load which had no iron in the armature was chiefly its first cost; they thought it important to save the first cost and space occupied by a special light load plant. Mr. Rider seemed to think that 3·4 H.P. was hardly worth saving—it was more than that—but even 3 H.P. or 4 H.P. for 16 hours a day for 365 days in the year cost an appreciable amount, and was certainly worth saving in a small station. Mr. Mordey said that it was possible to design his alternator to give on short circuit no more current than an iron-cored. Quite so—but what, then, became of the characteristic? It was possible also to design an iron-cored alternator with as good a characteristic as Mr. Mordey's—at a price. Mr. Nisbett thought that they had overlooked the losses in an injector due to condensation of steam. He thought Mr. Nisbett had hardly done justice to the remarks made under this heading in the Paper. They had given a great deal of consideration to the whole subject, and had come to the conclusion that nothing but careful and authoritative experiment could settle the point. They had looked up crowds of references, but had been unable to find any reliable results of experiments. He would ask Mr. Nisbett to reconsider the question, bearing in mind that all the heat in the steam went back into the boiler. Mr. Still had replied very fully to the criticisms of Thomson's law, but there was one point—Mr. Nisbett contended that if ¾d. per unit was taken as the cost of the energy consumed by the auxiliaries, that 1½d. ought not to be taken when considering the effect of the losses in the mains, but ¾d. The two problems were, however, entirely different. In the first instance the question to be settled was whether to drive the auxilliaries by the main engine. The main engine was running in any case, and therefore for the purposes of comparison, its standing losses would not be taken as chargeable against the auxilliaries, whereas the standing losses of a separate plant must be. That was surely good logic. But in the case of the losses in the mains the problem was different. There was no alternative to consider, and all losses as in meter shunt transformers, mains, &c., should be charged at the full works cost, including fuel, oil, wages, &c., based upon the output registered by the station, not the consumer's meters.

Mr. FAWCUS said that in rising to propose a vote of thanks to Mr. Cowan and Mr. Still for their Paper, he would just make only one remark about the steam pipes. He was rather surprised to hear Mr. Rider and Mr. Hesketh tell them that they could not keep their steam pipes tight, and he pointed out that there were thousands of plants where the steam was shut off every day. If electrical engineers could not do what steam engineers could, they had better learn.

A METHOD OF MEASURING THE LOSS OF ENERGY IN HYSTERESIS.*

BY G. F. SEARLE, M.A.

The extensive employment of transformers in the distribution of energy by alternating electric currents has caused the measurement of hysteresis in iron to become a matter of such commercial importance as to stimulate efforts to find a means for readily testing iron as to its quality with respect to hysteresis. The subject is important not only commercially but also from the purely scientific point of view, for it can hardly be doubted that our knowledge of the molecular structure of iron would receive some extension if a means were provided by which the effects of various physical conditions—stress, temperature, the passage of electric currents, &c.—upon the loss of energy in hysteresis could be investigated with a comparatively small expenditure of time.

As is well known, the loss of energy occasioned by any cyclic change in the magnetisation of iron is equal to $\int \mathrm{H}\,d\,\mathrm{I}$ in ergs per cubic centimetre of iron per complete cycle, H denoting the magnetic force and I the intensity of magnetisation, both in C.G.S. units. The waste of energy, $\int \mathrm{H}\,d\,\mathrm{I}$, I shall denote by W. The value of $\int \mathrm{H}\,d\,\mathrm{I}$ may be obtained by plotting in a curve the simultaneous values of H and I from a numerous series of observations, and then measuring the area of the curve. Or again, since, if B is the magnetic induction, we have $\mathrm{B}=\mathrm{H}+4\pi\,\mathrm{I}$, so that

$$\mathrm{W}=\int \mathrm{H}\,d\,\mathrm{I}=\frac{1}{4\pi}\int \mathrm{H}\,d\,\mathrm{B} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

(for $\int \mathrm{H}\,d\,\mathrm{H}$ vanishes when applied to a cyclic change), it follows that the hysteresis loss may be determined by plotting and measuring the curve given by simultaneous values of B and H. To obtain any satisfactory curve at least a dozen simultaneous observations of H and B are needed.

I have striven to design a method which should enable the hysteresis loss to be determined by a single observation of the "throw" of a spot of light along a scale. The method was far from being perfected when this communication was made to the Society on November 11, 1895, but it has been represented to me that though at present imperfect it is of sufficient interest and promise to justify its finding a place in the Society's pages.

A bar of iron of cross-section A is placed in a solenoid wound with N turns of wire per centimetre of its length. The current C which flows round the solenoid and magnetises the iron, also passes round the fixed coils of a sensitive electrodynamometer. A secondary coil of n turns is wound over the iron, and is connected in series with the suspended coil of the electrodynamometer, the resistance of the secondary circuit being R. When the primary current C changes, the magnetic induction B changes, and an E.M.F. $A\,n\,d\,\mathrm{B}/d\,t$ is set up in the secondary circuit. If the time-constant of the secondary circuit is very small compared with the time of a complete cycle, the effects of self-induction may be neglected, and then there is a current γ in the secondary circuit of amount $\gamma=\frac{\mathrm{A}\,n}{\mathrm{R}}\frac{d\,\mathrm{B}}{d\,t}$. Now the relation between C and H is expressed by $\mathrm{H}=4\pi\,\mathrm{N}\,\mathrm{C}$, so that $\mathrm{C}=\mathrm{H}/4\pi\,\mathrm{N}$. Hence, if the couple experienced by the suspended coil when a current i_1 flows in it and a current i_2 flows in the fixed coil is $q\,i_1\,i_2$ ergs, the couple experienced by the suspended coil at any instant due to c and γ is $q\,c\,\gamma$ ergs, supposing that the deflection is not so large that the value of q is appreciably different to its value in the equilibrium position.

Now, if the time of vibration of the moving coil is so great compared with the time occupied by the double reversal of the current that this process may be regarded as completed before the coil has moved sensibly from its equilibrium position, the angular momentum acquired by the coil for a single double reversal of the primary current is

$$\mathrm{K}\omega=\int q\,\mathrm{C}\,\gamma\,d\,t=\frac{q\,\mathrm{A}\,n}{4\pi\,\mathrm{N}\,\mathrm{R}}\int \mathrm{H}\frac{d\,\mathrm{B}}{d\,t}d\,t=\frac{q\,\mathrm{A}\,n}{4\pi\,\mathrm{N}\,\mathrm{R}}\int \mathrm{H}\,d\,\mathrm{B}, \quad . \quad (2)$$

where K is the moment of inertia of the coil and ω its initial angular velocity. Thus, since $\int \mathrm{H}\,d\,\mathrm{B}=4\pi\,\mathrm{W}$, we have

$$\mathrm{W}=\frac{\mathrm{N}\,\mathrm{R}}{q\,\mathrm{A}\,n}\,\mathrm{K}\omega \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

* Paper read before the Cambridge Philosophical Society.

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Let T be the time of the complete vibration of the coil, θ it greatest angular displacement or "throw" and η the restoring couple exerted by the suspension per radian of displacement. We have, by the conservation of energy,

Initial kinetic energy = Potential energy at extremity of swing, so that

$$\tfrac{1}{2} K \omega^2 = \tfrac{1}{2} \eta \theta^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Also

$$T = 2\pi \sqrt{\frac{A}{\eta}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

From (4) and (5) we find

$$K\omega = \frac{\eta \theta T}{2\pi}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Thus from (3) we have

$$W = \frac{N R \eta T}{2\pi q A n} \theta. \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The quantity η/q is easily determined as follows:—

Let currents i_1, i_2 flow in the suspended and the fixed coils of the electrodynamometer respectively, and let ϕ be the observed steady deflection, then

$$q\, i_1 i_2 = \text{couple} = \eta \phi, \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

so that

$$\eta/q = i_1 i_2/\phi.$$

If there is any appreciable damping, the expression must be multiplied by $1+\frac{1}{2}\lambda$, where λ is the logarithmic decrement. We have, finally,

$$W = \frac{N R T i_1 i_2}{2\pi A n \phi} . \theta (1+\tfrac{1}{2}\lambda). \quad . \quad . \quad . \quad . \quad (9)$$

Thus the "throw" of the coil is proportional to the energy lost in hysteresis.

It is evident that this affords a very ready means of testing the hysteresis of iron under different physical conditions for a given maximum value of H, the magnetic force, for all that has to be done after the constant of the instrument has once been determined is to observe (by means of a mirror and lamp and scale) the throw produced by a single double reversal of the magnetising current. For instance, a steady electric current may be maintained through the iron, and the value of W for each value of this current may be determined by simple observation of the "throw" in each case. If it is desired to investigate these effects for a given maximum value of B, the magnetic induction, the process is a little more complicated, because the value of B has to be found by the ballistic galvanometer method, and the strength of the magnetising current so adjusted on each occasion that the value of B may be kept constant under the varying conditions imposed upon the iron.

In the electrodynamometer which I have constructed for this experiment, the suspended coil is a long narrow coil of 120 turns, about 8cm. long and 1·5cm. wide, suspended by a silver wire $\frac{1}{1000}$in. in diameter. The fixed coils have 500 turns and are designed so as to fit closely round the suspended coil. With 1,285 turns in the secondary coil and with the resistance in the secondary circuit about 100 ohms, the instrument is sensitive enough to measure the hysteresis loss in the case of iron wire 0·02 sq. cm. in cross-section. I have made the instrument sufficiently sensitive to measure W for so thin a wire with a view of investigating the effects of tensile and torsional stress upon the hysteresis.

Up to the present (December 3, 1895) I have not been able to make any accurate determinations, owing to the fact that I have so far used an ordinary rocking mercury key for reversing the primary current. With this key, on breaking contact, the primary current is stopped very quickly, and when contact is re-established, the current very quickly rises to its full strength, and each of these changes takes place in a time not very large compared with the time-constant of the secondary circuit. On account of this the instrument has given results about 100 per cent. too large, as judged by the value of W obtained by a B-H cycle. When, however, a coil with a large coefficient of self-induction was inserted in the primary circuit, so that in spite of the key the primary current could not vary rapidly, the discrepancy was reduced to about 5 per cent. But I have designed a key (somewhat after the fashion of Prof. Ewing's "Sine Function" key) which will allow the current to be quite gradually reversed, and some preliminary observations have led me to expect that with this key the instrument may work quite satisfactorily.

Note added December 18, 1895:—The following method of determining the constant of the instrument is much more convenient than that described in the Paper. Let a constant current, C', flow in the primary circuit, and while this current is flowing suddenly produce a known charge, P, in the number of lines of magnetic force passing through the secondary circuit. This is conveniently done by suddenly inverting an "earth inductor" which has been placed in the secondary circuit. The time-integral of the current thereby produced in the secondary circuit is P/R, and thus the initial angular momentum of the suspended coil is

$$K\omega' = \frac{q C' P}{R}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

where ω' is the initial angular velocity.

But, if θ' is the "throw" produced, we have by (6) $\omega/\omega' = \theta/\theta'$, so that by (3) and (10)

$$W = \frac{C' P N \theta}{A n \theta'}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Two determinations of $C' P N/A n \theta'$ on two different days agreed to within 0·5 per cent.

The reversing key mentioned in the Paper has been constructed, and measurements of the hysteresis for a specimen of steel wire have given results agreeing, within the limits of accuracy of the observations, with the values obtained by B-H cycles. For very soft iron in which the maximum value of $d\,B/d\,H$ is over 8,000, and six times its average value, there is still a difficulty due to self-induction when a single wire about 0·01 sq. cm. is tested. But I hope to overcome this difficulty shortly.

PHYSICAL SOCIETY.

At an ordinary meeting of the Physical Society held on March 27, 1896, Prof. Carey-Foster, Vice-President, in the chair, Prof. J. A. Fleming read a Paper on

"The Edison Effect."

The Edison effect alluded to in the title of the Paper is that if a metal plate is placed inside the loop of an incandescent lamp, then a galvanometer, of which one terminal is connected to this metal plate and the other to the positive leg of the lamp, will indicate a current passing from the leg to the plate. If, however, the galvanometer is connected to the plate and the negative leg no current passes.

Prof. Fleming, by connecting the poles of a condenser (1) to the two legs, (2) to the plate and positive leg, and (3) to the plate and negative leg, and in each case discharging the condenser through a galvanometer, has shown that after the lapse of a certain time, depending on the position of the plate, if the lamp is working at about 4 watts per candle, the potential of the plate falls to that of the negative leg. If the plate, instead of being inside the loop of the filament, is outside, then the time taken by the plate to acquire the potential of the negative leg is considerably longer.

The space between the plate and the negative leg exhibits a kind of unilateral conductivity, for a battery having a low voltage is able to send a current from the plate to the negative leg, but not in the opposite direction. If, instead of using a cold metal plate, a second filament, maintained in a state of incandescence by an insulated battery, is used, then a current can be obtained between this filament and both the positive and negative legs.

If the voltage on the lamp is raised considerably above that required to give 1 c.p. for 4 watts, then a current can be passed from the plate to the negative leg, while a galvanometer connected to the positive leg and the plate will indicate the passage of a current from the positive leg to the plate. When the lamp is in this condition the space between the plate and the negative leg is very sensitive to the effects of a transverse magnetic field, such a magnetic field causing a large increase in the resistance.

The curve showing the connection between the current passing from the positive leg to the plate and the volts between the terminals of the lamp is found to be discontinuous. As the volts are raised the current suddenly increases about tenfold, and it is while the lamp is in the condition corresponding to this upper portion of the curve that it is sensitive to the influence of the transverse magnetic field.

By using a movable plate it has been found that the minimum current is obtained when the plate is nearer the positive then the negative leg.

When an alternating current is used to supply the lamp, a continuous current can be obtained passing from the plate to either of the legs.

If a small platinum cylinder is placed surrounding each of the legs, then a current can be obtained between the cylinder and the positive leg, but no current between the two cylinders. The largest effect occurs when a cylinder near the end of the negative leg is connected to the positive leg. The author considers that his experiments show that the resistance of a vacuum tube to the passage of a discharge would be greatly reduced if the cathode is made incandescent.

Prof. S. P. THOMPSON said he would like to have some information as to the state of exhaustion of the lamps; whether this was such as is found in ordinary commercial lamps or whether it more nearly approached that used by Crookes. A great change in the conductivity, &c., took place at an exhaustion slightly greater than that ordinarily found in incandescent lamps. It would be of interest to vary the size of the cathode and to investigate whether the magnitude of the effects observed depended on the fall of potential per unit length along the filament. Another point was whether the position of the plate for which the effect was a minimum was the same for all lamps, or whether it changed with the volts and the length of the filament employed. Again, did the minimum occur at a certain

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fraction of the distance between the positive and negative legs or, as was the case in some of the phenomena observed by Crookes, at a definite distance from either of the legs. These points might be investigated by means of a lamp with a straight filament, where the fall of potential per unit length along the filament might be the same as with the loop-shaped filament, but the fall of potential per unit length in the vacuum would be different. The author's proposed experiment of heating the cathode by concentrating on it the rays of a lamp did not seem to him (Prof. Thompson) to differ materially from Crookes' experiment in which an incandescent wire heated by a current was used as the cathode.

Mr. SKINNER said that the heating of the cathode by means of a "burning-glass" could easily be carried out.

Mr. BLAKESLEY pointed out that it would be quite possible to produce an increase of the current by means of a magnet.

Mr. SERLE said that Prof. J. J. Thomson had shown that a magnet affected the conductivity of a gas.

Prof. FLEMING, in his reply, said that no doubt the effects were largely dependent on the vacuum in the lamps. The lamps employed were exhausted to the ordinary commercial vacuum. Since it was found that the "treating" was more worn off the negative leg of the filament, and that a screen placed between the legs of the filament was more blackened on the side turned towards the negative leg, it would appear that the particles of carbon were shot off from the negative leg, and hence perhaps the charge was carried by these carbon molecules.

A Paper of a purely mathematical character, entitled "**Notes on the Electro-Magnetic Effect of Moving Charges,**" by Mr. W. E. MORTON was read by Mr. SERLE, who also made some remarks on his own investigations dealing with this subject. The Society then adjourned till April 24th.

CORRESPONDENCE.

THE ATKINSON REGULATING TRANSFORMER.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of April 3rd is published an interesting Paper by Messrs. Cowan and Still on "The Regulation of Pressure and the Reduction of Light Load Losses in Alternating Current Systems of Electric Supply." For the purpose of regulating the feeder pressures the authors describe the use of a regulating transformer, illustrated in Fig. 3 VI. and Figs. 4 and 4A. The authors give what purports to be an historical sketch of the genesis of this class of regulator, and show the advantages possessed by the type adopted by them, but omit to mention that the type of regulating transformer made by them was patented by the present writer in 1888 (No. 16 852), and a regulator of this class was first made by the author's then firm (Messrs. W. T. Goolden and Co.) in that year. The oversight is the more curious in that the Manchester Edison-Swan Company (Limited) have arranged to make these transformers under licence from the present owners of the patent, Messrs. Easton, Anderson and Goolden (Limited).—Yours &c.,

April 7, 1896. LLEWELYN B. ATKINSON.

Arc Spectra.—In the current number of the *Physical Review* Miss C. W. Baldwin describes some of her photographic researches in the spectra of different parts of the carbon arc, and in the effect upon these spectra of various alkalies introduced into the arc. Miss Baldwin was led to undertake these researches by the discovery by Prof. B. W. Snow that the curves of bolometric measurements of the carbon arc were materially changed by the introduction of the alkali metals. For example, while in the ordinary arc he had several very strong maxima in the ultra-violet and in the visible spectrum, he discovered that upon introducing the metals these intense regions disappeared, and strong maxima were now observed only in the infra-red. Miss Baldwin finds that many of the metallic lines are stronger nearer the negative carbon, and are weak or invisible at the positive carbon, while in others the brightness is uniform throughout, and in still others the brightness is a maximum in the outer sheath of the arc. These several characteristics are sometimes all noticeable in the lines of the same element. For example, in the calcium spectrum all the triplets of the second series of Kayser and Runge are strongest in the centre, while $\lambda = 3968\,63$ and $\lambda = 3737\cdot08$ and their companions, as well as certain other lines, are much stronger in the yellow part of the arc flame. Miss Baldwin appears to have exhaustively mapped the lines of the various parts of the arc spectrum.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.*]

SPECIAL NOTICE.—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations

NEW BOOKS AND EDITIONS.

The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices:—

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many origin illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables. 30s., post free.

"COMPREHENSIVE INTERNATIONAL WIRE TABLES FOR ELECTRIC CONDUCTORS."—By W. S. Boult, price 5s., post free.

TENDERS INVITED.—The Corporation of Sunderland are prepared to receive tenders for an evaporative tubular surface condenser, with air and circulating pumps. Specifications, &c., may be obtained at the office of the borough electrical engineer (Mr. C. S. Vesey Brown) at the electric supply station, Dunning-street, and tenders addressed to the Town Clerk (Mr. Fras. M. Bowey), Town Hall, must be in by 5 p.m. on Wednesday, the 29th inst. Our advertisement columns contain further particulars.

——— The Vestry of St. John, Hampstead, invite tenders for the supply, delivery and erection at the Central Station, Stoneyard, Lithos-road, Finchley-road, N.W., of a steam alternator, switchboard, steam and exhaust pipes, feed water heater, tank, and appurtenances, and these can be tendered for either as a whole or in part. The specification, &c., may be obtained after the 11th inst., at the offices of Mr. Arthur P. Johnson, Vestry Hall, Hampstead, to whom tenders must be sent not later than 4 p.m. of the 27th inst. Further particulars are given in our advertisement columns.

——— The Public Lighting Improvement Committee of St Helier, Jersey, invite communications from persons wishing to establish a lighting station in that town for the supply of electric, gas, or other forms of light for both public and private purposes. Communications should be sent to Mr. P. Baudains, Ecr. Constable, Town Hall, St. Helier, Jersey. Some further essential parti-

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culars will be found in our advertisement columns, and other information can be obtained on application to the Town Hall.

TENDERS INVITED.—The Bedford Urban Sanitary Authority invite tenders for the supply and delivery of vulcanised rubber cables. Tenders must be sent in to the Clerk, Mr. T. S. Potter, Town Hall, Bedford, by Tuesday, the 21st inst. Some further particulars appear in our advertisement columns.

——— The Commissioners of the township of Rathmines and Rathgar, Ireland, require tenders for the electric lighting of the new Town Hall and offices, for which about 250 lights with the necessary generating plant will be required; also for an installation of telephones and electric bells. Tenders to Mr. F. P. Fawcett, Town Hall, Rathmines, by 10 a.m. of Monday, the 20th inst.

——— The General Direction of the Roumanian Posts and Telegraphs require tenders for the supply of 60,000 porcelain insulators and 10,000 porcelain "buttons." Tenders, addressed to the Direction at Bucharest, must be in by the 18th inst.

——— The Harrogate Corporation require tenders for steel roofs, girders, &c., for their electricity supply station. Tenders to the Borough Surveyor, Mr. S. Stead, by the 13th inst.

——— The Wakefield City Council invite tenders for the building work in connection with the construction and erection of a chimney shaft and foundations and an electricity supply station. Tenders to the Town Clerk by the 22nd inst.

——— The Bedford Urban Sanitary Authority require tenders for the construction of five underground electric sub-stations. Tenders to the Clerk, Mr. T. S. Porter, Town Hall, Bedford, by the 21st inst.

TENDERS ACCEPTED.—The St. Pancras Vestry have accepted the tender of Messrs. Crompton and Co. for the supply of additional plant at the King's-road electricity station, including three engines and dynamos, steam pipe connections, switchboard, &c., for £6,456. 17s. 10d.

——— The Gas and Electricity Committee of the Bradford Corporation have decided to recommend for acceptance the following tenders for the supply of plant required for the new electric supply works:—

Epstein Electric Accumulator Co.... .	Batteries.
Cole, Marchent and Morley	Surface condensing plant.
British Insulated Wire Company	Cables.
Joseph Booth and Bros.	Travelling crane.
John Spencer	Steam and exhaust pipes.

——— The Huddersfield Town Council have placed orders for the supply of additional plant for their electricity station as under:—Babcox and Wilcox (Limited), two boilers; Messrs. Meldrum Bros., forced-draught apparatus; and Messrs. R. Stephenson and Co., surface condenser.

——— The Brighton Town Council have accepted the tender of the Reason Manufacturing Company for the supply of 500 switches for the incandescent lamps for street lighting at £487. 10s. Four other tenders were received, and the figures varied from £368. 15s. to £806. 5s.

LIQUIDATIONS.—At a meeting on March 25th it was decided to wind up Morris Brothers, Limited (electrical instrument makers) voluntarily. Mr. E. J. Abbott, C.A., Birmingham, has been appointed liquidator.

——— Claims against Fossick and Co. (Limited), makers of dynamo castings, &c., must be sent in to the liquidator, Mr. E. Lucas, 145, Cannon-street, E.C., by May 16th.

——— A meeting will be held at Messrs. Pratt and Norton's, 9, Old Jewry-chambers, E.C., on May 5th, to receive an account of the winding up of the Arcas Plating Company (Limited).

APPOINTMENT.—Mr. W. H. Woodall, who was for some time in the City of London Electric Lighting Company's employ at their Bankside station, has been appointed to succeed Mr. W. Bathurst as assistant to Mr. G. Cottam at the Hampstead electricity station. Between 60 and 70 applications for the post were received.

CORRECTION.—Mr. H. J. Dowsing, whose commencing in business as electrical engineer and contractor we notified last week, desires us to say that his address is 24, Budge-row, Cannon-street, London, and not 14, as incorrectly given in our last issue, from particulars supplied to us by Mr. Dowsing.

DISSOLUTIONS.—The partnership between Frederick Charles Allsop and Charles William Treacher, electric lighting engineers and contractors, of 165, Queen Victoria-street, London, E.C., has been dissolved. Debts by Mr. C. W. Treacher.

PERSONAL.—Mr. Wm. H. Booth has, we are informed, resigned his appointment as managing engineer for Messrs. Le Grand and Sutcliff, and has taken offices at 17, Shaftesbury-avenue, London, W., where he will carry on business in steam engineering, water supply, and electrical transmission of power, &c.

AGENCY.—Messrs. Mavor and Coulson, of 57, West Nile-street, Glasgow, have appointed Mr. C. R. G. Smythe, of 12, Idol-lane, E.C., their London agent.

BANKRUPTCY.—A first and final dividend of 1s. 10½d. in the £ is payable in the bankruptcy of Philip C. Pope, electrical engineer, of Hapton, near Burnley, at the Official Receiver's, Preston, on the 17th inst.

SCHUCKERT AND CO.—It is stated that Messrs. Schuckert and Co., of Nuremburg, are about to establish branch works in Vienna.

"CASSIER'S MAGAZINE."—The contents of the April issue of this magazine include "Electric Metal Heating and Working," by Joseph Sachs; "An International Standard of Screw Threads," by Thomas Mudd; "Power from Town Refuse," by F. W. Brookman; "American *versus* European Shop Practice," by Robert Grimshaw; and "The Evolution of the Horseless Carriage," by B. F. Spalding. The number also contains articles on "Sugar-Making Machinery in Cuba," "Floating Cranes and Derricks in Italy," "The Automatic Weighing Machine," "Power for a Modern Paper Pulp Mill," and "A Concrete Engine Foundation Block."

ABERDEEN.—The gas manager (Mr. A. Smith) and the electrical engineer (Mr. A. S. Blackman) have prepared a joint report on the extension of the electricity works. The report states that the capacity of the plant at the station is an equivalent of 8,400 8 c.p. lamps, but when the unit of plant on order is added they would be able to supply 11,600 lamps, and it is anticipated that by October next this number will have been applied for. Consequently they recommend that the buildings and plant be extended at an estimated cost of £10,000, and that various extensions of the mains be made at a cost of £9,500. Should the Council decide to carry out these extensions, the capacity of the station will be increased to an equivalent of 16,500 8 c.p. lamps, and, in addition, an adequate reserve will be provided.

"A GREAT TRAMWAYS SCHEME."—The *Pall Mall Gazette* is responsible for a wild statement "that a scheme is on foot which, if adopted, will revolutionise the tramway service of London and outlying districts. A powerful syndicate, consisting of tramway experts and financiers, has offered to take a lease of the existing lines from the County Council in order to consolidate the whole service, to make extensions and experiments, to apply mechanical traction throughout, and to offer the public greatly increased travelling facilities." So far the particulars given by our contemporary are as vague as anything even in an evening journal can very well be.

ASHTON-UNDER-LYNE.—On the recommendation of the Electric Lighting Committee, the Town Council have decided to appoint Mr. S. V. Clirehugh consulting electrical engineer.

BANGOR.—Lord Penrhyn is considering the question of lighting Penrhyn Castle electrically, and has applied to the Bangor City Council for the terms on which electric current would be supplied. At the last meeting of the Council it was decided, subject to certain conditions, to lay an electric light main to the Castle. Subsequently, the tenders recently invited for contracts Nos. 2 and 3 were opened, and were ordered to be submitted to the Electrical Engineer (Mr. F. H. Medhurst) for analysis and report.

BELFAST.—At the last meeting of the City Council the minutes of the Council in Committee stated that a system of electric traction would be of advantage to the city if an arrangement could be come to with the Tramways Company, and recommended that a committee be appointed to meet the Directors of the Company and report. The report of the Electrical Committee stated that, without making allowance for interest or sinking fund, there had been a profit of £385 on the electricity works for the past year. The minutes and report were, after discussion, approved.

BOLTON.—At the last meeting of the Town Council, on the motion for the approval of the minutes of the Gas, Electricity and Street Lighting Committee, a long and interesting debate took place on the question of the resignation of the borough electrical engineer, Mr. J. H. Rider. The electricity and gas works are in the hands of the Council, and one committee manages both departments. Mr. Councillor Proctor opened the discussion by expressing his regret at the absence of the chairman of the Committee. He regarded with considerable alarm the changing of their electrical engineer at this particular juncture, and said it must be a source of regret to every member of the Council that a gentleman who had served them so faithfully and so well was about to leave them. He strongly protested against the action of the Committee in refusing the electrical engineer's application for an increase of salary, while they proposed to pay his successor the very sum demanded by Mr. Rider. He thought therefore that an honorarium or something in the nature of an expression of regret at his departure should be presented to Mr. Rider. In the discussion which ensued, nearly every speaker testified to Mr. Rider's ability, and expressed regret at losing his services. The minutes were, however, passed by 23 votes to 16.

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BRIGHTON.—Electric light extensions are evidently the order of the day at Brighton. At the last meeting of the Town Council, the Lighting Committee submitted a report by the electrical engineer (Mr. Arthur Wright) with reference to borrowing additional money for electric light extension purposes. Mr. Wright gave figures showing the constant and rapid increase in the demand for current, and stated that it appeared likely that this rate of increase would be maintained. In 1894 the department sold 78,000 units, in 1895, 148,000, and in 1896, 228,000. These figures conclusively proved the soundness of the policy of constantly extending the mains, in arranging the tariff so as to enable small householders to avail themselves of the advantages of the electric light, and in gradually increasing the size and capacity of the generating station. Mr. Wright claimed that the cost of generating current in Brighton during the past year, exclusive of coal, was lower than that of any other town whose accounts had yet been published. £27,500 was now required for house connections, meters, extensions of mains, &c., and for additional plant in the supply station. The Committee recommended that application be made to the Local Government Board for sanction to borrow £23,000 on the Electricity Works Account for 25 years, and £4,500 on the District Fund Account for 15 years. Councillor Stafford, in moving the adoption of Mr. Wright's report, said it was so clear and comprehensive that it required very little explanation from him. The motion was seconded and carried unanimously.

CHELTENHAM.—On Friday, the 27th ult., Major-General H. D. Crozier, R.E., held an inquiry at Cheltenham into the application of the Town Council for the sanction of the Local Government Board for two further electric lighting loans amounting to £25,000. The present rateable value of the borough is £259,126, and the outstanding loans under the Sanitary Acts amount to £117,780. In the course of his observations, the Town Clerk said he did not know whether it was necessary to say anything as to the length of time over which the loan was to extend, but he hoped that the Local Government Board would give them 30 years. The Inspector remarked that the Local Government Board would do nothing of the kind, 25 years was the period now fixed for electric light loans. Alderman Norman stated that there were at present 6,200 8 c.p. lamps connected, and 700 lamps were waiting to be connected. The Inspector asked if all the extensions estimated in the £10,000 loan were within the authorised area of supply. It was stated in reply that they were, with one exception, which was an extension which had been made with the authority of the County Council to a residence taking 600 lights. The Town Clerk explained that he was aware that the Town Council had no legal power to do this, but that they did not ask the Local Government Board for any money in this connection, the outlay having been charged to revenue. General Babbage, as a ratepayer and owner, offered considerable opposition to the loan, his point apparently being that the Corporation should confine its operations to the compulsory area for which they obtained the original loan of £16,000, and not proceed to lay mains in other sections of the town until the compulsory area had been filled up; when they showed a profit on that part of the undertaking he would offer no opposition to the raising of further capital. Opposition was also offered by Col. Graham, who stated that when the electric lighting scheme was first brought up the ratepayers were not in any way consulted about it. There was no towns-meeting, and the ward representatives had not consulted their constituents on the matter. The Town Council had recently proposed to purchase the gas undertaking, but a towns-meeting having been called, the scheme was decisively negatived, and he thought it possible that a similar result might have taken place had a towns-meeting been called in connection with the electric light undertaking. At the conclusion of the proceedings the Government Inspector proceeded to inspect the electric light station and network.

CHURCH LIGHTING.—The Catholic Apostolic Church, London-street, Edinburgh, has been wired and fitted up for the electric light. The installation consists of about 160 incandescents of 8 and 16 c.p., 75 being placed in the nave, 35 in the chancel and sanctuary, and the remainder in the sacristry, hall, &c. In the nave the lights have been fixed in groups of six on the east side of each pillar, and on each side, about 45ft. from the floor, and concealed by the capitals of the pillars, clusters of lamps have been placed so as to throw a strong light on the subject painting over the chancel arch. In the chancel a pendant of beaten ironwork has been suspended over the priests' stalls in each arch, and behind the great chancel arch, and concealed by it, a long ornamental brass rod is fitted with lamps which throw down light on the altar and baldacchino, showing up the mosaics, statues and delicate stone carving of the latter, as well as lighting up the gilding and colours of the decorated ceiling. In the sanctuary hidden lights have been introduced into the dome of the baldacchino to light the altar and bring into prominence the colours of the marbles; while behind the baldacchino lights are hung in order to counteract the shadow thrown by it on the circular wall of the apse. The installation has been successfully carried out by Messrs. Anderson and Munro.

COOLGARDIE, WESTRALIA.—The local electric supply company in this town have found it necessary to apply for an extension of time for the public lighting by electricity. The rush of population owing to the gold discoveries has led to such demands upon the limited railway capacities of the district as to cause a serious block in the goods traffic, and the delivery of machinery has been delayed. At the meeting of the Scottish Westralia (Limited) on Wednesday reference was made to the important electric power works now in process of construction for the Yilgarn and Coolgardie goldfields, of which the Scottish Westralia (Limited) is the sponsor. Lord Kelvin, whose opinion has been sought, has pronounced in favour of the undertaking, and in a report has expressed the opinion that the extensive scheme is thoroughly practical, and likely to prove highly remunerative.

COVENTRY.—At the last meeting of the Town Council the minutes of the Electric Light Committee stated that in order to keep pace with the demand for electric current it would be necessary to provide an additional 200-kilowatt alternator and engine, two boilers, transformers, and various other plant and apparatus, at an estimated cost of £8,900. The Committee further recommended that application be made to the Local Government Board for sanction to borrow £13,000 for electric lighting purposes. In moving the adoption of the minutes, Alderman Hill referred to the very satisfactory progress the electric light was making in the town, and stated that, although they only started to supply current in November last, there was at present an equivalent of 6,000 8 c.p. lamps connected. The Committee's recommendations were adopted.

DERBY.—On Wednesday last Major-General H. D. Crozier, R.E, held a Local Government Board inquiry at Derby into the application of the Town Council for sanction to borrow £13,185 for electric lighting purposes. The inspector took exception to certain items, viz., £419 for obtaining powers (which he said the Local Government Board would not entertain) and to an item for loss on capital in the early stages of the undertaking. The Town Clerk said this money was paid to put the station into proper working order, and Mr. Harris said it was really interest on capital while the works were in course of construction. The inspector then suggested that the Town Clerk should draw up some explanation for the Board, as it seemed to him a very doubtful item. The inspector also said that he had not previously met with an item for interest on capital, and he asked for details, which were given by the borough accountant, after which the inquiry was adjourned.

EALING.—The report of the Electric Lighting Committee presented at the last meeting of the District Council contained a recommendation that the electric light mains be extended to Gunnersbury, provided the residents agreed to pay interest on the capital outlay and a certain sum annually for depreciation, and also guaranteed that the receipts from the sale of current would amount to at least £50 a year. The recommendation was agreed to.

EDINBURGH.—The provisional estimates of the Electric Light Committee show an estimated expenditure of £20,435, and receipts amounting to £27,925, an estimated profit of £7,490. The Committee propose to reduce the price of current to 5d. per unit.

GRIMSBY.—Although the Town Council have lately had several discussions on the question of carrying out the terms of their Provisional Order (obtained in 1894), still they cannot be induced to make a move forward. Last week Mr. Curry moved that steps be at once taken to comply with the provisions of the Order, and that a sub-committee be appointed to collect information, but after a lengthy debate it was decided to again adjourn the matter for a month.

HALIFAX.—The Board of Guardians have decided to erect an infirmary at a cost of £130,000. In addition to a very complete electric lighting installation, it is intended to utilise electricity for working lifts, for heating purposes in the wards, kitchens, &c. Gas will only be employed for cooking. The Guardians have decided to put down an independent generating plant.

HAMMERSMITH (LONDON).—A letter has been received by the Vestry from Messrs. S. Z. de Ferranti (Limited), asking that consent to the Provisional Order of the London United Tramways Company should be conditional upon their agreeing to take electric current for working their trams from the Vestry's supply station. The letter has been referred to the Electrical Committee.

HELENSBURGH.—At the last meeting of the Police Commission it was decided to form an Electric Lighting Committee.

LAMBETH (LONDON).—The Electric Light Committee presented a report, in which the Vestry is recommended to transfer its Provisional Electric Lighting Order to Messrs. Julius Sax and Co., who undertake to carry out the terms of the Order, to lay mains in all the streets of the compulsory area, and to maintain and supply electric current to 25 arc lamps free of charge. It is also proposed that the charge for current is not to exceed 6d. per unit. The Vestry are to have the option of purchasing the works at 21 years at 25 per cent. above the actual value of the undertaking. Messrs. Sax and Co. further agree to provide and erect a dust destructor plant, and to treat all the parish refuse at 1s. 6d. per ton.

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The Committee's proposal has excited strong opposition, and meetings have been held to protest against the suggested transfer. At a meeting held in Brockwell Park on Friday, Alderman Hubbard, Mr. George Offor, and several other speakers delivered speeches, and denounced the proposed surrender of the Order, advocating a temporary arrangement with a company for the supply of current, which would leave the Vestry freedom of action in the future. A resolution to this effect was carried unanimously. At another meeting Mr. Barclay Heward (Chairman), Alderman Hubbard and other speakers supported resolutions condemning the proposed transfer, and pledging the ratepayers to return members at the forthcoming election who would oppose the recommendation of the Committee.

LINCOLN.—At the last meeting of the Town Council the minutes of the Special Lighting Committee stated that they had fully considered the report of Dr. J. Hopkinson on the electric lighting question, and had come to the conclusion that the supply of electric current should be kept in the Council's hands. The Committee, therefore, recommended that they be empowered to take the necessary steps to establish electricity works in the town. Mr. Alderman Page, in moving the confirmation of the minutes, said that from every point of view it was desirable that they should undertake the supply of electric current, and that the initial cost of an installation would not be more than £15,000. Various speakers advocated the introduction of the electric light; but Dr. Collier thought that they should combine the electric light and dust destructor schemes, and moved an amendment to this effect. The recommendation of the Committee was, however, adopted.

LONGTON.—The Sub-Committee recently appointed to consider the offer of the North Staffordshire Tramways Company to lease them the tram lines in the borough, and to equip electrically, and also to make some extensions to the present system, now recommend the Council to agree to the following amended terms of the Company:—(*a*) The lease to be for 21 years, (*b*) a rental of £200 per annum to be paid for the existing lines, (*c*) a further annual sum to be paid equal to 7 per cent. upon the total capital cost of the proposed extensions, (*d*) the Company to pay the cost of repairs and renewals, and in case of dispute a reference to arbitration to an engineer, to be appointed by the Board of Trade. The Committee further recommend that the application for a Provisional Order be proceeded with. At the last meeting of the Council both recommendations were agreed to.

LLANDUDNO.—Mr. A. H. Preece has presented a lenghty report on the question of the establishment of electricity works in this town. The capital expenditure of an electric lighting scheme is put at £20,500, but if the Council decide to proceed with the dust destructor scheme the total would be about £23,400. Mr. Preece also reported as to combining a system of electric tramways with the above schemes, and the additional capital expenditure required for the triple scheme, which it is stated would be a certain success, would be £4,600, or a total of £28,000. The estimated annual revenue from these undertakings is put at £4,680, and the upkeep (including interest, sinking fund, &c.) £4,245, leaving a profit of £435. At a special meeting of the Council on Tuesday last it was decided to adopt so much of the report as related to the establishment of electric light and refuse destructor works, and to apply to the Local Government Board for sanction to borrow £25,000 for carrying out the schemes.

MEXICAN TELEGRAPHS.—There are stated to be 44,500 kilometres (27,500 miles) of telegraph lines in Mexico, serving a population of 12,570,000.

MOTHERWELL.—At Tuesday's meeting of the Police Commissioners the Lighting Committee recommended the Commissioners to establish electricity supply works at an estimated cost of £8,500, but, on the motion of Commissioner Dunlop, it was decided not to proceed with the scheme at present.

PADDINGTON (LONDON).—The Vestry have referred to the Electric Lighting Committee the question of obtaining a reduction in the price of electric current supplied by the Metropolitan Company from 7d. to 6d. per unit.

PADSTOW (CORNWALL).—The recent installation of the electric light at Mevagissey seems to have had a stimulating effect on the Padstow District Council. At the last meeting of the Council the Vice-Chairman (Mr. J. Williams) called attention to the introduction of the electric light into Mevagissey, and urged the members to adopt a similar course. They would obtain a far better and cheaper light than they were obtaining at present. The necessary capital outlay would not be much more than £1,000, and if they supplied current for private lighting they could, he urged, even make a profit on the undertaking. The matter will be further considered at a meeting of the Lighting Committee.

PETERBOROUGH.—At a recent meeting of the Lighting Committee the engineer presented a report as to the annual outlay which the suggested electric lighting scheme would entail. The Committee decided to make another canvass of the residents in th compulsory area in order to ascertain the probable demand for current.

POTTERIES EXTENSION TRAMWAYS.—About a fortnight ago Major Marindin, R.E, held a Board of Trade inquiry into the objections lodged by the Newcastle-under-Lyne District Council to the application for a Provisional Order by the promoters of the Potteries Extension Electric Tramways. In his report Major Marindin states that the Council's objections to the laying of the tramway within the borough were well founded, and that the promoters had failed in their contention that the assent of the Council to the present scheme, and without any modifications of the Order, should be dispensed with. The scheme did not offer the advantages which Newcastle might fairly claim, inasmuch as it merely provided a route between Newcastle and Hanley, and did not offer any facility for communication between Newcastle and the districts surrounding it. He thought that the tramways asked for by the Town Council to Silverdale and Chesterton were essential, and that the line to Wolstanton should be undertaken if the tramway between the latter place and Burslem were constructed, as this would supply a want and provide a through route to Burslem and Goldenhill; but he did not think that a case had been made out for a tramway to Trent Vale. As the Council and a large majority of the ratepayers were in favour of the construction of tramways, he was of opinion that, subject to these modifications, the scheme should be sanctioned.

THE TELEPHONE IN WAR.—A Cairo telegram states that Lord Cromer, accompanied by his financial adviser, proceeded on Tuesday to the War Office at Cairo at 10 o'clock in the morning, and remained until noon, conversing by means of the telephone with Gen. Kitchener, in charge at Wady Halfa, and was thus able to convey important instructions to the scene of operations.

TIGHNABRUAICH (ARGYLESHIRE).—This village can now boast of being up-to-date in its method of street illumination, for on Saturday last the residents celebrated the inauguration of the electric light. The cost of the installation has been generously defrayed by Mr. Samuel Millar, a local magnate. Current is obtained from a dynamo driven by an 8 H.P. oil engine. The contractors were Messrs. A. MacLellan and Co., of Glasgow.

WEST HAM.—At the last meeting of the Town Council the Highways Committee were instructed to submit the names of six electrical engineering firms who would be willing to supply and lay down the necessary plant and apparatus for the electric lighting of the borough.

WORKHOUSE LIGHTING.—The Portsea Island Board of Guardians have instructed Mr. Price, the superintendent of the Portsmouth Electric Light Works, to prepare specifications for wiring the centre block of the main workhouse building for the electric light.

WORKS LIGHTING.—The soap works of Messrs. Isdale and M'Callum, Paisley, are now lighted electrically. Current is supplied by an "Oldham" dynamo (60 amperes × 65 volts). The works and yard are illuminated by means of three 1,000 c.p. arcs, incandescents being employed for lighting the offices, &c. A complete system of telephones and electric bells has also been supplied by the contractors, Messrs. Robertson and Co., of Paisley.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fil. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

March 21, 1896.

6,269. C. J. WIGHTMAN and A. HUDSON. Bradford. Improvements in wooden and similar casings or mouldings for electric conduit wires and cables.

6,305. W. S. HULL. London. Improvements in surface trolleys for electric railways.*

6,306. A. GREENWOOD. London. Improvements in electric motors.

6 329. E. J. PRESTON, of the firm of J. Stone and Co., and A. B. GILL. London. Improvements in apparatus for producing, storing and applying electricity, especially applicable to the lighting and heating of railway carriages and other vehicles.

March 23, 1896.

6,374. D. KORDA and A. G. NEW. London. Improvements in electric traction.

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6,397. J. J. Bate. Liverpool. Improvements in conduits applicable for wires for conveying electricity.

6,407. W. S. Rawson. London. Method and apparatus for electrically coating articles with zinc.

6,423. W. H. Dingle and J. M. Urquhart. London. Improvements in electric switches.

6,437. H. H. Lake. London. Improvements in and relating to current-collectors for electrically actuated tramway vehicles with underground feed. (Union Elektricitäts Gesellschaft, Germany.)*

March 24, 1896.

6,477. G. O. Donovan. London. An improved cord grip for electric light fittings.

6,491. A. Mégroz. London. Improvements in apparatus for supplying electricity to electrically propelled vehicles on railways and tramways.*

6,487. J. Devonshire. London. Improvements in controllers for electric motors. (E. D. Priest, United States).*

6,504. J. Lengyel and A. Schlesinger. London. Improvements in electrically illuminated devices for advertising purposes.

6,509. L. Epstein and F. Marza. London. A process and apparatus for decomposing sodium or potassium chloride and generating electricity.

6,510. J. Brockie. London. An improvement in electric arc lamps.

March 25, 1896.

6,524. F. G. Robinson. Liverpool. Improvements in electric counters.

6,549. F. J. Head. Brussels. Carbon holder for dynamo rubbers.

6,576. P. Hardegen. Liverpool. Improvements in microphones.*

6,579. A. Graham. London. Improvements in telephonic apparatus.

March 26, 1896.

6,606. T. G. Smith. London. An electric cyclometer.

6,625. A. J. Fippard. Bournemouth. A new or improved holder for telephone receivers.*

6,692. A. B. Blackburn and W. L. Spence. London. Improvements in or connected with fusible electric cut-outs.

March 27, 1896.

6,732. J. H. Collings. London. Improvements in and connected with advertising devices operated by an electrical current.

6,751. W. P. Thompson. Liverpool. Improvements in or appertaining to carbons for electrical purposes. (A. Lessing, Germany.)

March 28, 1896.

6,864. G. A. Jewett. London. Improvements in short-circuiting or safety devices for overhead electric conductors.

SPECIFICATIONS PUBLISHED.

Note.—All Specifications can now be obtained at the uniform price of 8d. each.

1894.

23,697. Woakes. Electrodes.

1895.

4,660. Hiorns. Electro-deposition of iron on copper, &c.

5,515. Crompton. Electric measuring instruments.

8,507. Jeckell. Electric cut-outs.

8,573. Smith and Granville. Electric cables.

8,664. Crompton and Pochin. Arc lamps.

8,727. Siemens Bros. and Co. (Limited) and Lauckert. Electric switches.

8,728. Rhodin. Secondary voltaic batteries.

8,905. Menges. Galvanic batteries.

8,914. Davis. Chloride of lead for electric batteries, &c.

8,994. Jandus. Arc lamps.

9,286. Hopkinson. Electric switches.

10,029. Singer and others. Electric lamps.

10,792. Elliott. Galvanic batteries.

13,636. Crandall. Electric signalling, &c.

19,839. De Puydt and Poncin. Dynamo generators or motors.

1896.

156. Proctor and Gill. Regulating gas or electric light to railway coaches.

475. Bersey. Electric accumulators.

1,198. Darley. Electric railways.

2,545. Lake (Currie). Automatic current regulators.

2,717. Royce and Claremont. Electric switches.

2,767. Bennett and Somerville. Telephonic systems.

Memoranda.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31 $\frac{5}{16}$d. per oz. (April 1st). Consols (2$\frac{1}{2}$ per cent.) 110$\frac{3}{8}$—110$\frac{1}{2}$ for money, 109 $\frac{7}{16}$—109 $\frac{9}{16}$ for account; 2$\frac{1}{2}$ per cent. 105$\frac{1}{4}$—105$\frac{3}{4}$ (April 9th). Stock Exchange Settling Days: Consols, May 4th; Stocks and Shares Continuation Day, April 13th; Ticket Day, April 14th; Pay Day, April 15th; Mining Share Carry-over Days, April 11th and 25th.

COMPANIES' MEETINGS AND REPORTS.

Willans and Robinson (Limited).

The ordinary half-yearly general meeting of this Company was held on Wednesday at Cannon-street Hotel, Mr. Mark Robinson, M.Inst.C.E. (Chairman) presiding.

The SECRETARY (Mr. C. S. Essex) read the notice calling the meeting.

The CHAIRMAN said: Gentlemen, again the Directors are able to address you in terms of congratulation. The business of our second year has surpassed that of the prosperous first year of the Company, though, to speak plainly, we did our best to restrict it, and now in the beginning of our third year the volume of our orders has burst all restrictions, and has risen to figures which are nothing less than astonishing. When the report was written we could only say that in less than three months the orders had reached 22,300 H.P.; we can now say that in three months they actually reached 24 400, or some 28 per cent. more than in the whole 12 months of 1893—itself the record year up to that time. It was upon the figures of 1893, or rather upon those figures averaged with previous and less favourable years, that the sale from the old to the new Company was arranged, and the payment for the goodwill fixed, and you will bear with me while I express the pleasure of the Directors, who were responsible for the prospectus of the Company, at this brilliant fulfilment of the modest forecast of increasing business which they made to you, and at the proof now plainly given that the price you paid for the business was a moderate one. For not only does our business increase, but its profitableness increases too. 1895 compares well in every way with 1894. In 1894, if we had divided profits "up to the hilt," instead of carrying to reserve, we might have paid about 9$\frac{1}{2}$ per cent. upon the Ordinary share capital then paid up. In 1895 we might have divided about 12$\frac{1}{2}$ per cent. upon a larger Ordinary capital, and this in face of the fact that we have written off depreciation upon an almost lavish scale. Omitting the Thames Ditton freehold, which follows a practically uniform rule, the value of our plant and machinery and patents at the beginning of 1895, plus the additions to them during that year, was £60,600, and from this sum (although many of the additions would not rank for depreciation at all during the same year) we wrote off no less than £6,703, or between 11 and 12 per cent. on the total. Yet our plant and machinery are kept in first-class condition out of revenue, and our patents bear no value beyond the sums actually spent upon, or in connection with them. We have been not less prudent in other questions which involve valuing, and, therefore, you may take this earning of 12$\frac{1}{2}$ per cent. on the Ordinary capital for 1895 as very truly earned indeed—earned, too, upon a good deal of idle as well as upon productive capital. When the transition period is over, and the unproductive capital, and that capital which, in the form of debentures, we have soon to consider, are earning money for us in the new works, we have the fullest expectation of doing better still; but until we have actually tested the results of business carried on upon the larger scale, and, under the different, though we hope more favourable circumstances of the future, it would be unwise to depart in the smallest degree from our present prudent attitude, or to cede the claims of the reserve fund in favour of large dividends. It must not be assumed that the extraordinary influx of orders for the first quarter of this year is always to be maintained. It has been largely due to the fact that we were known to be full of orders, many of the public bodies and private companies which undertake electric lighting in this country pressed forward to get their orders placed with us for next winter, so that the first quarter really brought many orders which would normally have been given in the second quarter of the year. The explanation is in itself, however, a remarkable tribute to our position, and to the credit in which the Willans engine is held, and whatever discount we may make from the first quarter's figures, they undeniably show a magnificent accession of business. It has been the steady object of the Directors for some years past to promote a demand for the Willans engine in much larger sizes—so soon, that is, as we may be in a position to supply them. We are glad to say that among the recent orders is one for four engines of 1,100 H.P. each, to be made, of course, at Rugby. We have an engine of 750 H.P. on order, for electric lighting, for one of our municipal bodies, and two of 600 H.P. each for another. An engine of 750 H.P., and another of 700 H.P., are on order for driving mills on the Continent, while nearly 40 engines are on order of sizes from 300 H.P. up to 500 H.P. In fact, the average size of the engines ordered in the first quarter of 1896 was not less than 263 H.P. The development of the really large engine work waits, of course, the completion of the new works. Of the cost of the new works now being constructed, and of the plant required for them, it is still early to speak with exactness. If no substantial additions beyond those now decided on become necessary, we may expect the cost of land, buildings, fencing, tramways, drains, levelling, &c., to be about £50,000, in addition to £9,800, which had been spent up to the end of 1895. The plant required for the buildings, as now planned, including, of course, not only machine tools, but such plant as engines and boilers, electric lighting and power plant, shafting and pulleys, cranes and overhead travellers, rolling stock and fire appliances, will probably cost us fully £30,000, beyond what had been spent up to December last, and including an allowance for various things which it is not desired to order until we are actually at work at Rugby. The two sums added together make £80,000 still to be spent, but it is evidently necessary to allow a margin beyond this. With regard to the question of new capital, the sum the Directors propose to borrow is £75,000, which is one-third of the present paid-up capital. The Articles of Association permit borrowing up to the limit of one-half of the paid-up capital, but we have to consider the views of borrowers as well as our own powers, and the Directors are not at present disposed to recommend an issue of more than £75,000, to form part of an issue which may be increased later to £100,000 subject to an undertaking to form one of the

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conditions of the issue that the total issue shall at no time exceed one-third of the paid-up capital, whatever the latter may be, and shall never, of course, exceed £100,000. In the event of our business undergoing in the future any such startling expansion as its past history gives some ground for treating as possible, we have powers to issue £75,000 more share capital, and after that a further £35,000 could be borrowed, and this would raise the debenture debt to the proposed limit of £100,000. The authority to borrow up to £112,500 in all, proposed in the resolution, is necessary in order to give power to the Directors to obtain small loans (as from the Company's bankers) in the ordinary course of business. They have authority now, under Article 57, to borrow up to one-tenth of the paid-up capital, but this authority is, so to say, swallowed up in the debenture debt. When created it is necessary to provide by the resolution a margin of a few thousand pounds between the limit of the debenture debt and the limit of the total borrowing. This is why the resolution asks for a limit in excess of that which the Directors contemplate for the debenture debt. Allusion has been made to the Niclausse boiler. The delay in making it upon a large scale is not wholly an evil; it has enabled us to test it by extended use in various places before pressing it upon public acceptance. It has borne all tests most admirably. One electric lighting company which lately had two large boilers from us, has ordered three more, and quite enough are on order elsewhere to afford a most thorough trial. Arrangements have been made with the Admiralty for the manufacture of a set of Nic'ausse boilers for a fast boat, under royalty, by Messrs. Humphrys and Tennant, and the same eminent firm are also making other Niclausse boilers under licence from us. So far as we can foresee, this business promises very well indeed. I now beg to move—

"*That the report and accounts for the half-year ended December 27th last, submitted to the meeting, be, and the same are hereby, received and adopted.*"

Mr. W. H. WILLCOX seconded the resolution.

Mr. PEACH asked when they might expect to get a quotation on the Stock Exchange.

Mr. PERCY HUNTER thought the travelling and legal expenses were rather high, and inquired the reason.

The CHAIRMAN, in reply, said their application for an official quotation was now before the Stock Exchange Committee, and they hoped to receive a favourable reply at an early date. As to the expenses, he thought they were not unreasonable in view of all the circumstances which he explained in detail.

The resolution was then unanimously carried.

The CHAIRMAN next moved—

"*That a dividend for the half-year ended December 27th last at the rate of 6 per cent. per annum on the capital paid up on the Preference shares, and at the rate of 7 per cent. per annum paid upon the Ordinary shares be and the same is hereby declared.*"

Mr. G. W. ANDERSON seconded, and it was agreed to.

Sir GILBERT A. CLAYTON-EAST, Bart., moved—

"*That the Directors be, and they are hereby, authorised to borrow, for the purposes of the Company, any sum or sums of money not exceeding £112,500, to bear interest at such rate, to be secured in such manner, and to be issued on such terms as the Directors may determine.*"

He said that the idea of the Board was that the loan should take the form of Debenture stock, and that the amount should be £75,000, that the interest should not exceed 4½ per cent.; that the terms should be for a fairly long period, with the option of paying off earlier after 10 years, at a slight premium.

Mr. G. W. ANDERSON seconded the resolution, and it was carried *nem. con.*

The auditors (Messrs. Cooper Bros. and Co.) having been re-elected the proceedings terminated with a vote of thanks to the Chairman.

NEW COMPANIES, STATUTORY RETURNS, &c.

ERNEST F. MOY (LIMITED).—This Company was registered on March 20th, with a nominal capital of £5,000, in £1 shares, to acquire the business of a manufacturing electrical engineer and contractor, now carried on by Ernest F. Moy at Camden Town, London, N.W., and to carry on the business of manufacturing electrical engineers and contractors, electrical and mechanical engineers, founders, metal workers, electricians, suppliers of electricity, electrical apparatus manufacturers, &c. The first subscribers, with one share each, are: P. H. Bastie, electrical engineer; H. Gorton, electrical engineer; F. B. Gardiner, electrical engineer; H. Barton, engineer; J. Dyer, E. Dyer and C. G. Box.

NEW GENERAL TRACTION COMPANY (LIMITED).—This Company has entered into an agreement with Mr. Edwin A. King, of Winchester House, E.C., for the acquisition of a certain business, £15,000 fully-paid debentures in the Coventry Electric Tramways (Limited), the benefit of agreements with Messrs. W. Graff Baker and A. de Turckheim, with the said Coventry Company, with Messrs. W. Lowcock and G. Hill and with the Electric and General Contract Corporation (Limited), and also the benefit of tenders for the electrical equipment of tramways in Leeds and Glasgow, in consideration of the sum of £140,000, payable by the allotment of 4,000 Six per Cent. Cumulative Preference and 24,000 Ordinary shares of £5 each.

PERU TELEPHONE COMPANY (LIMITED).—The annual return to January 14th has been filed. Only seven shares have been taken up out of a capital of £100,000, in £5 shares, and no calls have been made.

QUEEN ANNE'S MANSIONS LIGHTING AND HEATING COMPANY (LIMITED).—The annual return to March 6th has been filed. The whole nominal capital of £60,000, in 3,000 Preference and 3,000 Ordinary shares of £10 each, has been taken up and issued as fully paid.

RUGBY SCHOOL ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return to March 2nd, has been filed. The nominal capital is £5,500, in £50 shares; 70 of these have been taken up, and calls amounting to £45 per share made.

CITY NOTES.

APOSTOLOFF AUTOMATIC TELEPHONE PARENT SYNDICATE (LIMITED). At a meeting of the proprietors of this Syndicate on Wednesday last, it was decided to convert the £1 shares into 40 shares of 6d. each.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended April 5th were £815, against £935 in the corresponding week of 1895, a decrease of £120. The total receipts for the half-year amount to £13,471, against £13,583 for the corresponding period of 1895, a decrease of £112.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the month of March were £3,123.

EASTERN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month of March amounted to £81,135, against £70,470 in the corresponding period last year.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—In our advertisement columns will be found a list of the numbers of 409 Five per Cent. Australian Government Subsidy Debentures of £100 each, which were drawn by lot on the 1st inst., and will be paid off at par on July 1st next, at Messrs. Barclay, Bevan and Co.'s, 54, Lombard-street London, E.C.——The traffic receipts of the Company for the month of March amounted to £47,747, and to £40,942 in the corresponding period of 1895.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company for the month of March amounted to £22,400. The total receipts from January 1st to March 31st were £66,800, against £68,000 and £63,000 in the corresponding months of 1895 and 1894.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 5th inst. amounted to £1,256. The amount for the corresponding week last year was £1,024. Increase £232.

ORIENTAL TELEPHONE AND ELECTRIC COMPANY (LIMITED).—The transfer books of this Company will be closed from the 13th to the 22nd inst. inclusive.

SUBMARINE CABLES TRUST.—Notice is given that on and after the 15th inst. the sum of £2 on account of this Company's coupon, due 15th inst., will be paid by Messrs. Glyn, Mills and Co., 67, Lombard-street, London, E.C. Coupons should be left four clear days for examination.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended April 3rd, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,180.

WESTERN UNION TELEGRAPH COMPANY.—This Company have issued their report for the quarter ended March 31, 1896:—The following statement, dated March 11th, exhibits the condition of the Company at the close of the quarter ended December 31, 1895:—

Surplus October 1, 1895, as per last quarterly report...		$7,854,622 99
Net revenues, quarter ended December 31, 1895		1,603,416 25
		$9,458,039 24
From which deducting for—		
Dividend of 1¼ per cent. paid January 15	$1,191,948 75	
Interest on bonded debt	223,557 33	
Sinking funds	20,000 00	
	$1,435,506 08	
Left a surplus January 1, 1896		$8,022,533 16
The net revenues of the quarter ending March 31st, based upon nearly completed returns for January, partial returns for February, and estimating the business for March, will be about		1,250,000 00
		$9,272,533 16
From which appropriating for—		
Interest on bonds	$223,560 00	
Sinking funds	20,000 00	
		243,560 00
		$9,028,973 16
It requires for a dividend of 1¼ per cent. on capital stock issued, about		1,191,950 00
Deducting which leaves a surplus, after paying dividend, of		$7,837,023 16

In view of the preceding statements, the Committee recommend that a dividend of 1¼ per cent. on the capital stock of the Company be declared, payable on and after the 15th instant.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half-month ended March 31st are £3,162, against £2,757 in the corresponding period of 1895.

WESTINGHOUSE ELECTRIC COMPANY.—It is stated that the Directors of this Company propose to increase its capital by $5,000,000, and it is further stated that the agreement between the Company and the General Electric Company has been signed. The new scale of prices will be issued next week.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Divi-dend.	Name	Previous Week's Price, Mar. 31.	Price Wednesday, Apr. 8	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Apr. 4. Highest	Lowest
						£ s. d.			
			TELEGRAPHS						
£1,012,880	Stock	18 0	Anglo-American	47 49	48 50	5 0 0	Jan., Apr., July, Oct.	..	..
£2,993,560	Stock	3 0	Do. Preferred	90 91	9 ½ 9 ¼	5 8 1	" "	90½	89½
£2,993,560	Stock	..	Do. Deferred	8 8½	9½ 10	..	..	8¼	7⅞
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)	110 114	110 114	3 17 8	January and July	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	10½ 11	11 11	..	..	..	..
130,000	£10	3 0	Brazilian Submarine x l	14½ 14¾	13½ 14¾	4 14 11	Mar., June, Oct., Dec.	13⅞	14⅛
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	113 116	113 116	4 7 2	June and December	..	..
10,000,000	$100	$ ¾	Commercial Cable Capital Stock x l	160 170	160 170	4 2 4	Jan., Apr., July, Oct.	..	..
16,000	10	3/0	Cuba Submarine	12½ 13½	13¼ 13½	5 14 4	February and August	13⅛	13⅛
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	21½ 22½	4 13 0	" "	21½	..
12,931	5	2/0	Direct Spanish (fully paid) x l	4 5	4 5	4 0 0	April and October	..	..
6,000	5	10%	Do. Preference 10 per Cent. x l	10 10½	10 10½	4 5 8	" "	..	..
£10,000	Stock	4½%	Do. 4½% Debentures of £50 each	101% 102%	102% 103%	4 3 5	" "	103½	..
60,710	20	2/0	Direct United States Cable, 1877	9½ 9¾	9½ 10	4 0 0	Jan., Apr., July, Oct	9¾	9⅝
400,000	10	2 6	Eastern	17 17½	17 17½	3 14 4	" "	17⅞	17⅞
70,000	10	6%	Do. 6 per Cent. Preference	18 18½	18 18½	3 4 10	" "	18⅛	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	129 132	80 133	3 0 11	May and November	132	131
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899	106 108	106 108	4 13 8	February & August	..	..
250,000	10	2/6	Eastern Extension	17½ 18½	17⅞ 18½	3 10 9	Jan., Apr., July, Oct.	18⅛	..
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128 131	128 131	3 1 5	February & August	..	..
£54,100	100	5%	* Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	1 1 105	101 105	4 16 5	January and July	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb., 1900	101 105	101 1 5	4 19 5	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.)	105 103	105 108	3 14 7	February & August	—	—
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 1 5%	3 10 8	May and November	..	..
189,227	10	1 6	Globe Telegraph and Trust	10¾ 10⅞	10½ 10⅝	3 16 9	Jan., Apr., July, Oct.	10⅞	10⅝
180,042	10	6%	Do 6 per Cent. Preference	16¼ 17¼	16⅜ 17¼	3 9 7	" "	17¼	16⅝
150,000	10	5 0	Great Northern	22½ 23½	22½ 23½	3 11 0	Jan., April, and July	—	..
£130,000	100	5%	* Do. 5 per Cent. Debentures, 1883 Issue	104 107	104 107	4 13 11	March & September	..	..
17,000	25	12/6	Indo-European	43 51	48 51	4 18 0	May and November	50½	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	107 110	1 7 1 0	5 9 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942	108 111	108 111	3 12 9	" "	109	..
11,889	8	4/0	Reuter's	5 6	5 6	..	April and October	6⅛	..
3,331	£100 Cert	21/0	*Submarine Cables Trust 6 per Cent.	134 138	134 139	4 6 4	" "	1 6	..
15,609	10	2.0	West African Telegraph	5½ 6½	¼ 6½	..	January and July	..	..
£233,300	100	5%	* Do. 5 per Cent. Debentures (red.)	101 104	101 1 4	4 15 7	March & September	..	..
80,000	10	2/0	West Coast of America	1 2	1 2	..	January and July	1	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	95 100	95 100	8 3 8	June and December	95½	..
88,821	10	1/3	West India and Panama	1 1½	1 1½	..	..	1⅜	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10⅜ 11⅛	10½ 11½	5 6 8	May and November	11⅛	11
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9 10	6 0 0	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	103 111	103 1 1	4 11 1	June and December	..	..
64,218	15	3/0	Western and Brazilian	8½ 9	8½ 9	5 5 8	May and November	..	..
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6½ 6¾	6⅜ 6¾	..	..	6¾	6⅞
33,129	7½	1/6	Do. Deferred Ordinary	2½ 2¾	2½ 2¾	—	—	..	..
£165,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 107	103 107	5 13 2	February & August	..	..
£208,400	100	6%	Do. 6% Mort. Debs., Series "B" 1910	103 107	103 107	5 13 2	" "	..	..
£1,177,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds	113 118	113 118	6 1 9	May and November	..	..
£164,300	£100	6%	Do. 6 per Cent. Sterling Bonds (red.)	102 105	102 105	5 14 10	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3 3½	3 3½	..	—	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance	⅞ 1	⅞ 1	..	May and November	—	—
171,504	£1	8·.15	Oriental Telephone and Electric (fully paid)	⅞ 1	⅞ 1	..	Yearly	..	..
484,597	5	3/0	National	6½ 7	6½ 7	3 18 7	June and December	7	6⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	..	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)	16½ 17½	16¼ 17½	3 8 7	" "	17½	..
119,224	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅜ 6¾	6½ 6¾	3 12 9	—	6⅜	..
1,100,000	Stock	8½%	* Do. Debenture Stock, 4½% (red.)	109 109	106 109	3 4 8	January and July	107½	..
58,000	5	3/0	United River Plate	3½ 4	3½ 4	..	" "	..	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	93 101	96 101	5 0 3	" "	93½	93
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	10/0	City of London Electric Lighting (fully paid)	14½ 15½	14½ 15½	3 4 6	—	15⅞	16⅛
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	16 17	16½ 17	3 10 7	—	16⅜	16⅛
£100,000	Stock	5%	* Do. 5% Debenture Stock (red.)	124 128	124 128	3 13 2	June and December	..	—
19,900	£5	..	Electricity Supply Co. for Spain	.. —	— —	..	—	—	—
£10,000	£5	2 0	Charing Cross & Strand Electricity Supply Corp.	7½ 7⅝	7½ 7⅝	..	—	7½	7½
£37,400	£100	5%	Do. 5 per Cent. Debentures, 1900	— —	— —	..	—	—	—
24,075	£8	..	County of London & Brush Prov. Ord. (fully paid)	8 9	8 9	..	—	..	..
10,000	£10	9½d.	Do. Pref. (£8 paid)	12½ 13½	12½ 13½	..	—	13¼	13
8,322	£5	..	House-to-House Electric	— —	.. ..	..	—	—	—
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid)	— —	— —	..	—	—	—
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid)	.. ..	.. ..	..	January and July	—	—
45,060	£5	3/0	Liverpool Electric Supply (fully paid)	7⅞ 7⅞	7⅞ 7⅞	3 16 2	—	—	—
111,000	5	..	London Electric Supply	.. ..	.. ..	..	—	..	..
49,900	£10	3/0	Metropolitan Electric Supply (fully paid)	13 13½	12½ 13½	4 3 1	—	13⅛	13
£150,000	Stock	4½%	* Do. 4½% Debs.	118 120	118 120	3 15 9	June and December	119	..
6,462	£10	4.0	Notting Hill Electric	8½ 9½	8½ 9½	..	—	—	—
..	..	..	Rand Electric	⅜ ½ prem.	⅜ ½ prem.	..	—	—	—
19,930	£5	5 3	St. James and Pall Mall	9½ 10½	9½ 10½	..	—	10	..
20,000	£5	7%	Do. 7 per Cent. Preference	9½ 10½	9½ 10½	3 8 4	—	10	..
59,900	5	4.6	Westminster Electric Supply (fully paid)	9½ 10	9½ 10½	3 8 4	—	9⅛	9⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	2	1/6	Brush Electrical Engineering	1⅛ 1⅜	1⅛ 1⅜	5 3 8	—	1⅜	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅜ 1⅝	1⅜ 1⅝	3 4 0	—	1⅝	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures	110 118	110 1 8	3 19 10	March & September	—	..
23,180	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref.	2½ 2¾	2½ 2¾	..	January and July	..	..
89,261	5	1/6	Edison and Swan United	1½ 1⅝	1½ 1⅝	..	..	..	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 5 0	..	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid)	.. ..	— —	..	..	—	—
110,000	2	..	Electric Construction	1⅜ 1⅝	1⅜ 1⅝	..	..	..	..
12,245	2	2 9⅜	Do. 7 per Cent. Cumulative Pref.	2½ 2¾	2½ 2¾	5 1 10	..	..	..
91,196	2	10.0	Elmore's Patent Copper Depositing	¼ ¼	¼ ¼	..	..	..	..
22,000	5	..	Fowler-Waring Cables (fully paid)	¼ ¼	¼ ¼	..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	20 21	20 21	4 16 8	February & August	20⅜	20⅜
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	.. ..	.. ..	..	March & September	..	..
15,995	£10	..	International Okonite Ordinary	.. ..	.. ..	..	—	—	—
16,000	£10	..	Do. 8 per Cent. Preference	.. ..	— —	..	December and June	—	—
20,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid)	¼ ⅜	¼ ⅜	..	..	..	..
37,350	12	2½/0	Telegraph Construction and Maintenance xd	38 41	38 41	4 7 10	March and July	39½	38½
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	102 105	4 16 5	January and July	—	—
37,614	£5	—	Woodhouse and Rawson Ordinary (£3 15s. paid)	.. ..	.. ..	..	—	—	—
41,098	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	—	..	..
£100,000	10	10/0	W. T. Henley's Telegraph Works Ordinary x l	16½ 17½	16½ 17½	3 8 7	—	16⅝	..
£30,000	10	7/0	Do. 7 per Cent. Preference xd	16⅝ 17⅝	16⅝ 17⅝	4 0 0	—	—	..
£50,000	Stock	4½%	Do. 4½% Mort ge Debenture Stock	107 112	107 112	4 0 6	—	..	..
			RAILWAYS AND TRAMWAYS.						
£680,000	Stock	1½%	City and South London Railway Con. Ordy.	40 42	40 42	2 19 6	May and November	—	—
7,650	10	5%	Do. 5% Perpetual Preference	14½ 15	14½ 15	3 6 8	" "	—	—
£10,171	Stock	4%	Do. 4% Perpetual Debenture	132 134	132 134	3 0 3	May and November	..	..
87,850	£10	3½%	Liverpool Overhead Railway	14 14½	14 14½	1 8 2	—	—	—
10,000	10	5%	Do. 5% Preference	16⅝ 16¾	16⅝ 16¾	2 19 3	—	—	—
135,000	Stock	4%	Do. 4% Debenture	114½ 116½	114½ 116½	3 10 2	January and July	—	—

* In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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THE ELECTRICIAN:

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NOTES.

Mr. HANBURY's remarks on the telephone service, in the discussion on Post Office estimates last week, were singularly devoid of all encouragement to Local Authorities desirous of working the town exchanges under municipal control. The subject was too large for us to do more than barely refer to it in our last Friday's leader; but unless the wishes of the large municipal bodies have materially altered within the past twelvemonth, their backwardness in Parliament is a little strange. If, however, they are still of the same mind, they could probably have what they desire by purchasing the plant and rights of the company outright, instead of setting up a competitive service, a course which it does not appear as if the present POSTMASTER-GENERAL would approve of except under conditions which are not likely to arise. To the acquisition by purchase, on the other hand, he would offer probably no opposition, for if that course were adopted by any considerable number of towns, the Post Office and the Government would be relieved of a grave embarrassment in the not very distant future. For somewhat similar reasons the National Telephone Company might not be unwilling to part gradually with rights which, sooner or later, it may be otherwise deprived of in a wholesale manner and on less favourable terms.

WHAT the terms of purchase by Local Authorities ought to be need not now be discussed. With the Post Office as an intermediary, they would no doubt be fair to both parties. That the telephone exchanges in any given area must be under exclusive control of one body is an axiom; and to attempt to create a new system for the mere purpose of superseding an existing one would be a wasteful proceeding, except where the existing system was hopelessly bad. We are not enamoured with the idea of municipal control, although there is a good deal to be said for it under present circumstances in relation to the telephone service. But where the Local Authorities are seriously dissatisfied with the present state of things, we would suggest that they inquire into the merits of purchase before irretrievably committing themselves to competition *à l'outrance*, or nothing.

IF the further progress of the electric lighting and electric traction industry were to be forthwith arrested, it would still have deserved well of the public. We will not to-day tackle that exceedingly thorny question, the relative merit and the relative cost of electricity and gas, nor go so far as to assert that the electric light, even as we now have it, is a distinct boon; indeed, with a view to avoid polemics, we will magnanimously assume that it is a distinct nuisance. Notwithstanding this, however, it deserves well of the British Public. But for the advent of the electric light we should scarcely have witnessed that sudden determination of the gas engineer to make better use of his opportunities—a determination which has resulted in the "Wenham" and "Welsbach" lights. It is true that the former of these is almost better as a source of heat than as a source of light, and that the latter too often modestly hides its light under a mantle (a broken one, of course), but these devices are nevertheless distinct improvements. But the section of the community which has perhaps derived most benefit is that praiseworthy section which devotes its spare time to municipal affairs. Not only has the arrival of the electric light given a tremendous impetus to municipal management, and thus broken the dull monotony of sanitary and lighting business, but it has afforded an excuse—a very reasonable excuse we hasten to add—not only for jaunts up and down the United Kingdom, but across the stormy waters of the English Channel. And now that electric lighting threatens to become a trifle jejune, electric traction comes upon the scene.

WE have before us the "Report of the Deputation appointed by the Council (of Belfast) to visit various Cities and Towns where Tramway Traction by Electricity is in practice, and Report for the information of the Council." This deputation has certainly not spared itself. Bristol and London, Paris and Brussels, Havre and Hamburg, Berlin and Budapest are a few of the towns "where tramway traction by electricity is in practice" included in the itinerary of this adventurous deputation. And since the result of these wanderings is a splendid "unsolicited testimonial" for electric traction there is nothing, from our point of view, to cavil at. We cannot do better than give prominence to a few quotations from the conclusions come to by the Belfast City Fathers. The italics are ours:—

"After a minute examination of the various systems of mechanical traction obtaining in the cities they have visited, and a careful study of their adaptability to the particular physical and other conditions relating to Belfast, your deputation have come to the conclusion that electrical traction, under certain conditions, is best suited to the wants of the public and requirements of the city. *They believe that any unprejudiced person, after having visited the leading European cities, could come to no other conclusion.* . . . Having regard, therefore, to the fact that

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all practical objections to the overhead system have been surmounted, and that any exceptions thereto from an æsthetical point of view have been reduced to an almost infinitesimal quantity in the best examples of the overhead system, the deputation feel perfectly confident that they are doing the right thing in recommending that system, with certain stipulations, as the best and most suited to the public interest. . . . The deputation could not fail to observe in the various cities they visited that along what was termed the suburban electrical tramway routes there is, in nearly every case, a rapid development of residential and other property, and a consequent enhancement of the value of the adjacent lands. . . . Their strong impression is that *the travelling public are perfectly satisfied and even delighted with this mode of transit.* This is evidenced in a marked manner by the quickness of the service and the manner in which the cars are filled."

WHAT a commentary upon the absurd attitude of the London County Council! According to this egregious local authority the overhead trolley would endanger the beauties of the Uxbridge-road, and until an economical conduit or accumulator system is forthcoming, no electric tramway traction of any other kind is to be permitted within its jurisdiction! There is, however, one paragraph in the Belfast report, which reminds us of Spring Gardens; it is that in which capitalists are invited to confer upon the Belfast public all the benefits enumerated in the Report, and are expected to be agreeable to being bought out after 14 years "without any allowance for compulsory purchase, goodwill, or other consideration." Belfast may get many things on such terms; it most certainly will not secure electric traction at its best.

THE announcement that coalfields in the vicinity of Dover are to be opened up, by the sinking of a full-sized shaft, should be welcome news for the Dover Electricity Supply Company. During the past nine months, since the commencement of supply, some 57,000 units have been sold for an average price of 3·9d., and have cost on the average 8·80d. per unit. Capital charges have no doubt weighed unusually heavily; for the maximum demand has not exceeded 74 kilowatts, while the station capacity is 325 kilowatts, and we understand that the mains are constructed for a still greater load. But, allowing for the very high capital charges, we are still face to face with works costs amounting to 4·59d. per unit sold, of which no less than 2·28d. went to pay for coal. Or, if we put the question of distribution entirely out of court, whether in regard to the capital expended or the energy losses in the mains, and consider only what has been going on inside the station, we still find that the generating expenses have amounted to 3·34d., of which 1·66d. went to pay for coal, per unit *generated*. This, unhappily, is a "record" in the wrong direction, and compares very unfavourably with, say, Burnley, with its 0·28d. for coal, and 0·78d. for total generating expenses per unit generated. But then the Burnley load factor was 5·77, while that at Dover (for nine months) was only 3·64, per cent., and the facilities for getting cheap coal at the two places are not to be compared.

IN another column we publish an account of some instructive experiments, made in Germany, with a device for putting broken telephone wires, when they break in the vicinity of trolley lines, immediately into good contact with the earth. Although the experiments would seem to show that so far as the protection of a telephone exchange is concerned, fuses can be relied upon to afford good protection, there can scarcely be such a thing as excess of precaution in a matter of this kind, in which valuable property is involved and possibly also human life. Of course, the immediate earthing of a broken telephone wire affords complete protection against shock, and there have been too many instances lately, both on the Continent and in America, of horses and human beings coming into disastrous contact with telephone lines temporarily forming part of a 500-volt traction circuit, for this additional safeguard to be depised.

THE concluding article of a series which has been running for a long time in these columns, and an article by Mr. W. BAXTER from the *Electrical World* of New York, are reminders of the preference that the English electrical engineers have for direct coupling, and of the determination of his American colleague to oust gearing from the unchallenged position it has held in workshops from time immemorial. At modern electric supply stations in this country, rope and belt gearing are now undoubtedly on the wane. On the other hand, we have, up to the present, been slow in using direct-coupled plant for tramway power stations; in fact, there is not a single direct-coupled tramway or railway generator in the United Kingdom. Curiously enough, in America, where they have just rediscovered direct-coupling for engines and dynamos, it is in street railway "power houses" that this re-discovery has been most welcomed, the engines, however, being of the slow-speed type. On the Continent, too, direct-coupled traction generators have found extensive use. The abolition of gearing from workshops is, of course, a different matter, and involves considerations which do not enter into electric generating station practice. Mr. BAXTER's article, while it does not present any new phase of the question, forms a useful summary of the principal considerations which should be taken into account before inducing owners of factories to change over to or to lay down electric motor plant.

Lord Rayleigh.—Lord Rayleigh has been appointed a foreign member of the Copenhagen Academy of Science.

Cable Interruptions.

	Date of Interruption.
Puerto Plata—Martinique	December 19, 1895.
Assab—Massowah	March 29, 1896.

The Amazon Cable.—The cable ship "Faraday" has returned to the Victoria Docks, after having successfully laid the Amazon cable network.

Colour Photography.—A meeting for discussion will be held at the Royal Society next Thursday, when the subject, "Colour Photography," will be introduced by Prof. Lippmann.

Burton-on-Trent.—At the last meeting of the Town Council the report of the Gas and Electric Light Committee recommended that the supply of electrical energy be discontinued, in accordance with the permission of the Board of Trade, during the daytime from April 1st to September 30th. The recommendation was agreed to.

The Endowment of Research.—At a meeting of the Edinburgh University Court, on Tuesday, an intimation was made of a grant to the University of £20,000, out of the bequest left by the late Earl of Moray for the benefit of certain institutions, as a fund for the promotion of original research in the University of Edinburgh, to be called "The Earl of Moray's Endowment."

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Iron and Steel Institute.—The spring meeting of the Iron and Steel Institute will be held on Thursday and Friday, May 7th and 8th next, at the Institution of Civil Engineers, under the presidency of Sir David Dale. Upon that occasion the Bessemer Gold Medal, which is awarded annually in recognition of meritorious services in advancing the science or practice of the metallurgy of iron and steel, will be presented to Dr. Hermann Wedding, of Berlin. The list of Papers down for reading and discussion is a full and comprehensive one, ten communications being on a variety of metallurgical subjects.

The Physical Society Abstracts.—The Council of the Physical Society, in a circular issued to the members, call attention to the expense attending the publication of abstracts of physical Papers, which has been undertaken by the Society for a little over a year. The proposals now submitted to the consideration of members with a view to meeting this expense are, firstly, that the annual subscription should be raised to two guineas; secondly, that existing life members should pay an annual subscription of one guinea or an additional composition of fifteen guineas; and, lastly, that an annual guarantee fund should be raised for the next five years to cover the probable deficit. Nearly £100 per annum has been already promised.

The Three-Phase Arc.—The three-phase arc, says a writer in *Electricity* of New York, is less noisy than the single phase, and its light is steadier and has less variation in its total intensity, owing to the fact that the current never stops, and there is always a positive carbon. Three cored carbons, placed parallel side by side, with slight magnetising coils to keep the arc at the ends of the carbon, will give a very satisfactory light in the direction away from the tips, and may be used when it is desirable to throw the light all in one direction. Four carbons at 90deg. apart, each with a suitable resistance in series with it, and connected to quarter-phase tap wires on a Gramme ring or other generator giving quarter-phase circuits, will also produce a rotary field arc of great beauty and interest.

Government Appointment.—Mr. John Hesketh, the well-known Borough Electrical Engineer at Blackpool, has been appointed Electrical Adviser to the Government of Queensland, at a salary of £600 per annum and travelling expenses. Mr. Hesketh will have to advise on all matters connected with telegraphy, telephony, electric lighting, and electric traction, and is exceptionally well qualified to do so, since he has served for nine years in the Postal Telegraph service, part of the time under Mr. A. W. Heaviside, and has since been with the Newcastle Electric Supply Company and the Blackpool Corporation. Mr. Hesketh will be known to many of our readers by his excellent translations of M. André Blondel's articles on public lighting which are now running through our columns. Mr. Hesketh was married on Tuesday, and received the cordial congratulations of numerous friends on the happy event.

Errata.—A firm of patent agents have pointed out to us that the patents Nos. 1,769 and 1,830 of 1882, which were said to have expired last week, lapsed, as a matter of fact, some three years ago, through non-payment of renewal fees. Our correspondents remark that "in very few cases do patents in this country last for the full term of 14 years, and even 10 years may be considered a long life." We may add that in these announcements of "Expiring Patents" it is always assumed that the patents have not prematurely lapsed through non-payment of renewal fees. These notes are mainly intended as reminders of the dates of the natural decease of old-time patents, but, alas, as our informants remark, there are many deaths from starvation.

Fothergill Prize.—The Council of the Society of Arts offer the Fothergill prize of £25 and a silver medal for a Paper on "The Best Means of Effectually Preventing the Leakage of Current to Earth in Electrical Installations from Generating Heat and Setting Buildings on Fire." This Paper should consist of about 8,000 words, and be written with a view to being read and discussed at an ordinary meeting of the Society. Papers submitted for the prize must be sent to the secretary on or before October 1, 1896. Each Paper must be typewritten, and bear a motto, the name of the writer being enclosed in a sealed envelope with a similar motto. The judges will be appointed by the Council. The Council reserve the right of withholding the prize or of awarding a smaller prize or smaller prizes, if in the opinion of the judges no essay deserving the full award is sent in.

Niagara as a Manufacturing Centre.—At the conclusion of an article on "Modern Machine Shop Economies," in the current number of the *Engineering Magazine*, Mr. Horace L. Arnold says that "So far the supposed vast advantage of power supplied from Niagara Falls does not cut any figure at all as a dominating factor of shop location. It is even denied that at near by Buffalo Niagara Falls motive power can be furnished more cheaply than steam power, and machine-shop motive power is, in a vast majority of cases, a very small cost item in the grand total of production outlay. A more extended consideration of the subject will, it is believed, fully warrant the conclusion that the character of the workers obtainable, the health and comfort of the workers, and the fixed charges of transportation of both raw material and finished product, should be the considerations deciding the location of a machine shop intending removal from its present location."

The Life of Incandescent Electric Lamps.—The following record of the life of some incandescent lamps used in the engine and machine room of the Great Southern and Western Railway at Cork is given in *Engineering* by Mr. W. M. Smith, District Locomotive Engineer, Great Southern and Western Railway:—

——	Lamps.	Hours.	Maximum life. Hours.
Average life.....	38	3,471	11,005
"	17	2,140	5,468
"	9	5,337	17,880
"	5	1,879	23,434
"	6	6,747	15,517

Lamps Still in Use,

	Hours.
4 lamps which have run over.....	30,000
1 " "	17,600
1 " "	15,000
2 " "	10,000
4 " "	4,000
1 " "	3,400

The lamps are all 50-volt 16 c.p. lamps, and are run off an alternating current circuit.

Physicists of the Impressionist School.—The articles on Röntgen rays now appearing in American newspapers almost daily seem to be too much for Prof. David Starr Jordan, of San Francisco, and he delivers himself in the following way in a local paper:—"Mr. Inglis Rogers and other physicists of the impressionist school are now prominent in the newspapers on account of the supposed relation of their achievements to the discoveries of Prof. Röntgen. Röntgen, and since him many others, have obtained shadow photographs from invisible light vibrations connected with the so-called cathode rays. These light waves passed through matter which is nearly impervious to the ordinary vibrations. Mr. Rogers has produced an impression on the photographic plate by simply gazing on it in the dark. Others claim to do the same by gazing only with the mind's eye, giving a photographic image of the subject of their thoughts. By this means they produce definite chemical action where no material basis for such action exists. Astonishing as all this is, greater works were done in the same line centuries ago. The sages tell us that when Odin and his friend tried to secure the golden mead of the giants, they found it locked up in a stone house. Then they sat down and gazed at the house all day, until by this means they had bored a small hole through the rock walls. This done by concentrated psychic effort, Odin had only to take the form of an angleworm and crawl through the hole to secure the mead. This he did, and, resuming his own form, carried it away with him to Asgard. This seems still more remarkable than any of Mr. Rogers' achievements, because Odin used neither lens nor photographic plate, and recorded his psychic impressions on a bare stone wall. Moreover, the record of his work is better authenticated than that of the recent impressionist photographers. If any one doubts, he will find anywhere the materials to try it for himself. Moreover, the old mythology rests on honest facts of Nature."

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MOTIVE POWER AND GEARING.*

BY E. TREMLETT CARTER.

(*Concluded from page 480.*)

Gearing in Relation to Electric Power Stations.

A short series of articles upon the subject of "Gearing" was contributed by the author to *The Electrician* in August and September, 1892. The construction, working and efficiency of engine and motor gears were discussed in that series. It will suffice, therefore, in the present series to supplement those articles by some discussion of the relation of gearing to the construction and working of an electric power station.

The following forms of gearing are in use at the present time or have been used in the past, in electric power stations:—

I. Single-motion rope gearing, with a free horizontal drive. This class may be subdivided into: (*a*) the American system, consisting of one rope passed several times around both pulleys; and (*b*) the English system, in which each pair of grooves carries a separate rope.

II. Single-motion belt gearing, with a free drive. This class may be sub-divided into: (*a*) horizontal drive, and (*b*) vertical or inclined drive, from one floor to another. Subsystem *b* is largely met with in the United States.

III. Single-motion belt gearing, with jockey pulley. This class is invariably worked with a horizontal drive. It is used in several British power stations, *e.g.*, at Manchester, the City and South London Railway power station, and in some of the Isle of Man railway power stations.

IV. Countershaft double-motion gearing. In this class the engine or engines actuate a countershaft, either by rope or belt gearing, and either on a horizontal, inclined or vertical drive; and the dynamos are driven from pulleys on the countershaft, by ropes or belts. Happily this class is practically obsolete in the United Kingdom; but examples of it are to be met with in the United States and in some of the Colonies.

V. Countershaft single-motion gearing. In this class the engine is direct-coupled to the countershaft, which drives the dynamos by ropes or belts. It is rarely used at the present time, but was formerly adopted in some small stations.

VI. Worm gear. A class exclusively confined to stations using very high speed steam turbines. The gear forms a part of the engine equipment, and the engine and dynamo are on one bed-plate.

VII. Bevel cog gear. Water-power stations in which the turbines drive a vertical shaft, while the dynamos are provided with horizontal shafts, are worked with bevel cog gear. *E.g.*, at the Worcester-Powick station.

The causes which have led to the use of gearing in power stations are numerous. In the majority of places its use may be said to have marked a transition period; some of these places having already emerged from that period, while others are still passing through it. Such a transition period arose from the want of adaptability in speed, between the dynamos and engines. It is the index of instability and lack of finality in engine and dynamo practice, as regards electric power stations. In the early days of electric lighting in this country, for instance, high-speed steam engines were not developed; and the small loads for which dynamos had to be built, together with an imperfect knowledge of dynamo design, led to the entire use of very high-speed dynamos. Some form of gearing, to adapt the slow engine to the fast-moving dynamo, was inevitable. And not until the construction of both dynamos and electric lighting engines had become a matter of importance, was it worth while for engine and dynamo builders to combine to produce plant which could be run without intermediate gearing.

That this cause, though adequate to explain much of the use of gearing, does not cover the whole case, is, however, apparent from the existence of a number of quite modern stations where gearing has been deliberately used. Where these are power stations for railway work, the reason is largely to be found in the lingering belief that direct-coupled railway generators are not reliable, or, at any rate, are not so reliable as rope or belt-driven sets. This, no doubt, will explain the use of gearing in nearly all the railway and tramway power stations in the United Kingdom; though, perhaps, other reasons have existed, in one or two instances, where stock American dynamos have had to be run by engines of British make. When electric traction has grown to be a matter of greater importance in this country, and when engineers here have learned from American practice that direct-coupled railway generators can be made a success, we may expect that the same adaptation of engine and dynamo speed, to enable direct-coupled sets to be used, will occur, as has already occurred in electric lighting stations.

There still remains to explain the causes which have led to the erection of recent electric lighting geared stations. An important factor, no doubt, is the business interests of firms whose steam engines are exclusively adapted to rope or belt driving, such as the makers of mill engines. But this is not the whole reason, for there still exists a class of engineers who disinterestedly believe that the slow-speed steam engine is to be preferred to the high-speed rival, and who, when they cannot get dynamos that can be coupled direct to such engines, have no hesitation in using ropes or belts. Upon these honest advocates of slow-speed geared engines the mantle of the pre-electrical engineers has fallen, and it is little to be doubted that their preference is due to their large experience of the mill engine and their slender acquaintance with the high-speed engine.

Finally we have to notice a cause of gearing practice which, until the last few years, applied especially to alternate-current stations. Until quite recently engineers have found insuperable difficulties in building direct-driven alternators of small or moderate power. Even at the present time the majority of small alternators are rope or belt geared. The cause arises from the necessity to develop a certain frequency of alternation, whatever the size of the machine; and this can only be done by means of peripheral speeds which, in the smaller sizes of alternators, have in the past precluded direct driving. Other considerations have also affected the question, but these are of so electrical a nature as to be beyond the scope of the present series. At the present time, by the use of steam turbines or by modifying the construction of both engine and alternator—as in the flywheel type of alternating current set—moderate, and in some cases even small power can be provided by means of direct-driven plant.

The history of electric power stations in all parts of the world supports the idea of a transition period already mentioned, and clearly shows that the majority of engineers—or, to put it somewhat differently, the weight of engineering opinion—tends to the ultimate elimination of gearing. Two distinct lines of practice have been followed in this resort to direct-driving: (1) the British practice, consisting in the use of high-speed sets; and (2) the Continental practice, consisting in the use of low-speed sets. In the United States there are now distinct signs that the transition period is nearing its close; for the number of direct-driven stations is rapidly on the increase. Both the British and the Continental plans are being adopted, though preference seems to be for the latter.

Influence of Gearing upon Station Construction and Prime Cost.

The use of gearing in an electric power station is very far-reaching in its influence, affecting not only the engine itself, but, indirectly though appreciably, almost every detail of the buildings and works. We will now briefly consider some of its most important effects in this respect; and, to simplify matters, we will confine our numerical considerations to rope-gear, since this is the most commonly-used form of gearing. But it will be understood that the conclusions affect, in a proportionate degree, every form of gearing.

I. **Influence upon the Engine.**—The size of the engine will be increased by the use of gearing: (1) because the additional frictional loss due to the gear will necessitate a greater engine

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indicated horse-power, and therefore a larger size; and (2) because the use of gearing implies the use of a low speed, and therefore of a larger engine as compared with a high-speed engine of *equal* power. Further, the side stress imposed by the gearing on the pulley will make it necessary to strengthen the engine accordingly.

The actual amount of power lost in gearing has been a matter much debated. The researches of the Committee of the Société Industrielle du Nord de la France, formed to investigate the comparative efficiency of ropes and belts for the transmission of power, threw little or no light upon the matter. A translation of the Report of this Committee was read by Prof. D. S. Capper before the Institution of Mechanical Engineers in October, 1895, and at the discussion on this Report the general opinion seemed to be that the efficiency of a free single-drive rope gear ranges from 90 to 94 per cent. at normal load. It would appear to be practically certain that the frictional resistance of rope or belt gear is constant at all loads, from zero load up to the normal load, so that if the engine is run at constant speed the power lost is constant and independent of the load on the dynamo or engine. We may, therefore, consider the frictional loss arising from the use of rope or belt gearing as being equivalent to an increase in the engine friction equal to from 6 to 10 per cent. of the full engine brake horse-power. Applying this to an engine-dynamo set, we see that to obtain 100 H.P. on the dynamo shaft we must provide an engine giving from 106 B.H.P. to 110 B.H.P., as against only 100 B.H.P. if we have direct driving.

And not only will the size of each engine have to be increased for these reasons, but it not unfrequently happens that in a geared station a much larger unit of dynamo power is adopted, with fewer sets. This would not matter if it did not give rise to an unnecessarily large margin of power in the station. In a direct-driven station the smallest unit is often one-twentieth or a less fraction of the total power of the station; in a rope-driven station it is usually one-fourth or one-fifth, but in some instances it is so great as one-third or even one-half. The effect of this upon the amount of stand-by plant, and on the capital outlay upon machinery is obvious.

II. **Influence upon the Dynamo.**—Assuming the speed of the dynamo to be the same, whether direct-driven or geared, the only effect of using gearing will be to necessitate strengthening the bearings, shaft and certain other parts, and the use of a separate frame, bed plate and foundations, with appliances for adjusting the length of the drive when the gearing wears slack.

III. **Influence upon the Boiler Plant.**—The boiler plant and, in fact, the entire equipment of the boiler house, as well as the steam mains, will have to be constructed to deliver at full load an additional amount of steam per hour, corresponding to the extra consumption which the larger size of engine and the gearing losses will involve. This additional capacity will be in simple proportion to the additional indicated horse-power of the engine plant.

IV. **Influence upon the Buildings and Area of Site.**—In the majority of British electric power stations the engines and dynamos are on the same floor, the former being in some few cases raised above the dynamo level to facilitate rope driving with large pulleys. In these stations, therefore, the use of gearing involves additional floor space and a larger machinery room. A type of station commonly met with in America, but very rarely seen on this side of the Atlantic, has an engine floor below the dynamo floor, the dynamos being driven by belts passing through the dynamo floor. In this case the area of site is not increased, but the height and cost of the building will be augmented, as compared with a direct-driven station. Moreover, in all geared stations, the fact that the engines themselves occupy more space, apart from the space covered by the rope drive, should not be overlooked; but this is a matter which only enters into the comparison of geared stations with *high-speed* direct-driven stations. The allotment of floor area in a number of electric power stations is given in detail in Table XXXVII.

V. **Influence upon the Prime Cost of the Station.**—A comparative study of the capital outlay effected by the various electric supply concerns in the United Kingdom leaves no room for doubt that the use of gearing, as opposed to direct-driving at high or moderate speed, does affect prejudicially the capital cost of the station. Nor could this be otherwise, considering the influence which the use of gearing has upon the various items already enumerated. Yet it is at first sight a matter for some surprise, that the comparison between the actual costs of geared and direct-driven stations does not show that great and invariable difference which the foregoing considerations might lead one to expect. The author has compiled Table XXXVIII. from the reports for 1895, issued, under the direction of the Board of Trade, by the various electric supply concerns enumerated. This Table gives the capital outlay, per 8 c.p. lamp of station capacity, for the entire station, including the cost of lands, buildings and machinery, but excluding the cost of transformers, accumulators, mains, switchboards and instruments. In a parallel column is given the cost, per 8 c.p. lamp of station capacity, of the generating machinery alone, including boilers, engines and dynamos, with all their auxiliary generating plant, but excluding transformers, accumulators, mains, switchboards and instruments. It is to be regretted that the published capital accounts do not permit of further analysis, for it is highly probable that a comparison of the cost of engines alone, per 8 c.p. lamp, would have shown even greater differences between the geared and the direct-driven stations.

By way of comment upon Table XXXVIII., it may be pointed out that the figures tend to show much more that the geared stations have been placed in small country stations or at distances from towns where land can be had cheaply, than that they have actually cost more than the direct-driven stations. Thus, a direct-driven London station may have cost actually more per 8 c.p. lamp of station capacity, than a rope-geared station, owing to the enormously higher cost of land per square foot, the extra sum paid for better buildings, and the cost of bringing the machinery to town and erecting it there. In support of this interpretation the author would call attention to Table XXXIX., which gives the proportion of geared and of direct-driven stations in large cities and in country towns in the United Kingdom.

In compiling this table stations which are equipped with both geared and direct-driven sets have been omitted.

Table XXXVII.—*Showing the Influence of Gearing upon the Floor Area of the Machinery Room in Electric Power Stations.*

Place.	Capacity of station in kilowatts.	Type of engines.	Arrangement of gearing or coupling.	* Sq. ft. gr'ss area per kilowatt.	* Sq. ft. net area per kilowatt.
Bristol	1,316	Vertical, high-speed.	Direct-coupled.	1·938	1·276
Brighton	810	Vertical, high-speed.	Direct-coupled.	3·024	1·518
Portsmouth ...	848	Horizontal, low-speed.	Direct-coupled.	4·068	2·948
Amsterdam ...	1,335	Horizontal, low-speed.	Direct-coupled.	4·768	3·018
Manchester ...	1,320	Vertical, low-speed.	Belts, with jockey pulleys.	4·848	3·333
Dublin-Dalkey (elec. tramw'y)	440	Vertical, high-speed.	Belts, free drive.	5·102	3·432
Cologne	1,160	Horizontal, low-speed.	Direct-coupled.	6·455	4·095
Belfast (gas engines).	393	Horizontal, tandem, low-speed.	Rope drive.	5·458	4·580
Amberley-road, London.	600	Horizontal, low-speed.	Rope drive.	9·666	4·753
Worcester (steam and water).	500	Vertical, moderate-speed, with water turbines.	Rope drive.	6·860	5·750
Wolverhampt'n	485	Horizontal, low-speed.	Rope drive.	8·907	5·752
Coatbridge (gas engines).	150	Horizontal, low-speed.	Rope drive.	16·467	10·133

* By gross area is meant the total area of the floor already occupied by the plant; and by net area is meant the gross area, *less* the uncovered space surrounding the block of machinery. The net area includes the floor covered by the engines, gear and dynamos, and the gangways between the separate sets of plant, but not the gangways surrounding the entire plant.

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Table XXXVIII.—*Showing the Relation of the Type of Engine and Method of Coupling or Gearing, in Some Electric Supply Stations, to the Capital Outlay on Lands, Buildings and Generating Machinery per 8 c.p. Lamp of Station Capacity.*

Type of engine and method of coupling.	Place of station.	* Capacity of station in 8 c.p. lamps.	Capital spent on land, buildings and generating machinery per lamp of station capacity.	Capital spent on generating machinery per lamp of station capacity.
			£	£
Steam turbines (very high speed).	Newcastle and District	25,000	1·160	0·917
	Scarborough	21,000	0·862	0·560
Vertical high-speed engines, direct-coupled.	Aberdeen	14,000	1·017	0·695
	Birmingham	30,000	1·751	0·795
	Chelsea	50,000	1·446	0·883
	Hove	13,000	1·552	1·075
	Hull	20,000	0·916	0·751
	Kensington and Knightsbridge	74,180	1·105	0·672
	Liverpool	50,000	0·973	1·089
	Notting Hill	16,000	1·811	0·661
	Preston	18,060	1·521	1·212
	St. James' and Pall Mall	78,000	1·946	0·838
	Westminster	102,900	2·141	1·150
Medium-speed engines, direct-coupled.	Dover	11,000	3·419	1·319
Stations with both rope-geared and direct-coupled engines.	City of London	150,000	3·122	1·499
	Hanley	20,000	0·847	0·519
	Northampton	7,000	1·437	0·983
	Sheffield	26,000	1·457	0·907
Horizontal low-speed engines, rope-geared.	Burnley	10,100	1·502	0·586
	Earl's Court	25,000	1·835	1·246
	Leeds	25,000	1·905	1·061

Table XXXIX.—*Showing the Number of Geared and Direct-Coupled Stations, according to the Size of the Station.*

Type of station.	Number of direct-driven stations (January, 1896).	Number of geared stations. (January, 1896).
Over 10,000 lamps capacity	37	15
Not exceeding 10,000 lamps capacity	16	22
Not exceeding 5,000 lamps capacity	3	14

Influence of Gearing upon Annual Expenses.

In the same way that gearing exerts an intricate influence on the amount of the capital outlay for a station, so will it affect many of the items of the annual expenses involved in running the station. We will now consider its influence in this respect, commencing with the generating expenses.

I. **Influence upon the Coal Bill.**—It has already been stated that at full load rope gear involves a loss of from 6 per cent. to 10 per cent. of the brake horse-power which is supplied to it, and that it wastes this *amount* of power during all the time that it is run at full speed. Considering this last as being equivalent to an increase of engine friction by an equal amount, we may calculate the reduction in efficiency of the engine-dynamo set, and the steam consumption, in the same manner as we have already, in a previous article, obtained the relation of the brake horse-power consumption to the indicated horse-power consumption of the engine itself. In this way we may obtain, for any engine and set of gearing, a Table similar to Table XL., which latter has been compiled on the following assumptions:—It has been assumed that 100 B.H.P. full load is required at the dynamo shaft, and that in one case this is supplied by an engine of 100 B.H.P., direct-driving, while in another case it is supplied by a proportionately larger engine, rope-geared. The steam consumption is assumed to follow Willans' straight-line law, and the two engines being of such nearly equal power, it is assumed that the *constant* loss of steam is proportional to the rated horse-power, and this constant has been taken at 500lb. for the direct-coupled engine and (*pro rata*) at 550lb. for the geared engine. These data are sufficiently removed from laboratory or test conditions to give practical value to the results. Thus the steam consumptions are taken according to the equations:—

$W = 500 + 15\ P$ . . . (for the direct-coupled engine), and

$W = 550 + 15\ P$ . . . (for the rope-geared engine) where W is the weight of steam per hour, and P is the brake horse-power developed at the *engine* shaft. The efficiency of the rope gearing at full load has been taken at 90 per cent.

It will be seen that, under the conditions assumed in Table XL., the effect of gearing is to increase the steam consumption by *at least* 10 per cent. This minimum augmentation occurs at full load; but the increase becomes greater as the load falls, so much so that at half dynamo load the gearing involves an increase of 16 per cent. in steam consumption; while at quarter load the increase is nearly 23 per cent. Obviously, the way to minimise this effect is to keep the set on a high load factor, and to avoid very low loads. But it is to be noticed that it is more difficult to do this, in proportion as the power of the station is contained in few sets; and that geared sets are, as a rule, larger units—in proportion to the station power—than direct-driven sets. Consequently, there must be a greater tendency in geared sets to run to low engine load factors, and a consequently greater loss by augmented consumption of steam and coal. In quite lurid confirmation of this the consumption of coal at the Worcester steam and water-power station may be cited. According to the official report of the resident engineer, the lack of water-power made it necessary to run the steam engines on low day loads for long periods. As a consequence, the engines being rope geared, the coal cost no less than 0·745d. per unit generated, including the units generated by the water-power.

Table XL.—*Showing the Influence of Gearing upon the Engine Brake Horse-power required to Supply 100 B.H.P. to a Dynamo, and on the Consumption of Steam per Hour and per useful Horse-power per Hour, when the Dynamo is running at various Fractions of Full Load.*

B.H.P. to be supplied to dynamo.	B.H.P. to be developed by steam engine.		Steam consumption in lb. per hour.		Steam consumption in lb. per hour per useful B.H.P. at dynamo.	
	Direct-driving.	Rope-geared.	Direct-driving.	Rope-geared.	Direct-driving.	Rope-geared.
100	100	110	2,000	2,200	20·00	22·00
90	90	100	1,820	2,020	20·22	22·44
80	80	90	1,700	1,900	21·25	23·75
70	70	80	1,550	1,750	22·14	25·00
60	60	70	1,400	1,600	23·33	26·67
50	50	60	1,250	1,450	25·00	29·00
40	40	50	1,100	1,300	27·50	32·50
30	30	40	950	1,150	31·67	38·33
20	20	30	800	1,000	40·00	50·00
10	10	20	650	850	65·00	85·00
5	5	15	575	775	115·00	155·00
0	0	10	500	700	...	...

II. **Influence upon the Generating Expenses.**—Not only the cost of coal, but other items in the generating expenses are affected by the use of gearing. It may be a disputed point whether more oil and waste will be used in every case if gearing be resorted to, though the author is inclined to believe that more would generally have to be used. Certainly more water will be used; and where water has to be purchased, or to be handled at any expense, the cost will be proportionately raised by the use of gearing. Repairs and maintenance of the machinery may also be affected by the use of gearing, though the point is open to doubt. It has been claimed that low-speed engines do not wear so fast as high-speed engines, a matter which may possibly be conceded in the case of vertical engines. In order to settle this point by appeal to actual stations, it would be necessary to examine the sums paid for repairs and maintenance over a considerable number of years; and the manner in which the accounts are rendered does not facilitate this, at present. In Table XLI. the author has analysed the influence of gearing upon the total generating expenses of a number of stations in the United Kingdom; and a parallel column gives the cost of coal at these stations. The extremely large variations in the prices paid for coal considerably affect the relative costs of various stations. The

* The lamp capacities are taken from "*The Electrician*" *Electrical Trades' Directory and Handbook for 1896.*

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statistics are for the year ending December 31, 1895; and the costs are given per Board of Trade unit generated, as measured at the station switchboard.

Table XLI.—*Showing the Relation of the Type of Engine and Method of Coupling or Gearing, in some Electric Supply Stations, to the Generating Expenses per Board of Trade Unit Generated.**

Type of engine and method of coupling.	Place of station.	Units generated in 1895.	Generating expenses per unit generated, in pence.	Cost of coal per unit generated, in pence.
Steam turbines.	Newcastle and District	782,868	0·8651	0·3760
High-speed engines, direct-coupled.	Aberdeen	159,777	1·0843	0·2899
	Hull	273,213	1·6904	0·5647
	Preston.....	300,699	1·1923	0·4078
	Westminster ...	3,371,327	1·1796	0·4822
Medium-speed engines, direct-coupled.	Dover	77,851	3·3418	1·6636
Stations with both rope-geared and direct-coupled engines.	Hanley	225,575	1·6106	0·5947
	Sheffield	418,197	1·7427	0·6122
Low-speed engines, rope or belt-geared.	Burnley	168,637	0·7754	0·2832
	Oxford	295,185	1·1998	0·3861
	Worcester†	348,251	1·6034	0·7454

III. **Influence upon the Management Expenses, &c.**—The items of expense included under "rent, rates and taxes" will to some extent be affected by the use of gearing, inasmuch as the station will cover a larger area of land, and will also involve a larger capital outlay on buildings and machinery, to be taxed. The item of "rent" cannot well be analysed in the official accounts, as the stations covering greater areas per unit of power are usually situated where land is cheaper. As to rates and taxes, the erratic manner in which these are assessed makes any analysis impossible. A direct comparative study of the sums paid for "management" does not yield any fruitful result, as the effect of using gearing is probably very involved. The history of electric supply, both in this country and in America, however, will furnish non-mathematical data from which it could be inferred that the management is often largely influenced by the behaviour of gearing. Where a station is suddenly extinguished during a busy hour on a Saturday night, and the cause is directly due to the parting of a rope gear, or where the same thing occurs on account of a belt leaving the pulley, a considerable loss of revenue occurs that will not be directly laid to the account of the gearing, but which would have been prevented by the use of direct-driven sets.

In conclusion, it may fairly safely be predicted that the use of gearing in both electric supply and electric traction stations will gradually disappear. So far as those stations which are already equipped with geared plant are concerned, it seems most probable that when extensions and renewals of plant take place direct-driven sets will gradually replace the present plant. And as regards stations for the development of tractive power, the success which the direct-coupled railway generator is meeting with in America cannot fail to lead ultimately to the abandonment of the use of gearing in these also.

Motocycle Civilisation.—"When the motocycle has performed its work," says a writer on "Horseless Carriages," in *Cassier's Magazine*, "it may be run into the shed or into the parlour after cleaning it. If the owner chooses, he may fit it with a coueh and make it a common article of furniture in the house."

* So few electric supply concerns publish, in their annual returns, the number of units generated, that this Table necessarily covers only a very limited number of stations. It is hoped to expand it as data increase.

† The Worcester station is partially driven by water power, but the units generated by this means are not distinguished, in the accounts, from those generated by steam. The generating expenses and cost of coal are therefore for each unit of the *total* number of units generated.

THE CALCIUM CARBIDE PLANTS AT SPRAY AND NIAGARA FALLS.

The carbide plant at Niagara Falls is the first to be erected and operated in America outside the parent plant in Spray, N.C., illustrations (Figs. 1 and 2) of the furnace of which and the electrode are given in connection with this article. Coke and lime are the simple and cheap ingredients from which calcium carbide is made. When finely divided and intimately mixed they are smelted together in an electric arc furnace.

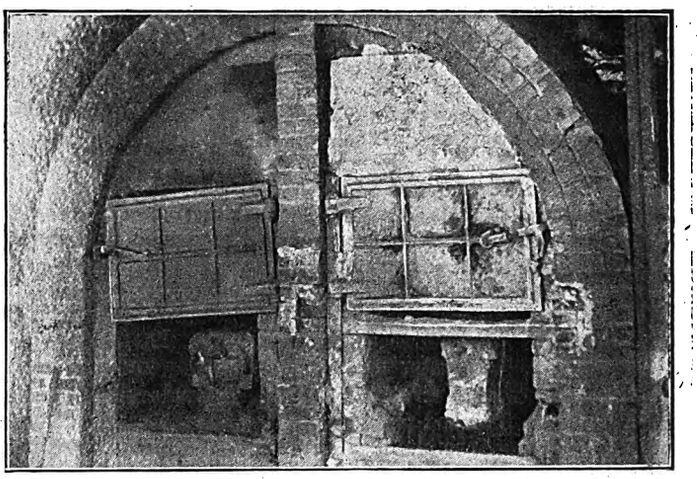

Fig. 1.—Calcium Carbide Electric Furnace at Spray, N.C.

Any form of carbon can be used, but coke gives the best results; any form of lime, either burnt lime, limestone, or slacked lime, but quicklime gives the best results. The coke is ground to an impalpable powder with crushers and rollers, then sieved through a 50-mesh sieve. The lime is crushed and ground the same way, but not sifted. The coke and lime are then weighed out in proper proportions and mixed in a mechanical mixer. It is impossible to overestimate the importance of finely crushing the constituents and of thoroughly mixing them. From the mixing machine the

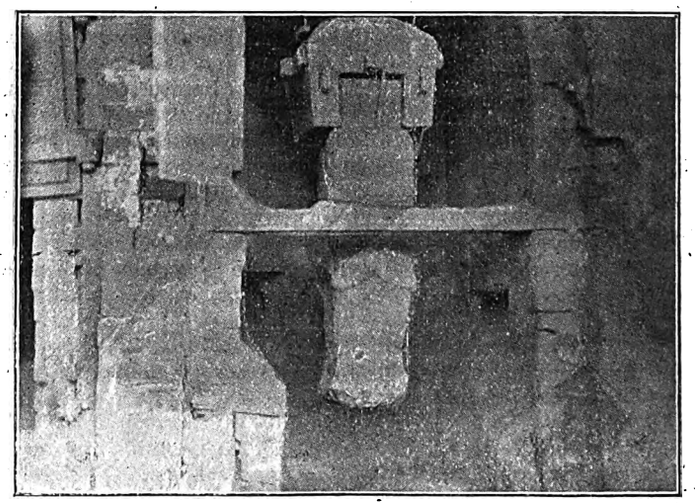

Fig. 2.—Electrode of Calcium Carbide Furnace.

mixed material is carried to the electric furnace. A supply for as long a time as the design of the building will permit can be stored. No deterioration takes place after the mixing of the materials. The lime air-slacks to a very limited extent. This, however, makes very little difference.

Each of the four furnaces at Niagara contains a cast-iron crucible 8ft. 6in. long, 2ft. 8in. deep, and 2ft. 2in. wide. The electric furnace consists of a horizontal bed plate or crucible connected to one pole of the generator or transformer, and of a vertical carbon pencil connected to the other pole, suspended

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above the centre and capable of moving in a vertical direction. The process is started by attaching the carbon pencil to the bed-plate. The carbon pencil is then raised, imposing an air gap in the circuit. Having established the arc in this manner, the material is fed in towards the crucible or bed-plate covering the arc and surrounding the pencil to a depth of from 2ft. to 3ft. The production of carbide begins immediately. The carbide thus produced forms under the pencil, and tends to close the air gap. As the air gap is shortened the resistance of the furnace is lowered, and the attendant in charge then raises the pencil so as to lengthen the air gap. This adjustment is necessary every few minutes. One man of ordinary intelligence can attend four furnaces. An ammeter showing the flow of current to each furnace is placed in immediate proximity to the carbon-raising device. After the process has been going on in this manner for from one to three hours, a column of carbide from 1ft. to 4ft. in diameter is formed between the bed-plate and the bottom of the carbon pencil, the arc being maintained between the top of the column of carbide and the bottom of the pencil. As the carbide formed is a substance of more or less high electrical resistance, and as this remains in circuit after it is formed, it is economical to stop the process, clear out the crucible, and make a new start after a column of 2ft. to 6ft.—according to the capacity of the furnace—has been produced. The process of drawing a charge consumes from three to five minutes. The carbide is then allowed to cool, after which it is broken up and may be stored.

Each of the furnaces at Niagara is designed to consume 500 H.P. The bed-plate in the furnaces at Niagara consists of a cast-iron crucible placed on a car, which is run into the furnace on a track under the carbon pencil. A clamping device makes the necessary electrical contact on the side of the crucible. The pencils consist of six carbon slabs 46in. long, 4in. thick, 8in. wide at lower end, and 16in. wide at the upper. These are clamped in a cast-iron holder, which in turn is secured to the end of a copper rod 3½in. by 3½in. Flexible copper cables are fastened into the upper end of this rod, to permit of a vertical movement of about 12ft. The carbon pencils, the carbon holder and the rod are all counterpoised to lessen the work of raising and lowering the electrode. After the arc is started the mixed material is fed into the crucible by opening a shoot and allowing it to drop in from a bin located above the furnaces.

The furnaces are of simple construction. They consist merely of retaining walls of ordinary red brick to prevent the material from flying about and being blown mechanically out of the crucible. Carbide has been and can be made on an open hearth without any side walls whatever. The furnaces for the present are wired in parallel, and two will be in operation at the same time. Some dioxide of carbon is produced during the process, and this carries out of the furnace mechanically a small portion of the lime and coke. To provide a settling chamber in which this can be recovered, a flue 12ft. long, with hanging walls and diaphragm, is built at the back of the furnaces and along the floor to a vent at some convenient point. Each 500 H.P. furnace will, it is asserted, produce in one day about 2½ tons of carbide.

The electrical equipment of the plant at Niagara consists of one 1,000 H.P. single-phase transformer and a "reactive" coil, to be used in starting the furnaces. The is also a 75 H.P. two-phase 2,000-volt motor running at 375 revolutions. This 75 H.P. motor is used for operating the crushing, grinding and mixing machines, elevators and conveyances. The electrical equipment was furnished by the General Electric Company, of Schenectady, N.Y., and Lynn, Mass.

At the time of writing but little remains to be done at the Niagara factory before it is operated. Some delay has been caused by the failure or oversight to make proper water connections, and this is now being done. The power for the plant will be obtained from the Niagara Falls Power Company, and as the factory site is some distance beyond the end of the subway, the cables are carried in boxes placed just above ground, and will so remain until the subway is extended, which probably will be this spring. It is highly probable that before this article is in print the electric current will be turned into the furnaces.

DESCRIPTION OF GEAR FOR THE JAPANESE SUBMARINE CABLE STEAMER, "OKINWA MARU."

Some months ago we announced that the new Japanese Government steamer, the "Okinwa Maru," would be equipped with cable-gear by Messrs. Johnson and Phillips, who had also secured the order for fitting the vessel throughout with electric lighting plant and fittings. We now give particulars of this equipment. The combined picking-up and paying-out gear, as shown in the photographs which we reproduce, is very compact, and has been constructed principally of steel so as to combine strength with lightness, the weight all told being only about 21 tons.

Although specified to pick up under a strain of 25 tons at 175lb. pressure, we understand that the gear on official trial showed itself equal to a much greater pressure. Compared with the gear by the same makers fitted on the "John Pender," "Great Northern," "Chiltern," "Electra," "Magneta," "Recorder," "Relay," "Citta de Milano," and many other steamers, it is equally powerful as the three first named, and twice as powerful as the others, while at the same time it is lighter and more compact.

The gear stands on a strong steel girder bed on the main deck, and the drums (which may be worked separately or together at will), &c., project through a hatch in the spar deck, and this is fitted with covers which form the driving platform for the machine. The gear has overhung drums, 6ft. 3in. in diameter by 2ft. 6in. wide, internally geared, and running loose on a fixed shaft carried on two steel frames, and is arranged for four speeds. The motive power consists of one vertical compound engine, having cylinders 12in. and 24in. in diameter by 14in. stroke, capable of developing 265 H.P. without the use of the condenser, in conjunction with which it will, however, generally be used. The engine is fitted with link-motion reversing gear, and also with automatic bye-pass valve for admitting high-pressure steam to low-pressure cylinder for starting. The crankshaft is geared to the first motion shaft of the machine by means of double-helical bevil gear. When it is desired to pay out without steam power, the only moving portion of the machine is the drum, which is readily controlled by the brake. To enable the drum to revolve independently of any other part of the gearing, provision had to be made for sliding the drum pinions out of gear, and as it was essential to keep the drums close up to the frames, these pinions have been arranged to draw through the frames. This has been effected in a very neat manner by the makers, two large holes being cut in the frame plates and a large pocket casting fitting into these, carrying bearings each side of the frames, so that the pinions which gear into drums run between two bearings, the arms of the drum being set back to allow for this outer bearing, and this arrangement ensures a very substantial job. These pinions are put into and out of gear by means of a combination of hand-wheels, screws and bellcrank levers. All wheels are arranged to draw out of gear when necessary, so that only the particular set required needs to be in gear. Fig. 1 shows a general view of the gear and engines.

The brake straps are of steel plate, fitted with elm blocks. The lower parts of the straps have large cast-iron eyes attached to them, and these are kept in position by means of a shaft of 3½in. diameter, which passes through both frames.

The brake power is applied by means of right and left hand screws working in nuts attached to the upper parts of the straps, the screws being actuated by means of hand-wheels from the starting platform, and when the straps grip the brake drum the pull is transmitted to the machine frames (through the before-mentioned eyes and shaft) and thus to the deck of the vessel. A water service is provided for the brakes, the water being distributed by means of a small Worthington pump.

Each drum is provided with two "knives" for fleeting the cable on the drums to suit either an inside or outside lead, as the case may be. A convenient arrangement is that the working face of each knife is fitted with a hard steel liner capable of being easily unscrewed and renewed when worn.

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There are three sheaves at the bows, 51in. diameter by 11in. wide, the two outer ones being V-section and the middle one U-section. These sheaves are of steel, with gun-metal bushes, and they are arranged to run loose on a steel shaft fixed in blocks carried on four steel girders, which are built into the ship for a distance of several feet, being connected to the beams and to the steel deck, thus ensuring a very substantial job. Each sheave is provided with a cast-iron "whisker," or guard at each side, to prevent the cable from coming off. The two outer whiskers carry davits with a cross-bar for convenience in launching mushrooms, grapnels, &c. The side plating of the ship is carried out to meet these castings, thus giving the bows a very neat appearance.

This has but one sheave, which is 38½in. diameter by 11½in. wide, and is fitted with gun-metal liner to run loose on a shaft fixed on blocks carried by rolled girders. These girders are attached to the deck by means of special castings, which also serve to secure the necessary stopper hooks.

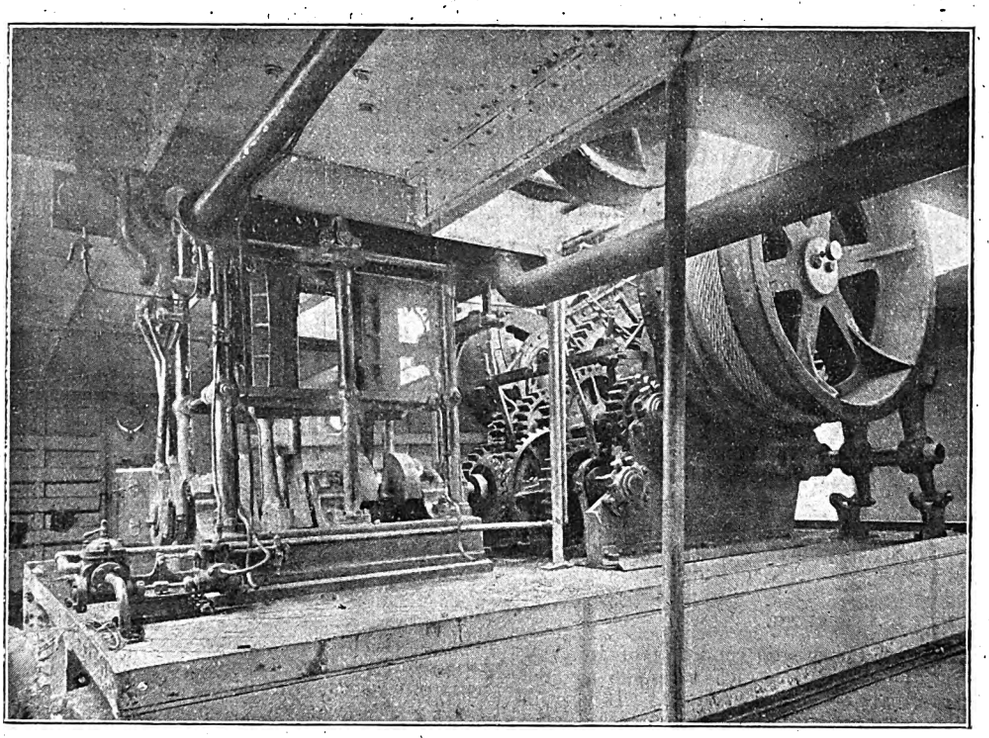

Fig. 1.—General View of Gear and Engines of the Cable Steamer "Okinwa Maru."

The cable machine is placed just aft of the foremast and between it and the bow sheaves are the two dynamometers, one for each drum, the necessary leads being placed at a certain distance on each side of the dynamometers. Fig. 2 is a view of the spar deck looking forward, and shows the dynamometers and gear, as well as the above-mentioned hand wheels needed for the application of brake-power.

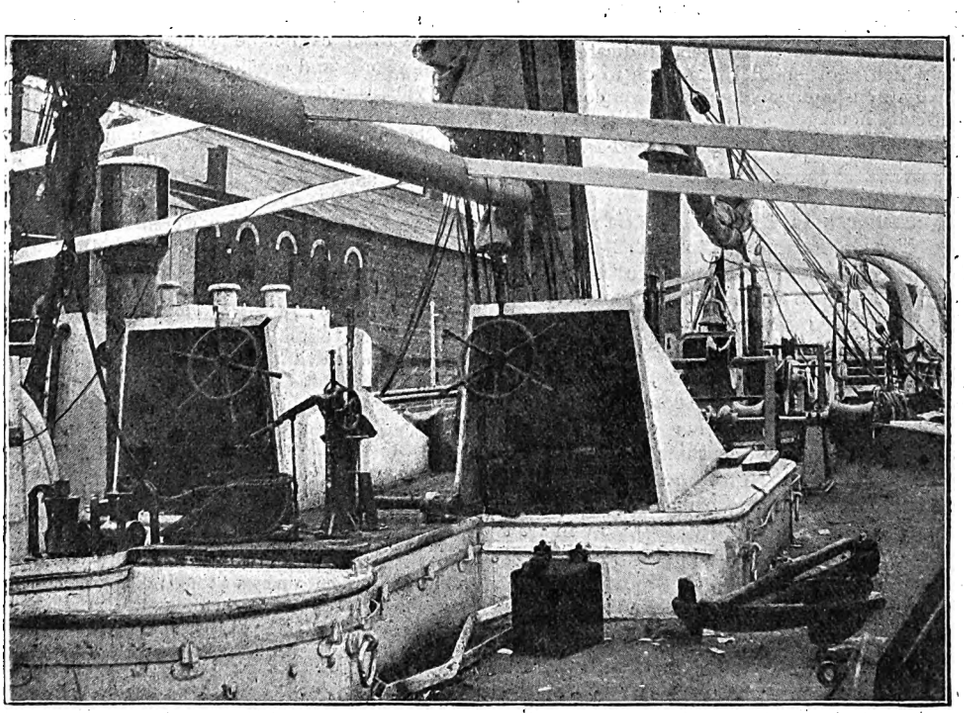

Fig. 2.—View of Spar Deck, looking Forward.

The dynamometers are of Messrs. Johnson and Phillips'

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design, consisting of cast-iron footstep with steel cylinders, on which a large cast-iron sleeve slides, and to this sleeve the sheave is attached, and also two side rods which carry a crosshead some distance above. To the crosshead is attached a piston rod with piston, which works on the outside of the steel cylinder, which is filled with oil, and the piston being a loose fit, this acts as a dash-pot to steady the movement. The top of the steel cylinder is, of course, fitted with a packed gland.

The "Okinwa Maru" was launched on Friday last from Messrs. Lobnitz's yard at Renfrew. She is 290ft. long, 40ft. beam, and depth 24ft. 6in. moulded. The electric lighting arrangements are very complete, the generating plant being provided in duplicate. Duplex electric mast and side lights are provided, and a complete outfit of portable electric lamps for outside use when the vessel is engaged on cable work. The whole of the electric lighting work has been carried out by Messrs. W. C. Martin and Co., of Glasgow.

The Japanese Government, with its characteristic enterprise, appears to have secured a cable ship which will compare favourably with any similar craft afloat. The cable equipment of the "Okinwa Maru" contains many useful novelties, and is in every respect, even to its galvanometers, which are of the Sullivan type, up-to-date.

THE EXAMINATION OF MAGNETIC HOMOGENEITY IN IRON AND STEEL BY MEANS OF ELECTRIC CONDUCTIVITY.*

BY DR. A. EBELING.

Since the examination of the magnetic condition of iron by magnetic methods is a very lengthy process, it is desirable to find some more rapid method of testing for inequalities. It is well known that the electrical conductivity of soft wrought iron is higher than that of soft steel, and the following experiments were carried out to ascertain if there is a direct relationship between the magnetic and electrical properties. Samples of iron and steel were tested magnetically, and were also examined for conductivity throughout their length. This latter test was performed by sending an electric current through the metal, and observing the fall of potential over a constant length at different points along the bar. Since the bars were all carefully turned to a uniform cross-section, the fall of potential was proportional to the mean specific resistance over the length between the contacts.

The result of the examination of some 20 pieces indicates that those iron and steel rods which show small differences in conductivity are also magnetically non-homogenous. To the converse statement that all magnetically homogeneous materials also possess uniform conductivity, there are, however, exceptions (*sic*).

High Admission Requirements in Engineering Schools.—In a leading article in its issue of February 13th, the *American Machinist* criticises the modern tendency to increase the standard of requirements for admission to engineering schools. This is regarded as the most unfortunate development of the educational system in these schools. "High admission requirements are supposed to test the ability of the applicants, and to sift out those who are least capable of pursuing the course of study with profit. In point of fact, they do nothing of the kind. Instead of testing the abilities of the student, their real effect is to test his opportunities, and to sift out those who, by reason of location, occupation, or lack of means, have been denied access to the best preparatory schools. We do not for a moment imagine this to be their object, but it is undoubtedly their effect. . . . Now, if it is desired to keep down the number of applicants, how would it do to require them to have served an apprenticeship in a machine shop? We do not doubt this would be still more effective than the present plan with a large number of the present class of applicants. Or, if this is considered too revolutionary, what is to prevent an arrangement by which previous shop experience should offset some of the more advanced of the present requirements. The time which the present class of students devote to shop work being given by the new class to the preparatory studies in which they would be deficient?"

* Abstract from the *Zeitschrift fur Instrumentenkunde.*

ADVANCES IN THE THEORY AND CONSTRUCTION OF SECONDARY BATTERIES.*

BY F. ZACHARIAS.

All lead batteries, as is well known, suffer from want of cohesion of the active material, even the Planté and Tudor types being no exceptions, for as soon as the oxidation has penetrated to a certain depth, the oxide begins to flake off. The latter types are not suitable for traction purposes on account of their great weight and small capacity. Careful observation and experiment have led to the conclusion that it is the formation of bubbles of gas at the contact of the active material and the support which leads to the destruction of the plates. As the evolution of gas cannot be prevented, means must be provided to facilitate its escape. All mechanical contrivances for strengthening the plates, such as grids and trellises, have failed, for the more rigidly the paste is contained the sooner the destruction of the plate follows, since the gas can only escape through the surface of the paste, which becomes disintegrated in consequence.

What part "Gassing" plays in the destruction of the plate can be best ascertained by the study of a plate in which no provision is made for the escape of gas. After about the fifth charge a small portion of the paste falls from the centre of each plug, but this is obviated if about 100 perforations per square decimetre have been made in the paste with a needle before the plate is formed. The process of forming in plug plates takes place inwards in concentric zones, since the current can only enter the paste from the edge of the plate. Thus the edge portions are formed before the centre, and an injurious strain is set up, which causes the destruction of the active material sooner or later, according to its density or porosity. Provision for the escape of gas from the negative plates is also absolutely necessary, or else the powdery reduced lead on their surfaces is blown off by the gas bubbles. Plug plates have the largest capacity for a given weight, and in them about one-third of the total weight is due to the frame, so in any improved plate this proportion must be approximately adhered to. A paste formed with sulphuric acid does not yield satisfactory results, therefore some other mode of formation must be employed. What is required is a plate of firm, porous, active conducting material of high capacity and small initial cost, so that within limits the durability need not be of primary importance.

The existing plug plate is not suitable for two reasons—first, because, owing to the narrow lead frame surrounding it, it can only be employed with low rates of charge and discharge; and, secondly, because in both the positive and negative plates the action of the current weakens the contact of the paste with the frame, so that the former is liable to drop out. Plates larger than 16cm. by 13cm. cannot be profitably employed.

These results and considerations led to the construction of plates embodying the following five principles:—(1) No portion of the metallic frame should pass horizontally through the paste; (2) the paste should not be retained at its upper edge by the metal frame, but should be free to expand and gas; (3) wherever the frame covers the active material it should be perforated to allow of the escape of gas: (4) the frame should distribute the current evenly, and have the least possible weight consistent with strength and securing the paste; (5) the frame should be so constructed that the material of the negative plates should not lose contact, even when disintegrated.

In the plates so constructed by Zacharias and Dannert all the parts of the plate retaining the paste are perpendicular, and in those plates whose thickness is greater than 15mm. perpendicular strips are also embedded in the paste, so that the surface of the paste in contact with the support is equal to or greater than that in contact with the acid. Great care is taken to provide for the escape of the gas, both in the frame and in the active material, and in the case of thick plates channels even are cut in the paste. It is claimed for these plates that they begin to give off gas during charge earlier than those hitherto employed, but that the gas escapes without forming the large bubbles which disintegrate the paste. After a year's experimental work it was found that an organic substance was most suitable for the preparation of the paste, and it is claimed that with the new plate a capacity of 100 ampere-hours per kilogramme of active material, or 65 ampere-hours per kilogramme of positive electrode can be obtained. The rate of charge is given as 1-2 ampere per square decimetre of surface of the positive plate, while a discharge rate of up to 5 amperes per square decimetre is admissible. Experiments have further shown that in order to obtain the best results the preparation of the paste, as well as the arrangement of the supports, must be altered to suit the requirements of each particular class of work.

Further particulars are promised as soon as the patent rights have been secured in all countries.

* *Zeitschrift für Elektrochemie*, Heft 23, 1895-1896.

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A CONTRIBUTION TO THE THEORY OF LEAD BATTERIES.*

BY DR. WALTHER LÖBB.

Under the above title C. Liebenow recently published his views concerning the reactions which occur in lead batteries, for which he sought a simple explanation, without involving the adoption of Le Blanc's hypothesis of the fourfold valency of lead ions. Working on different lines, the author has been led to adopt Liebenow's opinions in the main, and he hopes shortly to be able to give full experimental proof of them, but in the meantime he publishes a short note on the subject.

In the case of the electrolysis of organic lead salts, the simultaneous deposition of lead and lead peroxide can be obtained without any evolution of gas, and the quantitative estimation of the organic acid made after the cessation of the operation shows that the acid is unaltered.

The author argues that the lead has been replaced by hydrogen from the water, and that the appearance of lead peroxide at the anode cannot be due to the electrolytically evolved oxygen. The lead peroxide probably exists as such in solution, and the oxygen necessary for its formation is obtained from the water.

So far these conclusions are in accord with Liebenow's, but with regard to the part played by water, the author differs, for, in his view, water which acts as a solvent cannot be regarded as a pure liquid; but just as one speaks of the solution and concentration of an electrolyte in water, so the corresponding solution of the water in the electrolyte must be accepted. The liquid resulting from the solution of sulphuric acid in water, can be as well regarded as a solution of water in sulphuric acid, and all reactions which require the separation of the water into oxygen and hydroxyl, and thus represent hydrolytic dissociations, are only explicable as ion reactions if one admits that the capacity to produce oxygen and hydroxyl ions depends on the nature of the body dissolved in the water.

This theory and its results are discussed, and the conclusion arrived at is that the electrolyte is hydrolytically dissociated. The peculiar properties of the lead hydroxide enable it to form oxygen ions as well as hydroxyl ions, *i.e.*, to act as an acid as well as a base, and to this property is due the possibility of the hydrolytic dissociation of neutral lead salts. The appearance of metallic lead denotes the dissociation into lead and acid residue, while that of lead peroxide shows the presence of this ion, which can only be produced by the hydrolytic dissociation of part of the salt.

If only a low current density be employed, the electrolysis of a solution of benzoate of lead can be made to yield only lead and lead peroxide, no gas being evolved, which means that half the salt is electrolytically decomposed and the other half hydrolytically. Under these conditions it appears that as lead and lead peroxide are electrically equivalent, the whole amount of acid remains unchanged in the liquid, as there are four hydrogen ions to regenerate the four acid residues. The dissociation conditions are not always so simple, but from many lead salts the metal and the peroxide deposited are exactly equivalent. It is only under these conditions that no gas is evolved, but the organic acid is always unchanged.

The dual nature of lead hydroxide, which has also been dwelt on by Liebenow, can be easily proved by the electrolysis of an alkaline salt of lead hydroxide, which yields lead and lead peroxide simultaneously.

In considering the case of lead batteries, more prominence must be given to the part played by water, and its dissociation into hydrogen and hydroxyl ions, for it renders possible the formation of lead peroxide: and, owing to the slight solubility of lead sulphate, the conductivity of the electrolyte depends solely on the dilution of the sulphuric acid, *i.e.*, on the ions which yield sulphuric acid under the dissociating influence of the water, and *vice versâ*.

* *Zeitsch. f. Elektrochemie*, 23, 1895-1896.

SAFETY DEVICES FOR TELEPHONE CIRCUITS.†

BY F. MERTSCHING.

At Remscheid, a short time ago, a broken telephone wire came into contact with the overhead conductor of the electric tramway, causing a serious fire in the telephone exchange. This occurrence brought at once to the front the question of how best to prevent heavy currents from entering telephone circuits. At present there are several devices in use. In cases where only a few telephone wires cross the trolley line of a tramway, india-rubber insulated bronze wires can be employed as telephone conductors. It is, however, by far the most common practice to protect the overhead conductor of the tramway by means of a cover. Devices used by the Allgemeine Elektricitäts Gesellschaft are shown in Figs. 1 and 2. In Fig. 1 insulation is afforded by a split india-rubber tube screwed to the top of the conductor. The screws are soldered to the conductor, and large nuts of "stabilit" are employed to ensure good insulation, and prevent a telephone wire from being taken along by a passing trolley. Another device consists of a strip of impregnated wood of the section, shown in Fig. 2, carried by T-shaped brackets soldered to the conductor. As the wooden strip has a slot along the entire length, the different expansions of wood and copper are compensated for. Another way of protecting telephone circuits, especially where a great number cross a tramway, is to fix a wire netting, well earthed, underneath the telephone circuit. Still another arrangement is suggested in a German patent, in which a falling wire disconnects itself at the pole.

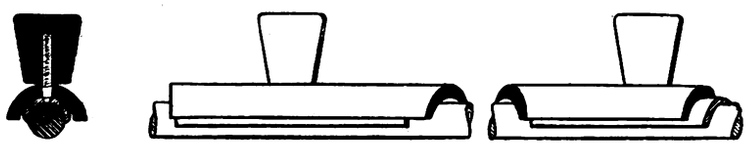

Fig 1.

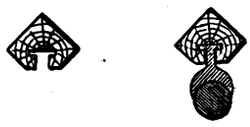

Fig. 2.

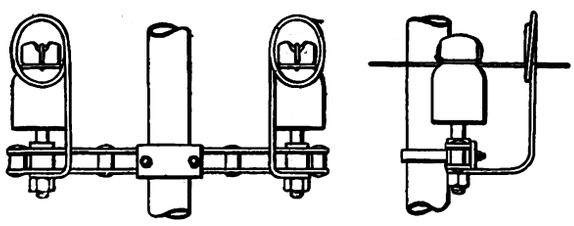

Fig. 3.

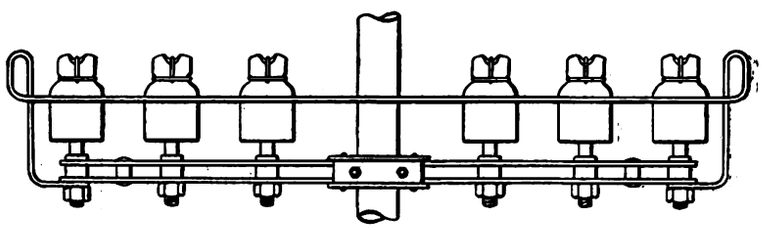

Fig. 4.

The construction of a new device, based on the principle of earthing the falling telephone wire before it touches the tramway conductor, is the direct outcome of an occurrence which happened at Strassburg on August 31st last. During the pulling down of a building two telephone wires were broken. The ends fell on the protecting strips of the working conductor of the tram line, and at the same moment all the enunciators in the telephone exchange dropped. One of the wire ends came in contact with the gutter on the roof of a building, and the gutter going right to earth, lightning-like phenomena were observed in the exchange. Fortunately, the wire leading into the exchange fused, and further damage was thus prevented. The greater part of the tramway current went to earth through the gutter and rain pipe, and not through the exchange.

This occurrence showed us how to construct an effective telephone protector. When a telephone wire breaks, the tramway current must not be conducted to the exchange but to earth. The Allgemeine Elektricitäts Gesellschaft has attained this object by encircling each telephone wire by a wire loop, as shown in Fig. 3. The wire loop is of such a size that even with the strongest wind accidental contact with the telephone wire is impossible. If there are several insulators in a row, a common guard wire can be arranged, as shown in Fig. 4. This arrangement, however, cannot be much recommended in cases where there are a great number of wires close together, as it might then happen that one of the highest wires in falling would get entangled with the lower ones, and consequently would never touch the guard wire. In these cases it is better to run a wire, well earthed, at right angles underneath the telephone wires, which would catch any of the falling wires and earth them. The poles, as well as the guard wire just

† Abstract from the *Elektrotechnische Zeitschrift* of March 26th.

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mentioned, must be in good connection with the earth, or better still, with the rails.

On February 25th last the Allgemeine Elektricitäts Gesellschaft, in conjunction with Schuckert and Co., made some experiments at Nuremberg with the device just mentioned, and the results obtained were most satisfactory. A 500-volt dynamo was employed and a load of 5 amperes was put on. The machine was protected by fuses and an automatic cut-out. The telephone wires were fitted with wire loops, as shown in Fig. 3, and the telephone instruments were protected by 1-ampere lead fuses.

First Experiment.—The telephone wire was dropped on to the working tramway conductor. At the moment of contact the 10-ampere fuse of the dynamo blew and the automatic cut-out became disengaged. No damage was done to the telephone.

Second Experiment.—At the moment of contact of the wires the 15-ampere dynamo fuse remained intact, but the automatic cut-out acted. The telephone was used during the experiment, and when the wires came in contact, only a cracking noise was heard.

Third Experiment.—The looped guard wire of the telephone conductor was taken away. On letting the telephone wire fall on to the tramway conductor, the telephone fuse went. The instrument, however, remained intact. This proves that lead fuses afford good protection for telephones. The length of the fuse must correspond with the pressure in use.

Fourth Experiment.—The telephone wire was again fitted with the guard loop; and before cutting the wire, an additional piece of wire was joined to it, which, after falling, reached down to the ground. It was absolutely harmless to touch this wire. The safety device acted as in the first and second experiment.

To indicate any interruption of the line at the generating station, and also to show how long these last, the Allgemeine Elektricitäts Gesellschaft arranges parallel to the automatic cut-out five 110-volt glow lamps in series, or one lamp and a sufficient resistance. In case of an earth occurring, the glow lamps will light up at the moment the automatic cut-out acts, and they will continue to burn till the interruption is removed. At the suggestion of Prof. Ulbricht, of Dresden, the lamps were replaced by a needle indicator, which received its current from a small battery instead of the dynamo. When the automatic cut-out acts, the battery circuit is closed, the instrument, as well as a bell which is put into the circuit, indicating the interruption. This arrangement has been made use of at Leipzig.

PUBLIC LIGHTING BY ARC LAMPS.*

BY ANDRÉ BLONDEL.

(Continued from page 793.)

II.—UTILISATION OF THE CONTINUOUS-CURRENT ARC—ORDINARY METHODS.

The ordinary methods, so far as continuous-current arcs are concerned, may be reduced to the two following:—(1) The naked arc is used; the lantern windows or the globes are of ordinary clear glass, and are used simply as a protection against the atmosphere. This is the American system. (2) The arc is fixed in a lantern or a globe of diffusing glass.

The first or second solution is employed according as we wish to reduce the quantity of light lost, or to tone down the brilliancy of the source of light.

Clear Globes.—The naked arc is perfectly satisfactory from a photometric point of view, seeing that, thanks to its natural distribution of light, more than 85 per cent. of the light is sent downwards, and only a loss of about 10 per cent. is experienced in passing through the clear globe; but from the physiological point of view, this system is generally detestable, because of the unendurable brilliancy of the arc, which causes the pupil of the eye to close to its minimum possible size. We have already seen that this effect quite counterbalances any of the photometric benefits of clear glass. It is difficult to understand how American cities can adhere to a system which has such a very fatiguing effect on the eye[27]; we are forced to believe that the public takes no more care of the preservation of its sight than of its stomach. In Europe more attention is paid to this point. In my opinion, naked arcs should be absolutely proscribed for public lighting, except in some exceptional circumstances where the use of very high pillars is justified, as, for instance, in the lighting of ports, &c.[28]. Even under these conditions it would still be desirable to tone down the brilliancy of the sources of light, and to better distribute the light which is concentrated in and about the angle of 45 degrees. I should add also, that with clear glass globes there is about a 10 per cent. reflection of the rays passing through the glass, which sends a far more considerable portion of the light upwards than would be imagined from the photometric curves of the naked arc.

Diffusing Globes.—Diffusing globes are to-day almost exclusively used on European public thoroughfares. They are made of translucent diffusing or semi-diffusing substances. A translucent substance is said to be diffusing when at each point of its surface it transforms an incident ray into a small, conical and very divergent bundle of rays. The globes of this class most used are of a roughened glass or opal (milky throughout), of which alabastrine is the best quality. Globes of this latter description do not allow the source of light to be perceived, but themselves become luminous over the greater portion of their surface, this surface being more extended the softer the source of light (Fig. 30). This is the

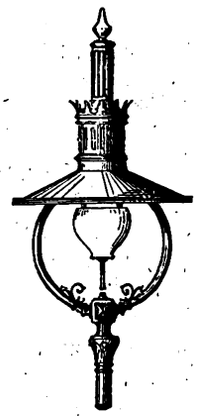

Fig. 29.—Lyre used at Marseilles with Hood Reflector.

characteristic of all diffusion. To diminish the thickness of the opal without weakening the globe, *opaline* globes have been invented. They are formed of a layer of clear glass, coated on the interior with a fine layer of opal. The effect of these globes is shown in Fig. 31, which is a reproduction of a photograph[29]. Such globes allow a great portion of the light to pass directly through them, and therefore are only semi-diffusing. By modifying the thickness of the coating of opal we may pass through all the stages between the clear and the opal globe. To this list of globes should be added that of roughened glass. This is also semi-diffusing, seeing that the luminous point cannot be seen directly through it. The diffusion by it is more or less extended as the roughening is varied, but the

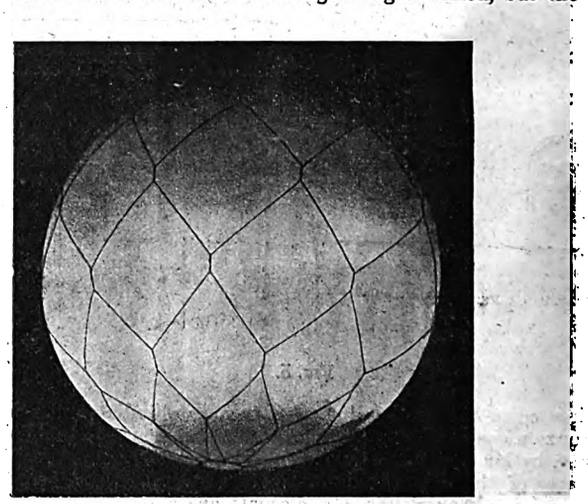

Fig. 30.—Continuous-current Arc in Opal or Alabastrine Globe.

greater part of the light passes through the globe in the same direction as the incident rays. We shall see later how it comes to pass that this globe is at the present time almost out of use.

All globes have the following defects—and in a greater degree as they are more diffusing:—First, they absorb a certain proportion of the light which traverses them. According to measurements I have taken, and to others which I shall quote later, this proportion varies from 20 to 40 per cent. Second, they alter the law of the distribution of light by tending to render the distribution of the rays uniform, seeing that each point of the diffusing surface sends out rays not only in the natural direction of the light, but into all the

* From *La Révue Technique*. Translated by Mr. John Hesketh.

[27] Excepting in the Fifth-avenue at New York, opaline globes are rarely used.

[28] At Havre the pillars are as high as 28 metres, and on the Bavarian railways 18 metres. This is, in my opinion, a mistake, for a considerable loss of light results, and the illumination on a vertical plane, which is very important is much reduced.

[29] These photographs were kindly taken for me by M. A. Laporte, civil engineer, to whom I am extremely indebted.

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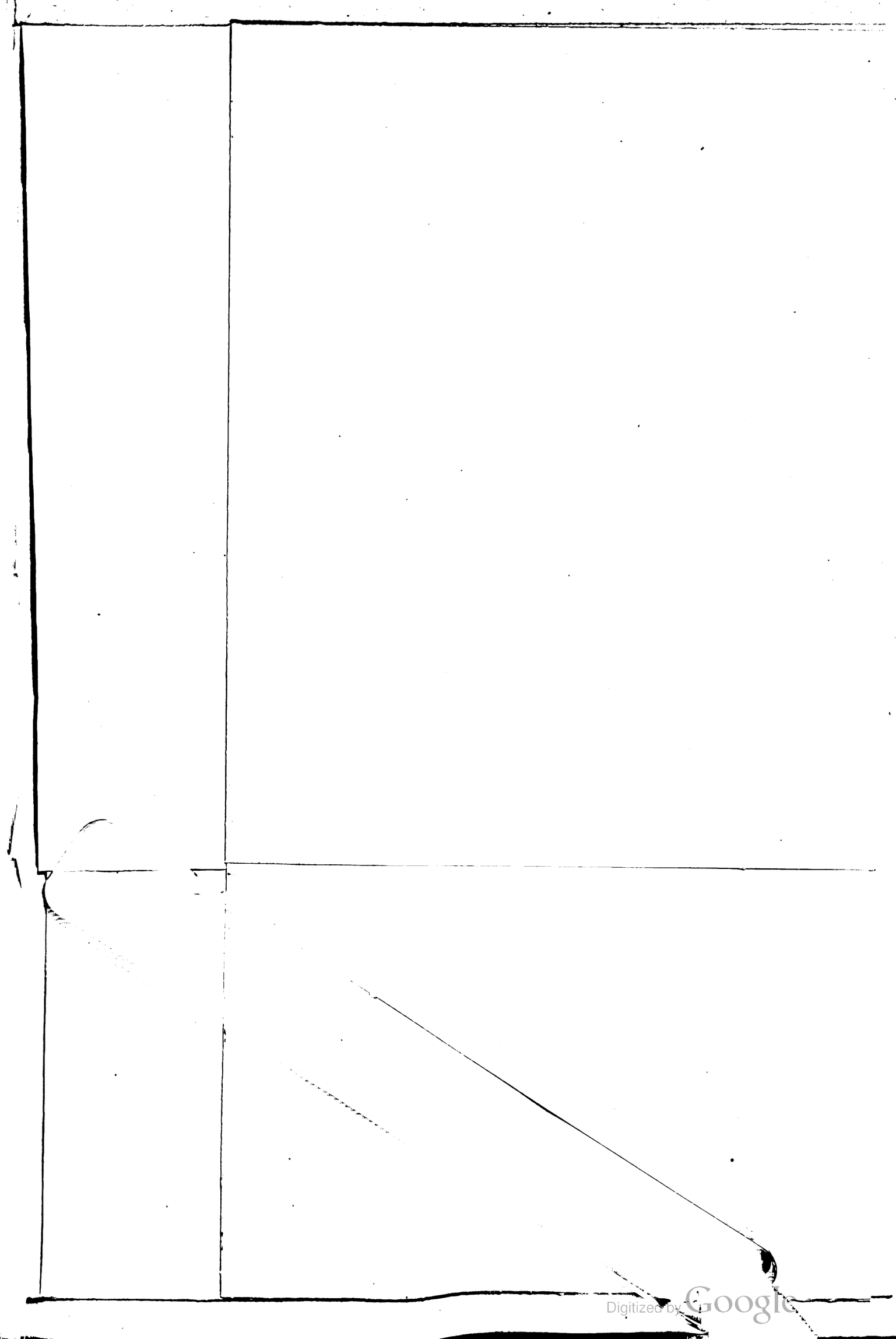
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neighbouring space. If we consider the opal globe as shown in Fig. 32 lighted by a continuous-current arc, A, any point of the globe, *m*, situated below the plane HH′ will emit rays in every direction on the right of *t t′*, which is tangent to the globe, and seeing that the continuous-current arc sends most of its light downwards, a more or less important part of the light will thus be sent upwards towards *t′*, and lost for all practical purposes. It is only right to add that, on the other hand, the rays which are sent downwards in the direction *m t* play a very important part; they light the portion of the roadway close to the lamp post, which without them would be altogether in the dark through the shadow cast by the bottom carbon, the carbon-holder of the lamp, and the lantern itself. It is due to this effect that the refuges on the boulevards are satisfactorily lighted.

The use of diffusers as globes offers, in addition, a certain æsthetic advantage, for the globes appear uniformly luminous on account of the interior reflections (although in reality the continuous-current

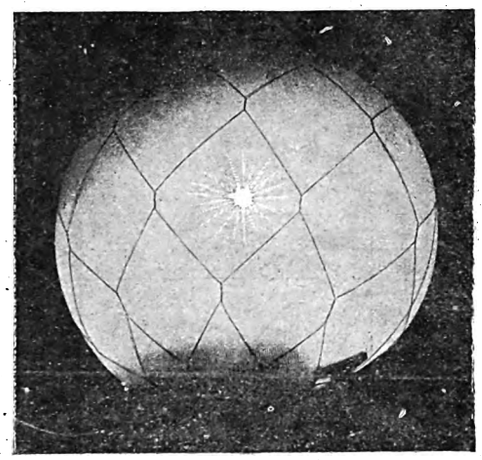

Fig. 31.—Continuous-current Arc in Opaline Globe.

arc sends scarcely any light upwards). This effect is best attained by placing the arc, not in the centre, but in the upper portion of the globe, and almost in the plane of its opening. This arrangement is besides almost necessary in the case of lamps with a long travel. But as the eye instinctively looks for the source of light in the centre of the sphere, it would appear strange for it to be seen right at the top, and therefore from this point of view it is advisable to use globes which do not allow it to be seen. This is all the more necessary when non-focussing lamps, such as the Brush, Thomson-Houston, &c., are used, for nothing can be more deplorable than to see an arc first in one position and then in another. This is, no doubt, responsible for the fact that in France almost all lamps of this class have been abandoned, despite the advantages they possess over focussing lamps on the score of simplicity. It should also be noticed that with opal globes the position of the arc always influences the luminous efficiency.[30]

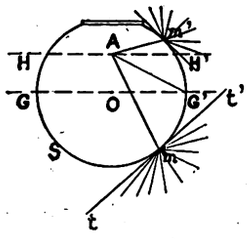

Fig. 32.—Diffusion by Points on an Opal Globe.

If we wish to calculate the reduction of the useful luminous flux produced by the use of the diffusing globe, we should first obtain the loss due to absorption and then that due to diffusion or change in the direction of the rays. The first is arrived at by comparing the total flux emitted by the naked arc with that of the arc in its globe; and the sum of the two losses, by comparing the total flux of the naked arc with the lower hemispherical flux of the arc in the globe. Generally speaking it is these total losses which should be considered in view of the bad use made of reflectors. The ratio of the hemispherical flux utilised, to the total flux, gives the *luminous efficiency* of the globe under consideration.

I intend later to give figures obtained with globes which have been submitted to actual experiments. I will here, however, mention the results obtained by other experimenters. The most classic tests are those of M. Wedding, whose work I have already quoted. The lamps of the Unter-den-Linden are 14-ampere lamps, and the mean of a long series of tests places the mean lower hemispherical candle-power as 1,228 German candles with a naked arc, and as 777, 710, 590 candles with globes of varying degrees of opalescence. The total losses then due to the globe are 40, 45, and 53 per cent., and even these are lower than the reality, because the naked arc was only credited with its hemispherical flux, the light emitted above the horizon, which amounts to at least 10 per cent. of the total light being neglected. Mr. Preece has given the following losses:—with a roughened globe 46·24 per cent.; with an opaline globe 25·18 per cent.[31] I do not see the use of the decimals when we consider the degree of precision of which such measurements are capable. More recently Messrs. Guthrie and F. E. Redhead[32] published the four curves reproduced in Fig. 33;

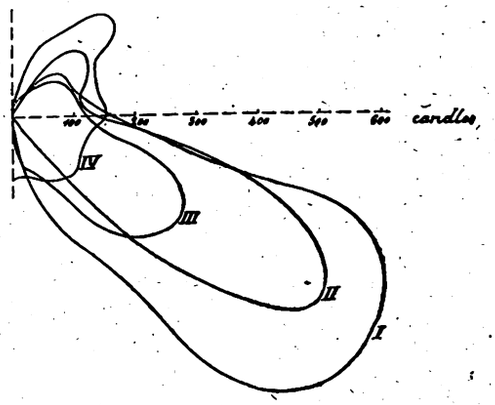

Fig. 33.—Photometric Curves by Messrs. Guthrie and Redhead. I. Naked Arc. II. Clear Globe. III. Roughened Globe. IV. Opal Globe.

which, except curve IV. (which in my opinion is certainly an error) appear accurate. The following are the figures which they obtained in English candles:—

Table III.

—	Naked Arc.	Clear Globe.	Rough'ned Glass Globe.	Opal Globe.
Mean spherical candle-power	319	235	160	144
Mean hemispherical candle-power	450	326	215	138
Percentage value of the mean spherical intensity candle-power	100	53	23	19
Percentage loss	—	47	77	81

The corresponding efficiencies then are 51·3, 33·7, and 21·7 per cent., which I think too low. They and the other figures quoted show that in any case the loss of light is rarely lower than 30 or 40 per cent. and is very often higher[33]; and that, of the 500 to 600 watts supplied to a lamp, at least a third may be considered as thrown away to obtain diffusion.

It is to escape this deplorable state of things that we very often see globes insufficiently opalesced, allowing the arc to be seen almost as plainly as with a clear globe. This is an error, for if we gain a certain quantity of light photometrically speaking, we in reality lose much more in consequence of the physiological effects previously mentioned.[34] Besides which, we have the bad effect of a globe not appearing uniformly lighted. We should therefore consider as bad every opal or opaline globe which allows the arc to be seen, except as a scarcely visible glowing point. In short, diffusing globes of opal give us two evils to choose between—photometric loss and physiological loss. They cannot both be avoided at the

[30] In short, the proportion of light diffused upwards by a point on the surface of the globe is greater as that point is situated higher up the globe. We see how this arises if we examine the effect of the two points *m m′* of the globe, Fig. 32. If a continuous-current arc is placed at the centre O, the most effectively luminous portion of the globe is that portion situated 45deg. below O, while if the arc is placed at A the most illuminating part is near the equator C C′. The quantity of light utilised will evidently be less in the second case than in the first. From this point of view, polygonal lanterns have an advantage on account of the obliquity of the panes.

[31] See *The Electrician*, March 2, 1894, p. 484.

[32] See the *Electrical World*, March 3, 1894, p. 238.

[33] Some writers give lower figures, but this arises from the fact that generally they have measured only the absorption losses, and considered as useful the spherical flux instead of the hemispherical flux. It also happens that very good results are often the result of errors of observation. Again, some so-called opaline globes are so transparent that they produce no diffusion at all.

[34] See *The Electrician*, Vol. XXXVI., November 15, 1895.

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same time, and the diminution of the ultimate impression on the retina appears never to fall below 50 per cent. We can never recommend the use of roughened glass globe despite its small absorption, for only a very small portion of its surface appears brilliant, the rest being almost obscure, and the effect thus obtained is as disagreeable to the eye as that of a too transparent opaline globe. The roughened glass besides soon gets very dirty under the influence of carbon dust. This last reason alone is sufficient to veto its use in public lighting.[35]

Reflectors.

To utilise the light sent upwards the most natural idea is to employ a reflector. Reflectors of silvered glass being too fragile,[36] and those of metal too difficult to preserve from oxidisation, reflection properly called has almost universally been replaced by diffused reflection by employing white or blue enamelled sheet iron hoods. The use of the latter colour is difficult to explain, for it has a very small reflecting power; while a good white enamel reflects and diffuses about 80 to 90 per cent. of the incident light, which is almost as much as that reflected by a silvered mirror.

Reflectors as a rule are employed in three different ways. In polygonal lanterns they are placed inside under the head of the lantern. To place them outside could not be thought of, for this would make the lanterns, which are already far from elegant, even more ugly. When a suspended globe is used, a reflector is fixed on the upper portion and quite close to the globe, as shown in Fig. 34. In lamps of the lyre type with domes, the reflector is generally saucer-shaped and forms the roof of the dome.

Let us see if these arrangements are of any real utility. We have seen that it is not sufficient to arrange a reflecting surface, even if it be of considerable area, in the neighbourhood of a source

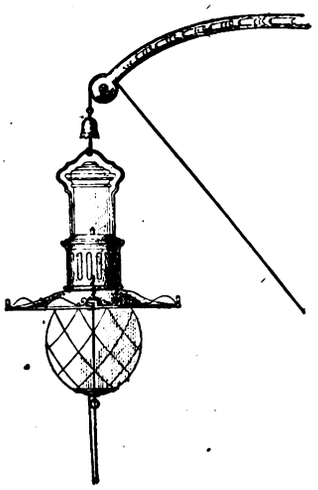

Fig. 34.—Lamp and Reflector used at Munich.

of light. It is necessary that the reflector should play a really active part. We should first make sure that it subtends a large enough solid angle in regard to the source of light, and take care not to confuse the *solid* angle with the *plane* angle subtended by the profile of the reflector. For example, in Fig. 35 there are two reflectors, R_2 and R_1, both of which cut an equal angle ($eoc = gof$) in the vertical plane of the source. But the *solid* angles subtended are proportional to the segments ce and gf. A grave error would, therefore, be committed if we considered only the plane angles. It is also necessary to ascertain from the photometric curve of the source employed, what flux may be received by the solid angle subtended. One source may emit an important portion of its light in one direction while another will send almost none. In the case shown in Fig. 35, the flux received by the reflectors is in the ratio of the two shaded surfaces, $gff'g'$ and $cc'ee'$.

The application of these remarks to the continuous-current arc is very easy. Let us consider, first, the case of a naked arc, or an arc placed in a polygonal lantern. Fig. 35 shows that the flux sent above the horizon is very small relative to the total flux (at most 20 per cent.), and that to reflect it entirely the reflector R must be fixed on the level of the arc. All the light from the arc is then sent on to the panes of the lantern; but if these be opal or opaline, a considerable portion of the rays are lost, as previously pointed out. When globes are used, it is not usual to put the reflector inside, though it can be done, and is done in the case of alternating-current arc lamps. The reflector generally used above the globe (Fig. 36) can play only an almost imaginary part, if given the usual dimensions, for it reflects only the rays sent upwards by a small portion of the globe A C A′ C′ (Fig. 36) and for a point m the useful solid angle subtended by the reflector (limited by m D and normal $m\,h$) is relatively small. For it to play any really useful part, it should be made into a veritable extinguisher, and a very flat one, too, to avoid the reflection in the opposite direction to the one desired. The surface of the reflector should also be kept absolutely clean. If these conditions are not observed, reflectors fixed on globes, suspended or placed in domes, are generally so inefficient that in many cases they are replaced by simple hoods of sheet iron or zinc whose duty is simply to preserve the lamp from the weather, and to stop the rays which would otherwise be troublesome to tenants of neighbouring houses. The hoods at Havre, for instance (Fig. 37) are intended to make the lamps invisible at a distance of 100m. In narrow streets, the tenants of neighbouring houses should be prevented from seeing the arc.

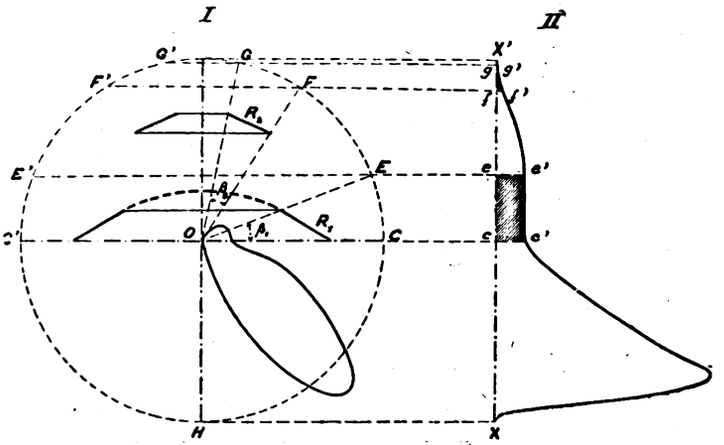

Fig. 35.—Effect of a Reflector According to its Position Relative to the Arc, and According to the Photometric Curve of the Arc. I. Photometric Curve. II. Curve of Flux. R_1. Large Hood Reflector. R_2. Reflector in Cupola or Dome of Lyre.

For this purpose many lyres (such as that at Marseilles, Fig. 29) are fitted with very large hoods. The strangely-shaped hoods used in the United States (Figs. 21, 22, 23) which shade the naked arcs, will also fulfil this object, but they are primarily used as mechanical protection. In Europe, where more artistic taste prevails, hood reflectors for use with the lyres and cupolas have been almost everywhere abandoned, and a small reflector placed in the interior of the cupola (doubtless an imitation of the practice followed with gas lanterns) used instead. But this arrangement can scarcely be of any use; for in the case of a naked arc (Fig. 35) the reflector of the cupola is represented by R_2, and only receives a flux proportionate to the shaded surface $fgf'g'$, which is very insignificant. It is almost the same even for an arc in a globe, for the solid angle subtended always remains extremely small.[37] In short, we see

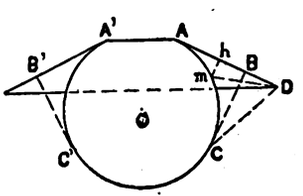

Fig. 36.—Possible Useful Effect of a Reflector fitted to an Opal Globe.

that reflectors usually employed, even admitting that they are very white and carefully kept so, do not, on account of their form, have more than a slight effect; and even this may only be gained by an arrangement which looks absolutely hideous.

Lately attempts have been made to make a better use of reflectors by making them play the leading part in the fittings of lamps. With this end two interesting solutions have been proposed, by Messrs. Hrabowsky and Schuckert. The first, which relies on the use of diffusing reflectors, can be used only for interior lighting; the second seems to have been conceived with the same end, but as it has recently been tried in the public lighting of Munich I will mention it here.[38] The Schuckert apparatus consists of a special

[35] The St. Petersburg lanterns are still fitted with them.

[36] Globes, silvered over part of their surface, have been employed, but have been discarded for many reasons. (1) They only allow the light to be concentrated in a restricted area, which, though advantageous for interior lighting, is useless for public thoroughfares. (2) The silvering rapidly deteriorates with heat, &c. (3) Reflected rays burn away the carbons when focussed upon them. This effect may also be produced by opaline globes, but to a less extent.

[37] In almost all cases, besides, the light regained by the reflector is sent into the immediate neighbourhood of the lamp post, where the light is already superabundant, and is, therefore, useless.

[38] From two interesting articles by Herr Nerz, chief engineer for Messrs. Schuckert (*Elek. Zeit.*, 1894), and Herr Uppenborn, chief engineer to the city of Munich (*Zeit. für Beleuchtungswesen*, January 30, 1895).

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lantern of large dimensions, as shown in Fig. 38. All the flat panes in it between A B C are made of opaline; those between A E F of silvered glass. The latter send all the rays above O A on to the former, and thus allow nearly all the light to be used and quite diffused; besides which, the great obliquity of the lantern windows makes the quantity of light sent upwards very small indeed. Unfortunately, this arrangement has the effect of concentrating the light in the immediate vicinity of the lantern, to the

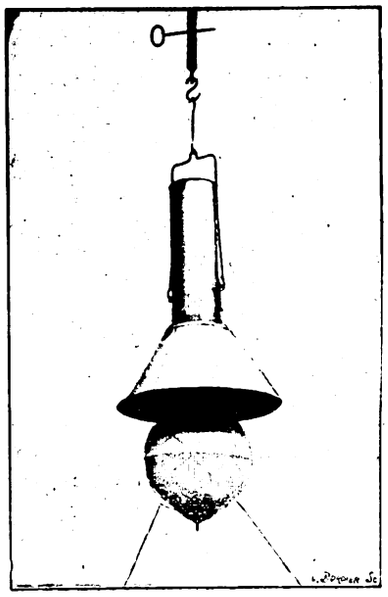

FIG. 37.—Havre Lantern with Hood.

neglect of the other parts. At Munich, on the square in front of the railway station, the experiment was made of placing this apparatus on the top of posts 15 metres high, in lieu of ordinary globes, and of measuring the illumination at various points. It was found that the lighting was less uniform than before, although it was sensibly increased at the foot of the post. It appears, therefore, that though the apparatus may be of use for lighting works, &c.,

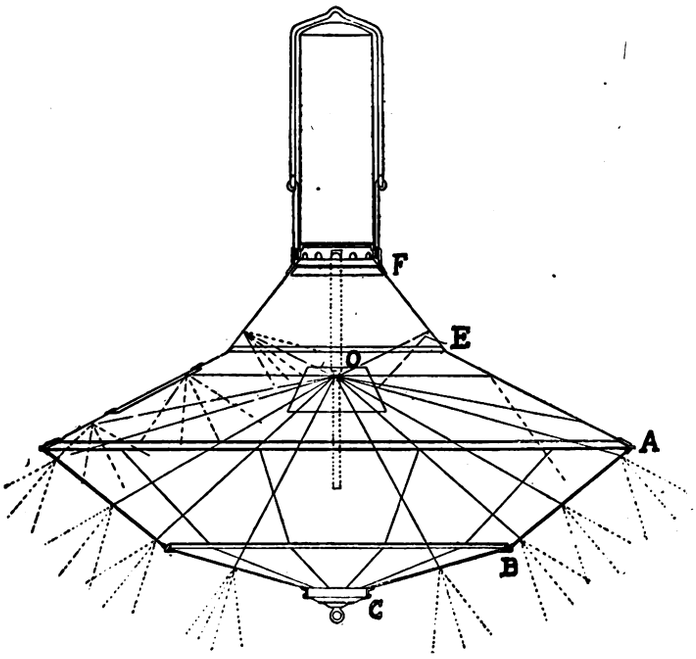

FIG. 38.—Schuckert Reflecting and Diffusing Lantern.

it does not quite meet the requirements of public lighting. The same may, I believe, be said of all other combinations of mirrors and reflectors, &c. They have all the disadvantage of necessitating the use of cumbersome and ugly lanterns. It seems therefore that the problem must be solved in another manner, and we shall see that dioptric methods are able to give better results.

(To be continued).

THE MAGNETIC HOMOGENEITY OF IRON AND STEEL AND THE EFFECT OF ANNEALING.*

BY DR. A. EBELING AND DR. ERICH SCHMIDT.

It has been found during the comparison of various methods of testing iron that different samples of soft wrought iron, and even different portions of the same sample, present distinct differences in magnetic properties, but it has not been clearly established whether the lack of uniformity is inherent or is removable by sufficient annealing. Certain variations in chemical and physical properties have been identified even in small samples of iron, the effect being most marked in wrought metal and much less so in cast iron and cast steel. The following research was undertaken to determine the efficiency of thorough annealing in rendering iron magnetically homogeneous, and to discover in which form it exhibits the greatest uniformity.

In order to test the condition of the metal, short rods were prepared of uniform cross-section and wound with small search coils in the middle, and near the two ends. The rod was magnetised by insertion in a coil of wire placed in a yoke piece of large area, as in Hopkinson's permeameter. Changes in the value of the induction were determined by the currents induced in the search coils due to changes in the magnetising current, and the usual B/H curves were plotted for each of the three positions on the rod.

The result of tests on many samples of wrought and cast iron and steel showed that homogeneity was very rare, a single sample of cast steel being the only specimen in which perfect uniformity was discovered, and the wrought metals exhibiting considerable variations. The effect of long-continued heating was then tried, in order to test the efficiency of this treatment in removing irregularities. The sample, enclosed in an inner tube of porcelain and an outer one of earthenware, was placed in a pottery furnace for many hours. The maximum temperature attained was nearly 1,000°C., and the time occupied in the heating and subsequent cooling was about 50 hours. On testing the metals after the treatment it was found that all the metals were much softened by the prolonged heating, and the hysteresis was considerably reduced. In their uniformity, however, the results differed in the various specimens. The wrought iron was no more homogeneous than before; the wrought steel (wolfram steel) was much improved; the rolled iron was hardly changed, but it was from the first fairly uniform, while the cast steel, which was initially very uniform, showed, after the annealing, a slight variation in its different parts.

It may therefore be concluded (1) that while thorough annealing is beneficial it cannot be relied on for eliminating want of uniformity; (2) that carefully prepared cast metal is more likely to be homogeneous than wrought metal.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, April 17th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Colour Photography," by M. G. Lippmann.

TUESDAY, April 21st.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. The Papers read last week by Messrs. G. H. Hill and G. F. Deacon to be discussed.

WEDNESDAY, April 22nd.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "The Perfected Photochromoscope and its Colour Photographs," by F. E. Ives.

THURSDAY, April 23rd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture (II.): "Recent Chemical Progress," by Prof. Dewar, F.R.S.

FRIDAY, April 24th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read: (1) "Symbolism in Thermodynamics," by R. A. Lehfeldt; (2) "Adjustment of the Kelvin Bridge," by R. Appleyard; (3) "The Effect of Wave-Form on the Alternate-Current Arc," by J. Frith.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting. Paper to be read: "Underground Conductors," by E. Ray and V. Watlington.

*** Particulars of Meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

* Abstract from the *Zeitschrift fur Instrumentenkunde.*

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THE METRIC SYSTEM.

A series of articles on the metric system recently appearing in *The Times* has resulted in the usual valuable aftermath, a lengthy correspondence in which this important question is discussed from all possible points of view. Mr. R. KAYE GRAY's letter in Monday's issue calls attention to a curious point in connection with the subject under discussion which has not, so far as we are aware, been previously publicly noted; we allude to the fact, well-known to all residents in France, that even in the home of the system the metric creed is only skin-deep. Penetrate a little below the surface, and *sous*, *toises*, *barriques*, *arpents* and all manner of strange old-world measures are found in daily use.

This phenomenon indeed scarcely amounts to an argument against the adoption of metres, kilogrammes, litres and hectares, any more than the fact that there is an occasional recrudescence of cannibalism among comparatively civilised tribes would justify the abrogation of the laws directed against cannibalism. This obstinate survival of scientifically obsolete units among a people peculiarly exposed to and peculiarly amenable to bureaucratic influence, and whose minds at the time of the first legal institution of the metric system in November, 1801, had been rendered abnormally receptive of novelties by the general upheaval of the previous decade, needs

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something more than "inborn conservatism" to explain it. Mr. Gray gives all decimalists, metrists and other enthusiasts a clue to this "something more." The most serious point in the whole scheme is, he rightly remarks, "the unnecessary forcing of units on different trades which bear the relation to one another of tens or multiples of ten. The jeweller in exercising his trade finds a carat a very serviceable unit, and no doubt the student of exact sciences finds the decimal relations between the units which exist in the metric system a great advantage; but why this jeweller should insist on the student's adopting the units the jeweller finds best, or *vice versâ*, I fail to see. The weight of a truckload of coals can hardly be conveniently expressed in carats, and as the greatest weight mentioned in the metric system is the myriagramme of approximately 22lb., this system is also unserviceable for dealings in large weights."

The question of the undoubted defects of the metric system is, however, somewhat of an academic one in the present year of grace. With the exception of ourselves, the leading nations of the earth have nominally adopted, or are adopting, a decimal system based upon the metre—a fundamental unit which alas has no longer an absolute basis, but rests on the concrete foundation of the *mètre des archives*. Can we, commercially speaking, afford to hold aloof from this movement? That is the crux. So far we have not been convinced by the arguments on this head adduced by the indefatigable Decimal Association. The statements made as to the trade lost to this country by the use of English weights and measures in English catalogues have always seemed to us, assuming their correctness, more weighty as indictments against the business energy and enterprise of our manufacturers, than as arguments in favour of the adoption in the United Kingdom of a revolutionary system. To the scientific man there can be no question as to the immense superiority of a decimal system. He knows that constant dripping will wear away a stone, and he is equally sure that time, plus Board Schools, will likewise break down the thick crust of custom, and open the eyes of the multitude, at any rate, to the general advantages of the metric system, even if it can still be shown that the system does not here and there exactly square with the particular convenience of a particular trade. To the philosophical statesman, the political economist, and the philanthropist, who are in agreement as to the benefits to all concerned to be derived from the facilitation of international intercourse, any system of weights and measures likely to be generally adopted would commend itself even if it were admittedly inferior in precision or in flexibility to some other system, the use of which was confined to a single race. Hence the adoption or non-adoption by the British Empire of a decimal system based upon the metre rests entirely with the engineer, the manufacturer, and the man in the street; the remaining sections of the community are in complete accord, not merely as to the intrinsic desirability of a decimal system, but as to the irrationality of a compromise which would it is true, indefinitely prolong the life of those picturesque mediæval survivals, the yard and pint pot, but which would forego the innumerable advantages accruing from the adoption of an international common measure. The metric system is both decimal and international. No hybrid device could possess both these properties, and nothing short of this double gain would repay us for a disturbance in which so many of our ancient landmarks would disappear and be lost to the eye of the law, if not to the eye of the man who buys and sells and cares not a jot for logical completeness or an accuracy carried to the second place of decimals.

REVIEWS.

Die Metallcarbide und ihre Verwendung. By Dr. F. B. Ahrens. [London: Williams and Norgate.]

This short monograph forms the first part of a volume dealing with chemical and chemico-technical questions which have lately acquired prominence and have become of general interest. The subjects are necessarily disconnected, and each is dealt with by a writer competent to speak as one having authority.

In the mind of the average technologist the term carbide connotes but two members of the class, viz., silicon carbide (carborundum) and calcium carbide, the raw material from which acetylene is now usually prepared. It must not, however, be overlooked that these are but individuals of a large series of substances, some of which have been known for many years, while others have been but recently prepared. A systematic and sufficiently complete account of them is to be found in this little book, and to speak of them in a review at any length would be superfluous, seeing that the book itself is cheap and accessible. With regard to those which, as we have indicated above, are of immediate industrial importance, somewhat more may be said.

Calcium carbide—whatever may have been ignorantly stated to the contrary—was first prepared by Wöhler in 1862. In 1893 Travers succeeded in making crude calcium carbide by heating a mixture of sodium, calcium chloride and retort-carbon. In 1894 Moissan obtained a good output by fusing lime with carbon in an electric furnace, a process immediately afterwards patented, not by its discoverer but by a person named Bullier. Willson's experiments, made apparently in ignorance of Moissan's discovery, date from the end of 1894, and being noisily bruited abroad caused what Dr. Ahrens appropriately calls "ein volkommenes Carbidfieber." This has gradually died out, doing little harm save to those who found capital for colossal manufacturing enterprises based on fallacious estimates and invalid patents, and the era of steady development of the industrial application of a useful product has now set in. The estimate of the cost of production put forward by the Willson Aluminium Company has an air of unreality; the figures there given are £3 for 908 kilos of calcium carbide or about £8 per ton of acetylene. No reliable data exist for reckoning the electrical energy required for the production of a given weight of carbide, and the figures just quoted appear moreover to be based on the assumption that the carbide produced is of 100 per cent. purity—a result scarcely probable. A comparison may be usefully made with the rates ruling at the works of the Aluminium Company, of Neuhausen. The carbide there produced has an average content of 79 per cent. of CaC_2, and is sold in large lots at 0·4 marks per kilo, whence it follows that 1 ton of acetylene costs about £62. 10s. The discrepancy is striking, and cannot be caused to disappear by allowing any reasonable profit to the Swiss Company. The synthesis of various organic substances using acetylene (from calcium carbide) as a starting point, has been much debated. A favourite subject for discussion is the preparation of alcohol in the manner shown in the following equations:—

(1) $C_2H_2 + H_2 = C_2H_4$
acetylene hydrogen ethylene.

(2) $C_2H_4 + H_2SO_4 = C_2H_5HSO_4$
ethylene sulphuric acid ethylhydrogen sulphate.

(3) $C_2H_5HSO_4 + H_2O = C_2H_5OH + H_2SO_4$
ethylhydrogen sulphate water ethylalcohol sulphuric acid.

Equations (2) and (3), showing the preparation of alcohol from ethylene, are well known, and their smooth fulfilment would allow of the recovery of the sulphuric acid. It is equation (1) which is the crux. Berthelot has stated that he has succeeded in realising it by acting with a reducing agent (zinc) in ammoniacal solution on acetylide of copper. But when calcium carbide was used instead of the copper compound repetition of the experiments by other observers proved wholly fruitless, and even when Berthelot's method was carried out in its entirety, although some hydrogenation of the acetylene certainly took place, yet no alcohol whatever was obtained.

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Further, taking the cost of calcium carbide at the improbably low price of £4 per ton, assuming the conversion to take place with theoretical accuracy, and ignoring all charges except that of materials for manufacture, the cost of alcohol produced in this manner would be about 7d. per litre, at which price the preparation would be unremunerative.

The author calculates the quantity of electrical energy necessary for the gasification of carbon in the form of acetylene, and from thermo-chemical data arrives at the value 86,540 gram-calories per gram-molecule of acetylene produced. He justifies the conclusion that even putting aside the question of monetary cost of the electrical energy (as distinct from its energy value), acetylene cannot yield as high a percentage of its energy when exploded in a gas engine as does Dowson gas, the deficit being represented by the CO which escapes from the electric furnace in the fundamental reaction $CaO + 3C = CaC_2 + CO$ for the production of calcium carbide.

The prospect of using acetylene for lighting is much better than that of employing it for the purposes mentioned above. When burned under suitable conditions, so as to avoid smoking, 71 litres of acetylene, costing 11·33 pfennig, give 100 c.p. hours, at which estimate its use is cheaper than that of glow lamps, though, of course, dearer than that of the arc; it is even 28·5 per cent. cheaper than ordinary coal gas burned in an Argand lamp. (For portable lamps and similar purposes, liquid acetylene may now be obtained in steel cylinders from the Aktiengesellschaft für Chemische Industrie, of Mannheim.) In spite of these excellent results, there is no likelihood of acetylene replacing coal gas (having regard to the extensive use of the incandescent gas burner), or of being adopted for enriching coal gas (seeing that benzene is cheap and efficient for that purpose), but it may well be used for isolated and locomotive lighting. One incidental but important advantage possessed by acetylene as a lighting agent depends on the fact that for a given output of light it evolves a smaller quantity of heat and carbon dioxide than does any ordinary illuminant. Dr. Ahrens gives a useful table comparing various factors in the practical efficiency of numerous lighting methods which is well worthy of study.

A few words must suffice for notice of what is said in this little book about silicon carbide. The mode of production has been frequently described and need not be repeated. It is interesting to note, however, that when clay is used instead of pure silica the product contains alumina, ferric oxide and apparently silica as well as silicon carbide; it is solely by the use of approximately pure raw materials that a product with a composition corresponding nearly with that indicated by the formula SiC can be obtained. Grinding and polishing wheels of carborundum are made by mixing the small crystals, as obtained after washing and grading the furnace product, with a fusible agglutinate, moulding the mass into the required shape and heating to the sintering point of the binding material.

At the end of the book the author reviews Moissan's attempts to prepare the diamond from non-crystalline carbon, and adduces good evidence for regarding the product obtained by the French chemist as a silicon carbide extremely rich in carbon, rather than a pure crystalline carbon. The matter is in need of further investigation.

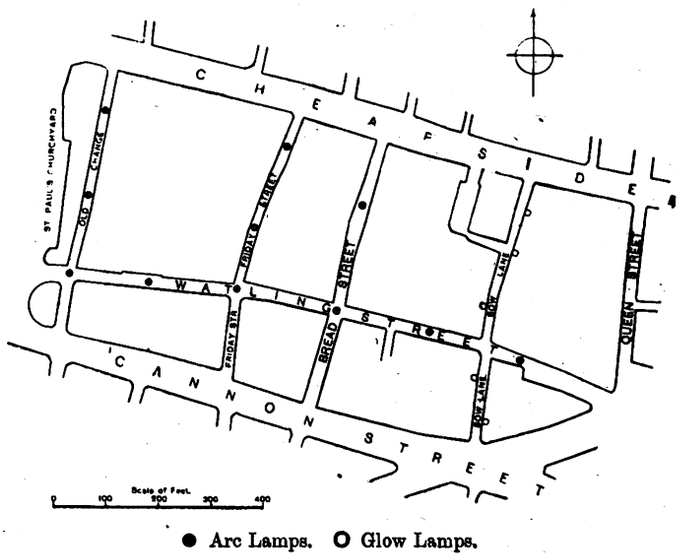
Our opinion of the brochure may be stated very briefly. It is an admirable compendium of many facts hitherto widely scattered, and will save much labour and many weary searches on the part of chemists and electricians interested in certain novel and growing industries.

Les Rayons-X et la Photographie a Travers les Corps Opaques.
By Ch. Ed. Guillaume. (Paris: Gauthier-Villars et Fils.)

In a well-printed well-arranged little brochure of some 124 pages M. Guillaume not only sums up the most discoveries in connection with Röntgen rays, and gives his readers the inevitable collection of radiographs, but he also provides a much-needed historical *résumé* of the work done on electrical phenomena in rarefied gases, and an introductory section linking the latest phenomena with current physical theories. The book exhibits but few traces of the haste in which it must have been got together.

THE ELECTRIC LIGHTING OF THE SIDE STREETS OF THE CITY.

Those who have been courageous enough to undertake the defence of the alternate-current arc have, when confronted with the tell-tale records of the photometer, invariably brought forward the argument that no sensible man expects a mechanism to do its best unless it is worked in the best possible manner; when alternate-current arcs have been supplied with carbons of proper diameter and suitable quality and with the correct number of volts and amperes, it will be time enough, they say, to dogmatically assert that the alternate-current arc is hopelessly inferior to its continuous-current congener. This is a safe and by no means unreasonable attitude. The interesting and exhaustive experiments, however, which are about to be undertaken by the City Commissioners of Sewers in conjunction with the City of London Electric Lighting Company, with a view of ascertaining the cheapest and most effective way of lighting the alleys and side streets of the City, ought, if the contemplated programme be completely carried out, to settle this thorny question once and for all. In the area bounded on the north by Cheapside, on the south by Cannon-street, on the east by Queen-street, and on the west by St. Paul's-churchyard, there will shortly be at work 11 arcs and 5 glow-lamps. The number is indeed small, but it is sufficient for the purpose. The arc lamps will at first be supplied



● Arc Lamps. O Glow Lamps.

with alternate-currents, each one from a separate transformer, and measurements will be made of the useful illumination. It is proposed to supply them with about 7 amperes and to use globes, the lower half of which will be obscured, the top half remaining clear. Some of these lamps will be slung from girders or rods, others from brackets. Some of these are substantial-looking cambered girders, others slender, not to say "skimpy" looking straight rods, supporting the lamp at about 20ft. from the road way. All of them will be supplied with combined traversing and hoisting gear, so arranged that by the time the lamp is vertically over the pavement it will have been lowered to a suitable height for trimming. When the luminous output of these lamps with alternating-current has been photometered they will be supplied with continuous current, and the photometric measurements will be repeated. As will be seen by the sketch map (Fig. 1) the 11 arc lamps will be distributed along Watling-street, Old Change, Friday-street and Bread-street. At the same time five 200-watt glow lamps, run straight off the supply mains, are to be brought into use. The first three, which one encounters on entering Bow-lane from Cheapside, are suspended from substantial-looking gilded wrought-iron brackets, designed and made by W. B. Reynolds, the remaining two being suspended from more ordinary looking supports. The reflectors of the first three are of a peculiarly curved dish-shape

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pattern. They look effective, and should, prove optically superior to the common cone-shaped reflectors by which glow-lamps are generally well-nigh extinguished. The merits of the Frédureau projector globe are also to be tested in Bow-lane.

THE DIRECT CONNECTION OF ELECTRIC MOTORS WITH MACHINES OF VARIOUS TYPES.*

BY WILLIAM BAXTER, JUN.

The efficiency of transmission by shafting is less with light running machinery than with heavy; but lightness of machinery is not the only factor that determines the efficiency. The continuous or intermittent use of power has as much to do with the subject, if not more, than anything else. If a machine absorbs a large amount of power when in operation, it must be driven by heavy shafting. If it is in constant use the loss of energy in shafting and belts will be small, but if not in constant use this loss may become very great, and will depend wholly upon the ratio between the time when work is being done, and when the machine is standing idle. From a consideration of this fact we can see that under certain conditions of intermittent use the loss in operating heavy machinery by shafting may be very much greater than with the lightest machinery, especially if the latter is kept in constant motion.

The field in which the direct connection of motors with machines would make the poorest showing would be that when the power required is not very small and the work continuous. On the other hand, the best results would be obtained with machines requiring a large amount of power while in operation, but only in use for short periods of time, with long intervals of rest. In the former class may be mentioned cotton and woollen mill machinery, and all kinds of automatic machinery used in manufacturing processes. Among the latter are printing presses, paper cutters, embossing machines and, in fact, most of the machinery used in this line of industry, also wood and metal working machinery of all kinds.

We cannot say that the work performed by machines of the classes just named is always of an intermittent character, but it is generally so. Printing presses, in some cases, are used continuously, but as a rule their work is intermittent, and they are frequently stopped for periods some times of several hours' duration, owing to the fact that the number of copies required of any one forme is seldom sufficient to keep them in operation for any great length of time. Even when the work on hand is enough to keep all the presses in an establishment in constant use, the number of hours when power is used is not a very large proportion of the whole. It requires a considerable length of time to remove the old formes and put new ones in place. To clean the rollers, try the press, and examine the proof copies, and to make sure that everything is in proper adjustment before starting to run off the edition. In most printing establishments it is not uncommon to see half the presses idle at a time. It is evident, therefore, that in this line of work the energy lost by shafting is a large percentage of the whole, so that as far as efficiency is concerned this is a very favourable field for the direct connection of motors.

What has been said in relation to the work of printing presses not being always intermittent also applies to wood and metal working machines. Thus, for example, we may consider the case of a lathe used for turning shafting. In such a case the use of power would be almost continuous, because it would require a considerable length of time to finish one piece, and the work of removing this and putting in place another piece would only require a few minutes, owing to the fact that the work is of a routine character, and all the appliances for setting and holding the work in place are made with a view to saving labour in manipulation. But if the same lathe is used for general work the results will be very different. More time will be required to set and secure the work in place, because special means to accomplish this end will have to be used in almost every case. After the work is properly set and secured, and the latter is set in motion, there will be a considerable time lost, from the fact that frequent stoppages will be made to examine the progress made, and to take measurements, and perhaps to make comparisons with other parts of the apparatus to which the piece may belong. In some cases the time consumed in cutting away the metal of a casting or forging is very small compared to that required to set the work and make the necessary examinations and measurements as the cutting progresses.

These few illustrations are sufficient to show that in operating machines by the ordinary method of shafting and belting the loss of energy is greatest where the work is of such character that the machines do not run continuously, and that the very lowest efficiency is attained in cases where, in addition to the work being intermittent, the machinery is light, and, therefore, the transmission of energy per unit of length of shaft very small. On the other hand, the highest efficiency is reached in that class of work where the machinery is in continuous use, or nearly so, and where length of shafting is greatest.

From these facts we must conclude that in the direct connection of motors with machines we could obtain the best results in the efficient use of energy by selecting machines that require a small amount of power for their operation, and are used for a class of work in which the intervals of rest are numerous and of considerable duration.

It is somewhat unfortunate that these are the conditions that will enable the direct connection of motors to give the best results in point of efficiency, because, as will be presently shown, the class of machines in which these conditions obtain are generally those in which the combination would compel the motor to undergo the severest test. But no one need be discouraged on this account. Electric motors, when properly constructed, are wonderfully enduring machines, and have been accustomed to hard knocks since the days of their infancy. The ideal condition of running for a motor, that is, for ease of task, would be when it could be started in the morning and be kept in motion with a constant load all day long. But these conditions do not obtain in any of the direct connections so far made, with the exception of fan blowers and pumps, and are hardly to be expected in any of the work of the future. The work that is now being done by direct-connected motors imposes the severest conditions that are possible. It is difficult to conceive of any kind of work that would impose a greater strain on motors and the operating apparatus used therewith, than that to which they are subjected in railway and elevator service. Such motors when starting under a heavy load are subjected to a rush of current that almost amounts to a short circuit; that is, if they are geared for a high velocity, and therefore are compelled to set the mass in motion without any undue loss of time. Under these conditions the strain on the insulation is very great, and it would soon break down unless of the most substantial construction. But this is one of the minor troubles which is easily guarded against. The effect on the commutator is far more difficult to contend with. But absolutely sparkless running in such a motor is not possible, because the flashing at the instant of starting roughens the surface of the commutator over a considerable arc, and as the motor seldom starts with the armature in the same position, each start roughens a new spot, and finally the whole surface becomes rough. If the starts were at long intervals apart, the action of the brushes during the long intervening run would smoothe up these spots, but as the starts are very frequent no such results can be effected. Therefore the surface of the commutator remains constantly rough, and consequently the brushes spark continuously. Yet a motor that would act this way, when subject to the severe test imposed upon it in railway or elevator work, would in all probability run sparkless if in continuous motion and subject to the ordinary variations in load that stationary motors have to contend with. It will therefore be seen that for this class of work a motor must be proportioned with much greater accuracy, to avoid sparking, than is required in machines subject to the ordinary conditions encountered in stationary work.

If the question of the efficient use of power were to decide whether the combination of a motor with any particular machine would be desirable, the prospects in this line of work would not be very bright, particularly if the cost of maintenance were to be brought in to off set the saving in power. The cost of power in most manufacturing establishments is but a small percentage of the total expenses, therefore the saving of a portion of this expense would not affect the economy of operation to any very great extent; and if this slight saving were to be reduced by the increase in cost of repairs, as well as first cost—if these should be against the motor—the chances are that, in most cases, the advantages of the new method would not be enough to justify its adoption. But other considerations as well as economy have a bearing on the case. Among these may be mentioned that in many establishments the belts and shafting are in the way, and interfere with the proper handling of the work. These conditions exist in large iron and other metal manufactories, where heavy work is handled, and where overhead travelling cranes are almost indispensable. These cannot be used if line shafts and belts are in the way. This difficulty is overcome in many places by running a line of shafting against the wall on each side of the shop; but if the building is of any considerable width it will be found that in most cases there is more unoccupied floor space along the centre than is really required, and that some of it could be utilised if power could be conveyed to tools located thereon without interfering with the crane. In several shops of this kind experiments are being tried with lathes, planers' boring mills, and other tools operated by motors. There can be but little doubt that these experiments will be successful, and in the course of time a large number of direct-connected iron-working tools will be used in establishments of this kind.

A considerable work is being done at the present time in the direct connection of motors with printing presses of various kinds.

* Abstract from the *Electrical World* of New York.

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Perhaps one of the largest plants of this class, if indeed not the largest in the world, is that of the American Book Company, located in the new building erected on the site of the old University Building, on the east side of Washington-square, New York. This plant, when completed, will consist of nearly a hundred machines, each provided with a direct-connected motor, with the exception of some of the smallest machines, which are driven in groups of four or six to one motor.

What the advantages of direct-connected machines in printing establishments may be, the writer would not undertake to state, not being familiar with the requirements in that line of work, but that the advantages must be quite apparent is evident from the fact that those who know what the requirements are have been sufficiently impressed with the advantages to be derived to induce them to try the experiment on such a large scale.

There is another field, however, for the electric motor in manufacturing establishments, in which the advantages to be derived from its use are more apparent than those that may be claimed for the system of direct connection with each machine. This field is that of operating each line of shafting or system of shafting by an independent motor. It frequently happens that the construction of a building is such that it is not possible to drive each line of shafting from the main line, and that the only way in which the power can be transmitted is from one shaft to the other, and so on through to the last. With such an arrangement one line of shafting could not be used without driving all the other lines, and this, in most cases, would be a decided objection. But if each line were driven by a separate motor, they would each be independent of all the others, and any one could be used without any reference to the others. In other cases the direction of the lines of shafting is not always the same, and motion is transmitted from one to the other by means of quarter-turn belts. In such cases, especially if the power transmitted is large, a motor would give by far more satisfactory results.

In very large works, where there are numerous buildings running in different directions and some distance from each other, it would be found that very good results would be obtained by generating all the power required for the entire establishment in one central power-house, and transmitting it to the various buildings, where it would be utilised through the agency of motors. In this arrangement, if each line of shafting were driven by a separate motor, it would be possible to run any part of any building, or the whole, so that anything from a single line of shafting up to the entire plant could be used, if desired.

TELEPHONE EXCHANGES AND THEIR WORKING.*

BY DANE SINCLAIR.

In introducing this subject I find that, to give you anything like a clear idea of the working of telephone exchanges as they exist in this country, it will be necessary for me to refer to a few fundamental principles underlying all telephone exchange work, which, however, have been previously explained in journals, text-books and elsewhere.

In all telephone systems there are three branches into which they may naturally be divided, viz.—

1. The line wires connecting subscribers' offices to exchanges;
2. The instruments in subscribers' offices; and
3. The switchboards in the exchanges.

With reference to the lines, it is not my intention here to say much in regard to them, although, indeed, the lines now used for telephonic purposes differ very greatly from those formerly used for telegraphic work. It was not until the introduction of the teelphone that such subjects as the static capacity and self-induction of lines received so much attention in other than submarine telegraph work. In telephone work, however, these points are of the very highest importance, and necessitate a large amount of attention. We have arrangements working on our telephone lines which, at first sight, would have appeared to the telegraph engineer to be the worst that could possibly be devised. I have made some experiments on telephone lines, and, under certain conditions, have obtained better speaking results over a line 40 miles in length, on which there was a series of earths, or leakages, than could have been obtained with a well-insulated line. The same applies to metallic circuits, but in this case the leakage is from the out-going wire to the return. This subject, although interesting, is, however, outside the scope of my present Paper.

Broadly speaking, all the calling instruments now used in this country in subscribers' offices are those known as the magneto pattern, and there is fitted along with each a transmitter, battery, and receiver, the whole forming a complete set.

It is, however, the switchboards at the exchanges that I wish specially to bring before your notice to-night.

* Paper read before the Institution of Electrical Engineers March 25th.

The diagram at Fig. 1 shows the connections which, with certain modifications, are made on all kinds of switchboards. The apparatus includes a line jack, marked J, and an indicator, marked I, through both of which the circuit passes either to a general earth wire, or, in the case of metallic circuits, to a return wire. I may explain that what is called a "jack" is that part of the apparatus into which the connecting plug is inserted. When any two lines are to be connected together, two of these plugs are inserted into

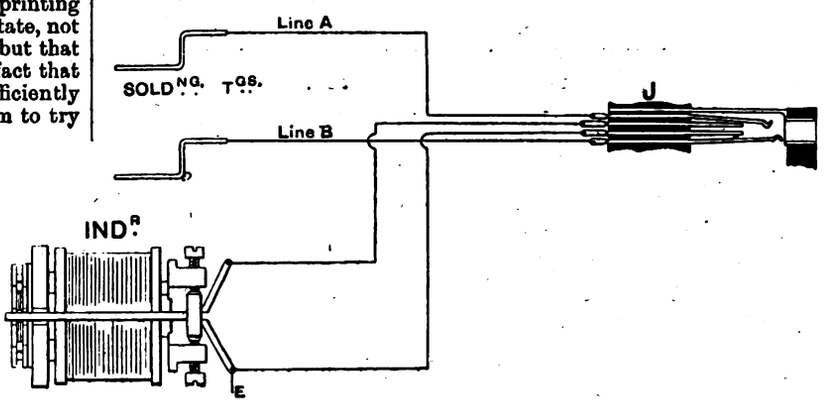

FIG. 1.—Line Connections of a Double Cord Board.

the two jacks of the lines concerned, the plugs being connected together by a flexible conducting cord.

It is our usual practice in this country for small exchanges (of, say, under 200 lines) to make up the switchboard in sections of 50 lines. The drawing at Fig. 2 shows the type of section which has been adopted by the National Telephone Company for general use

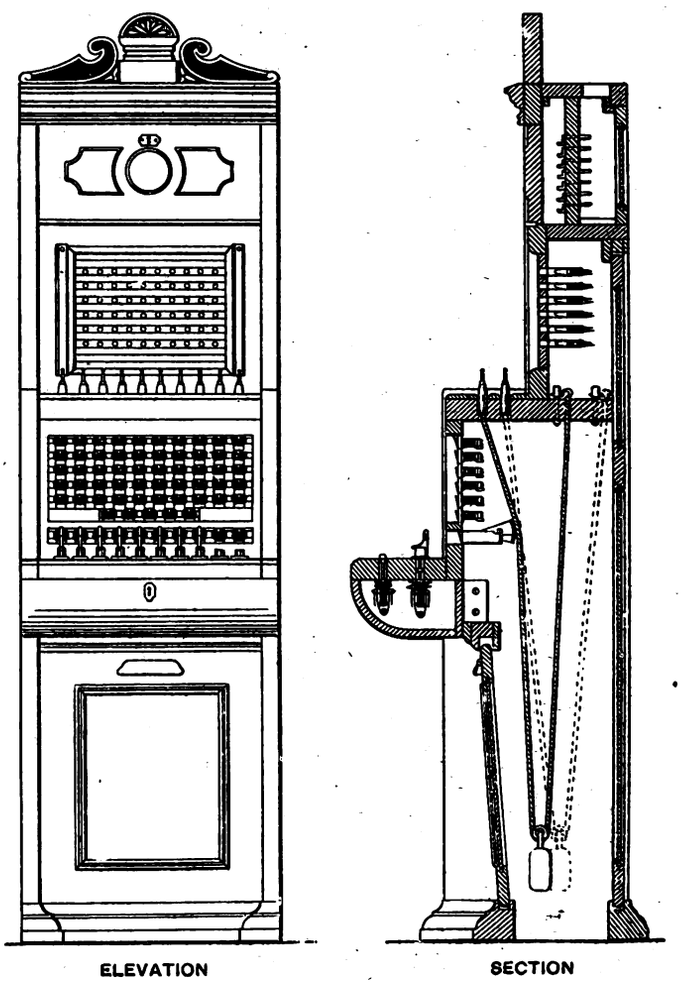

FIG. 2.—50-Line Switchboard. Double Cord Metallic Circuit.

in these small exchanges. In its main principles it is the same as other small standard boards, but special attention has been given to the details; facilities have been provided for connecting the line wires to the switchboard, and all the working parts have been covered so as to exclude dust as much as possible.

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A further reference to Fig. 1 will show that here, as before described, the line passes through the jack and indicator, and back by the return wire. Cords, similar to the one already mentioned, are fitted on a shelf, each cord having a pulley and weight to bring it back to its proper place when out of use. A ring-off indicator is also provided, which can be put in bridge across the cord by means of the key designed for that purpose. This key is shown at Fig. 3, and by it the operator can also throw her telephone into or out of circuit as required. A separate pair of keys is provided to enable the operator to ring on either of the lines she is connecting. The ringing current is, as a rule, produced by a small generator driven by an electric or other motor. These listening keys and ringing keys are now universally used by the National Telephone Company, and are all of the standard patterns shown.

When a subscriber turns the handle of his generator the shutter of his indicator in the exchange drops and shows his number. The operator then inserts one of the plugs of a double cord into the jack belonging to this line, and asks the subscriber what he wants. When this information is received the operator inserts the plug at the other end of the cord into the jack of the line wanted, and completes the operation by turning the lever of her key, which cuts her telephone out of circuit and brings in the ring-off indicator. This indicator, as before mentioned, is now connected across the line in bridge in the case of metallic circuits, or tapped to earth in the case of single wires. This indicator is of a special type, being wound to a resistance of 1,000 ohms, and placed inside a tube of soft iron, so as to give it large self-induction and cause great impedance to the passage of telephone currents, which are, of course, of high frequency. The object of this indicator is to show the operator when subscribers have finished their conversation. When this signal is given to the operator the plugs are withdrawn and everything restored to its normal condition.

As the subscribers' indicators are cut out of circuit when their lines are connected as described above, they are of the ordinary type, and are wound to a resistance of 100 ohms.

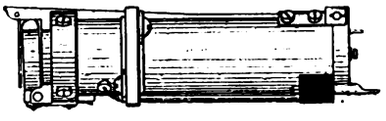

FIG. 3A.—S. R^{G}. Indicator.

In addition to the type of board already mentioned, shown at Fig. 2, we have used in this country very largely, for small exchanges and for private installations, a class of switchboard known as the "single-cord" board. In this pattern of board a cord and plug are provided for each line, and, as shown on the drawing (Fig. 4), the lines come to the outer springs of the jacks, and, without breaking, pass to the cord and terminate in the plug. In addition to this, a high-resistance indicator, of the same type as the ring-off indicator previously described, is provided for each line. To make a connection, the plug of the line of the calling subscriber is inserted into the jack of the line wanted, leaving the indicator of the first line in circuit, and, as will be seen in Fig. 4, the indicator of the second line is cut out of circuit. For working this class of board, the operating instrument is provided with a plug for answering the calling subscriber, and for ringing the subscriber wanted.

It will be readily understood from what has been said that, as exchanges increase in size, the switchboards become too large for the operators to be able to reach to make all the connections. In the earlier days, wires were run between the various sections of the board for the purpose of connecting the different groups of subscribers' wires together. At this point commenced the difficulties of telephone exchange work, because there was no certain method of showing to the operators in the exchange when any subscriber's line was engaged, and also because the first operator had not complete control of the connection, and consequently it was liable to be interfered with by the second operator. In practice this became a very serious trouble. A remedy was found by our friends on the other side of the Atlantic, where they had to deal with the question of large exchanges earlier than we in this country. To overcome the difficulty they invented what is known as the "multiple" board, the possession of patents for which must have given the owners very considerable satisfaction, as well as yielded them enormous profits.

In this connection I may mention that the multiple system was independently invented by an employé of the United Telephone Company, but subsequently to the date of the American patent.

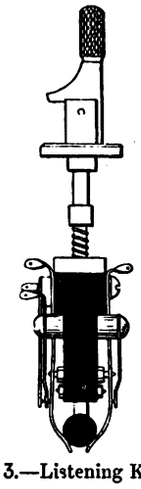

FIG. 3.—Listening Key.

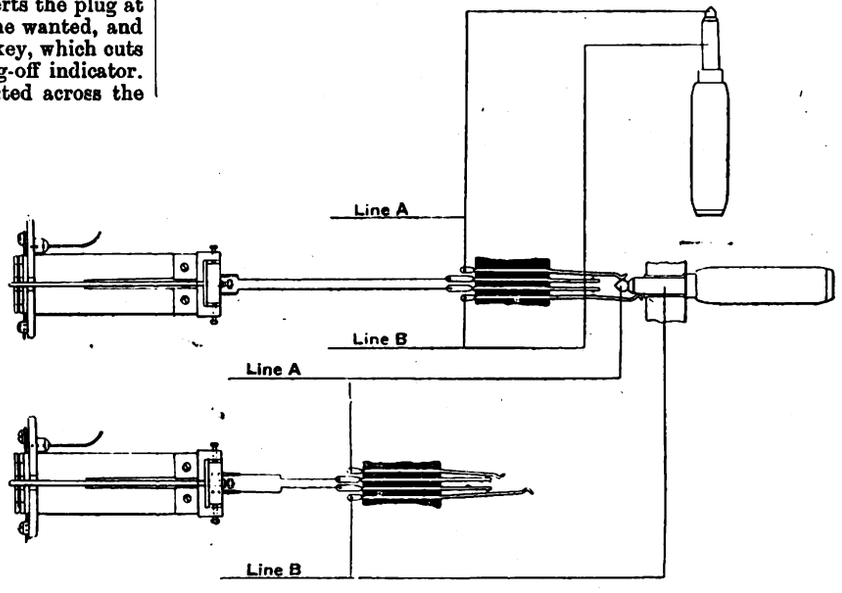

FIG. 4—Line Connections of a Single-Cord Board.

The multiple switch-boards used generally in this country are made up of the required number of sections, each containing all the apparatus necessary for 200 lines. Each section is 6ft. 6in. in length, and is subdivided for four operators, each having 12 pairs of connecting cords, with the usual equipment of listening and ringing keys of the type shown at Figs. 3 and 5. In addition to the full equipment of apparatus necessary for 200 lines, each section is also fitted with jacks, through which all the lines in the exchange pass.

On this principle the number of jacks necessary in an exchange increases in an amazing manner. For instance, an exchange with 400 subscribers' wires would require only 800 line jacks—*i.e.*, the 400 lines in the exchange would come to jacks on section No. 1, and be repeated on section No. 2; but, if we consider an exchange of 5,000 subscribers' lines under similar conditions, we find that there would be 25 sections of 200 lines each. As in the case of the two sections mentioned, the line jacks would be repeated on each of the 25 sections (5,000 on each), making a total of 125,000 line jacks. In practice every exchange is provided also with junction wires to other exchanges, and many of them with trunk wires to other towns.

The junction wires are divided into two approximately equal groups, one carrying the outgoing and the other the incoming traffic. To render the outgoing junctions accessible to all the operators, they are, like the subscribers' lines, multiplied on every section. Incoming junctions do not require to be multiplied, but special sections are provided for working them, and these also contain a multiple of all the subscribers' lines. As it is found in practice that an operator cannot attend to more than 25 of these junction lines, each section, with four operators, will accommodate 100 junction lines.

In an exchange of 5,000 subscribers, forming part of a system similar to that existing in London, there would be 1,000 junction wires, say 500 outgoing and 500 incoming. The latter would necessitate the provision of five extra sections, thus bringing the total to 30 sections, whilst the former would involve the use of 500 additional jacks on each section, making the total number of jacks 165,000.

It will thus be seen that a multiple board for 5,000 subscribers' lines is a huge electrical equipment. The number of soldered joints

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on such a switchboard, in connection with the jacks alone, is nearly a million, and the total length of wire is between 1,500 and 1,600 miles.

The largest switchboard we have in this country is one which has been provided for taking the total number of jacks required for 8,400 subscribers' lines—*i.e.*, including junctions, 9,000 line jacks on each section—and for such an exchange, fitted on the ordinary multiple system, there would be required a total of 432,000 line jacks; so that, while we have only increased the number of subscribers' lines from 5,000 to 8,400 (*i.e.*, 68 per cent.), we have increased the number of multiple jacks required from 165,000 to 432,000, or 162 per cent.

In Fig. 5, A, B, C, D, &c., represent a subscriber's line passing through separate sections of a switchboard. The wires come to the outer springs of jack A, and pass from the inner contacts to the outer springs of jack B, and so through all the sections. If the number of this subscriber's line is between 1 and 200,

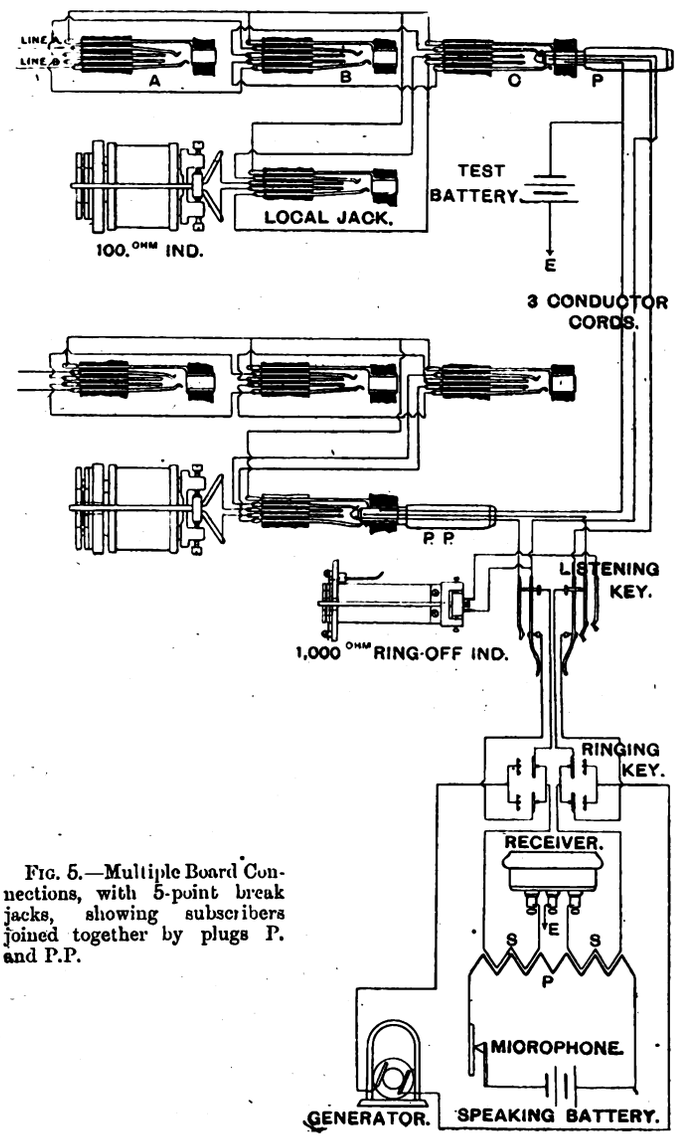

FIG. 5.—Multiple Board Connections, with 5-point break jacks, showing subscribers joined together by plugs P. and P.P.

the wires, after passing through all the sections, would return to section A, pass through the local jack, and end in the indicator. A third wire in connection with the barrels of the jacks is also carried through all the sections, and is normally an insulated wire. This is the test wire by means of which an operator ascertains whether or not the line wanted is engaged at any other section.

When an operator replies to a subscriber she inserts a plug into the jack of his line. The tip and ring of the plug connect to the line wires, and the sleeve joins the barrel of the jack to a battery, the other side of which is connected to earth or a common return. To complete the connection the jack of the line wanted is similarly treated. Should either of those subscribers now be asked for at another section of the board, the operator there would touch the barrel of that subscriber's jack with the tip of the plug with which she proposed to make the connection, when a current would pass from the test wire through her telephone, causing a click, and so advising her that the line was engaged.

The spring jacks are made up in strips of 20, mounted on two parallel pieces of vulcanite 1⅝in. apart. I submit a sample strip of these jacks. The front piece is 11½in. × ½in. × ½in., and the distance from centre to centre of the jacks is ½in. The back part is slotted, and the springs which fit into these slots are shouldered; so that they cannot be forced out of position by the plug. Each jack has two long springs to which the line wires are connected, and these grip the plug. These springs rest on shorter springs (both being provided with platinum contacts) which are connected to the corresponding jacks in the succeeding sections of the board, and, lastly, to the local jack and indicator. A strip of metal is connected to the barrel of the jack, and is carried to the back as a soldering tag, and to this the test wire is attached. These strips are secured to stiles in the upper portion of the board by special fasteners, which allow of any strip being readily withdrawn for repairing purposes.

I have here a sample showing how one row of jacks is connected by cable with the corresponding row in the succeeding section of the multiple.

The wires are carried throughout the switchboard in 63-wire cables, each cable serving 20 subscribers or one strip of jacks, and having three spare wires to provide for breakages. The copper conductor is No. 22 gauge, insulated with rubber and paraffined cotton. The wires are laid up in threes—two line wires and one test wire for each subscriber. Seven such strands are twisted together, and three such groups of wires are laid side by side and covered with cotton braiding saturated with paraffin. The size of the finished cable is about ⅞in. by ⅜in. inch.

The listening and ringing keys, and their connections, are the same as those shown with reference to small boards.

The operator's telephone has received considerable attention of late years. It was, until lately, the practice to suspend the transmitter from the top of the board, and the receiver had to be held to the ear by hand. Now the transmitter is fitted in an aluminium case, which is fixed to a light breast-plate of the same metal, and this is suspended round the neck of the operator, so that the mouthpiece is always conveniently placed for talking into. The receiver is also made up in a light form, and kept against the operator's ear by metallic springs or an elastic band. By the use of these instruments both her hands are left free for operating. The induction coil of the transmitter and the coils of the receiver are differentially wound, and the centre point of the latter coils is joined to earth to allow of the "engaged" test being obtained, and of the operator working earth circuit and metallic circuit lines on the same board indiscriminately. The earth being connected to the centre of the differentially-wound coil has no detrimental effect on a metallic circuit line.

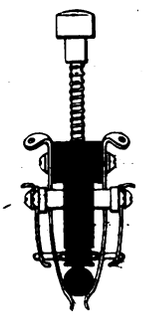

FIG. 5A.—Ringing Key.

The boards just described are complete metallic circuit boards, and are used very extensively in this country. They work satisfactorily on earth circuits, and, if necessary, may be employed on earth circuit systems as transition boards. When on this system metallic circuits are joined to other metallic circuits they form a perfect metallic loop, but when joined to earth circuits one side of the metallic circuit is earthed at the exchange; the circuit so formed being but little better than a line with earth return throughout, the second line simply acting as a screen to lessen induction. All these connections are made in an exactly similar manner, the operator not having to distinguish between single and metallic circuits.

The problems in switchboard work have always been, firstly, how quickly can a connection be made? and secondly, how can efficiency be best obtained?

With reference to the first, the desired end is attained by reducing to a minimum the number of movements necessary, and making those movements as easy as possible.

With reference to the second condition, in the earlier boards it was usual to leave the two line indicators in circuit when the lines

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were joined together; and the first step taken to improve this was to cut one out, or to cut out both line indicators, substituting a special indicator for the purpose of receiving the subscriber's clearing signal. The electromagnet of this indicator was, however, directly in the circuit. It was observed that any such electromagnet in the line circuit cut down the talking very considerably, one indicator having probably as much effect in reducing the efficiency of the speaking as 50 miles of an ordinary aerial line. The next step was to increase the resistance and self-induction of the ring-off indicator, and place it in shunt across the two lines of a metallic circuit, or as a tap to earth on single lines. It had also been found that trouble was sometimes caused by dirty contacts in the spring jacks. To obviate this difficulty some of the later boards have all the spring jacks wired in parallel, and the two line indicators, which are of special pattern, left in shunt. This system is sometimes called the "self-restoring" and sometimes the "branching" system; but, as the latter name had been correctly applied to other systems which had preceded it, and of which this is an extension, I prefer to use the former term.

In this system the work of the operator is lessened, inasmuch as the shutter of the indicator is automatically restored in answering the subscriber. This allows the indicators to be placed at the top of the boards, where space is not so valuable, and the spring jacks to be placed lower, thus bringing a much larger number within easy reach of the operator, and materially increasing the ultimate capacity of the board. The general arrangement of this class of board is much the same as that previously described, except that, as just mentioned, the indicators are placed over instead of under the spring jacks. The apparatus, however, is somewhat different. The springs of the jacks are let into a solid slab of vulcanite. There are three of these springs, two being of equal length, and one shorter. The front of the slab of vulcanite carries two bushes, one behind, but insulated from, the other. The line wires are continuous throughout the exchange, ending at the subscriber's indicator. Branches are brought from these at each section, one to the short spring and the other to the inner bush of the jack. The two springs of equal length a rejoined, one to a common battery wire running round the exchange and the other to the corresponding springs of all the jacks in the same line, and, finally, also to the indicator. This latter spring is also in metallic contact with the front bush of its own jack. When a plug is inserted in a jack, the tip comes into contact with one line through the short spring; the sleeve, through the barrel, with the other line; and the two springs of equal length are connected by an insulated metallic ring between the tip and the sleeve. The tip and the sleeve are joined to the two conductors in the flexible cord used for connecting two subscribers.

The indicator consists of two separate single-coil electro-magnets, both sheathed with iron, and fixed one in front of the other. To the back one, which has a resistance of 1,000 ohms, the line wires are attached. The front one, which has a resistance of 45 ohms, is connected on one side to the test circuit, and on the other to earth or to the common return of the restoring battery.

When a subscriber calls, a heavy armature pivotted in front of the restoring cell is released, and, falling forward a short distance, lifts a light aluminium shutter, disclosing the subscriber's number. When the operator inserts the plug to answer the subscriber, the heavy armature is drawn backward, and held fast in its normal position so long as the plug remains in the jack. The aluminium shutter, of course, resumes its normal position at the same time.

As before explained, the front bush of each jack is connected to this restoring circuit, and the connections of the operator's instrument are so arranged that, when she touches this bush with the tip of one of her plugs, part of the current is shunted through her receiver, showing her that the line is engaged. As one of the connections is dependent upon the contact between the inside of the bush and the sleeve of the plug, which must fit somewhat loosely, the plug is provided with what we call "umbrella" springs. The ring-off indicators are of the same pattern as those above described, but are so arranged in connection with the listening keys that when the operator's instrument is in circuit the indicator is locked, but is free to respond to the subscriber's ring-off current, when, by pushing the lever forward, this instrument is cut out of circuit.

This class of board with self-restoring indicators is being introduced into London at the same time as the subscribers' lines are being metallic-circuited, and this work will be entirely finished in a few months. One of the principal exchanges fitted with this class of board is that at Lime-street, City.

It is to be noted that, as these self-restoring indicators require permanent current to keep them locked while the lines are in use, special arrangements have to be made at each exchange for providing this current. As a typical case, I may mention that at Lime-street the current is supplied by 12 E.P.S. cells of 23 L type, charged by an Elwell-Parker dynamo running at 800 revolutions, and giving an output of 45 amperes at 15 volts. This dynamo is driven by a Tangye gas engine of 1 H.P. nominal. The engine also drives the generators which supply the ringing current. One-half of the cells—*i.e.*, 6—are in use at one time, arranged in three groups of two each; and each group supplies current for one-third of the whole exchange—*i.e.*, about 1,300 indicators. The current for the operator's transmitters is supplied by a similar number of cells divided in the same way. In this case each group supplies current for about 30 transmitters. To prevent overhearing it is found essential that the circuit of each transmitter should be taken separately by direct leads from the terminals of the batteries. A duplicate set of cells is provided, and one set is being charged whilst the other is in use.

From what has previously been said as to the number of jacks required for an exchange with 5,000 subscribers' lines, and the increased proportion in the number required when the exchange is fitted for 8,400 lines, it is evident that, apart from cost, the question is a very serious one; indeed, it becomes so serious that while on every hand it is acknowledged—and I think rightly acknowledged—that the multiple system is the best, a point may be reached where the vast number of jacks and large quantity of cables used introduce troubles almost equal to those previously overcome by the use of the multiple board. In America they are trying to meet the difficulty to some extent by the introduction of what is known as the "divided multiple" board, whilst I have endeavoured to meet it by the use of flat boards. The weak feature of the divided board is that no connection is made without being dealt with by two operators, and, consequently, the chief advantage of the multiple system—viz., that the operator who receives a call completes the connection—is lost. But with the flat board, fitted as I shall presently describe, this advantage is retained, whilst, broadly speaking, one-half only of the line jacks and cable are needed.

It is about eight years since I commenced the use of flat boards, when a small one was fitted at Paisley. The working of this board proved that the flat board as a system, if fitted with the proper material, could be worked very successfully. I am aware that flat boards had been tried in this country before that date, and that some were in use in America; but, so far as I can learn, the number of jacks used was not less than that on the ordinary upright board. I, therefore, cannot see the reason for introducing them, unless, indeed, it was considered they were better flat than upright from an operating point of view. I am aware that there are in this and in other countries telephone engineers of the highest reputation who are not at one with me on the question of the advisability of introducing flat boards; but, after the fullest and most mature consideration, and experience of their working for several years, I see no reason why they should not be used largely under certain conditions. When flat boards are fitted up in comparatively small exchanges the saving on the jacks and cable is not equivalent to the extra expense of the framework, and therefore I do not recommend their use for small exchanges. But for large exchanges, with from 2,000 to 8,000 subscribers' lines, there is to my mind no doubt that this is the best class of board to use.

The principal reasons for this opinion are—

1. That, in consequence of the smaller number of jacks and quantity of cable used, better speaking results are obtained, and fewer faults occur. I have only to point out to you, as electrical engineers, that for an 8,000-line exchange the number of soldered connections is reduced in the flat, as compared with the ordinary upright board, by over half-a-million, to bring this point of efficiency forcibly before you.

2. In many cities it is very difficult to find switch-rooms large enough to take from 5,000 to 8,000 subscribers' lines; but with the flat-board system this difficulty does not exist to the same extent, as practically they take only half the floor space required for upright boards.

There are likewise the questions of the cost of the boards, rent of switch-rooms, lighting, heating, &c., which bear some proportion to the space occupied; but these are secondary considerations, the principal one being efficiency.

I should like to make it perfectly clear that, while I consider flat boards the right pattern to use under certain conditions, I do not recommend their use in all circumstances. With self-restoring indicators, which do not require to be within reach of the operator, and may consequently be placed overhead, and the jacks for use with which have no breaking contacts, with the consequent trouble arising from dust, I consider them the right class of board to use. I also consider the flat board the best to use in connection with exchanges of all sizes worked on the call-wire system.

Fig. 6 shows a section of the type of flat board with self-restoring indicator before referred to. It will be seen that when a plug is inserted into a jack the springs of the jack do not break any connection, and when the plug is withdrawn there is no contact point to be restored.

The table carries the multiple spring jacks, the barrels all facing upwards. The local, or home-section jacks, which are always used when answering subscribers, are at the side on the upright. The listening and ringing keys are fixed on a shelf at the side of the table, one half of the cords and plugs being fitted on the same

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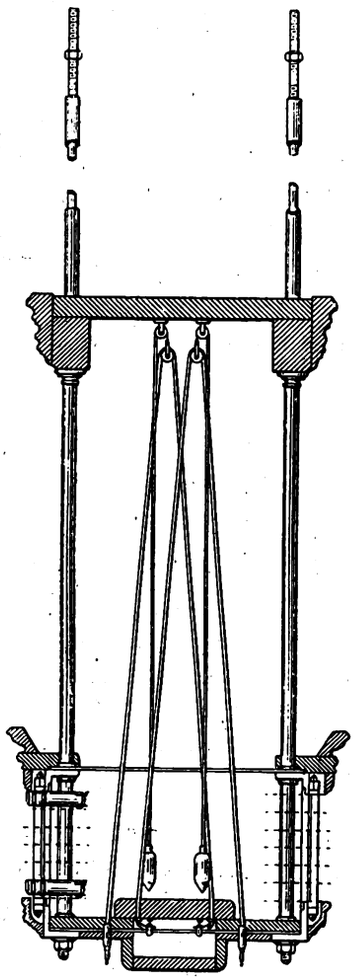
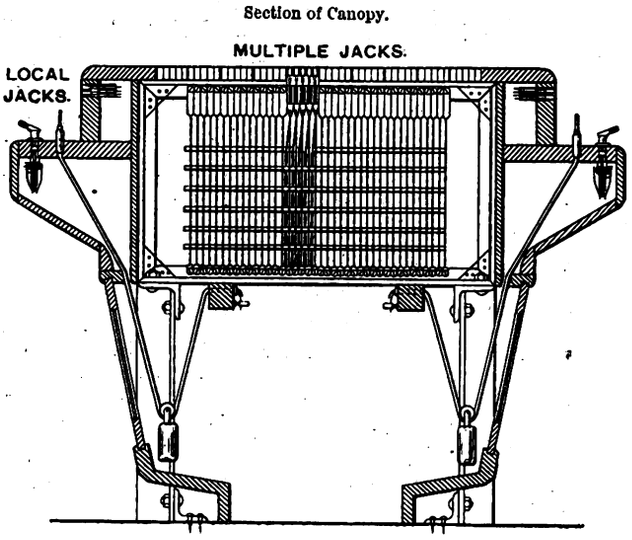
shelf, and the other half in a canopy above the table, which canopy also carries the self-restoring indicators. The lower plugs are the answering plugs, and are inserted in the local jacks only; the overhead plugs are used only for making connection with the line jacks on the top of the table. The operators (FIG. 7), each working 50 subscribers, sit on both sides of the flat table; and the 6ft. 6in. section of multiple jacks, which, on the upright board, is common to four operators with 200 subscribers, is here common to eight operators working 400 subscribers. The framework is built of T and L iron



Section of Canopy.



Section of Table.

FIG. 6.—Flat Board with Self-Restoring Indicators.

faced with wood, the details being as shown by sectional drawing at Fig. 6. Vertical oblong iron frames cross the tables at regular intervals of 11½in. for carrying the jacks and cables. The ends of the strips of spring-jacks rest on and are fastened to the upper edge of these frames, the jacks being placed in a vertical instead of a horizontal position. The cables are carried by racks inside these frames. Each block of 100 jacks occupies a space of 11½in. by 2½in., and as there are six such blocks in the length and 10 in the width of the multiple, it will be at once seen that the board has a capacity of 6,000 lines. A special type of 63-wire cable is used. The cable is formed of seven groups of three strands of three wires each, laid side by side and covered with braided cotton, the external dimensions of the cable being 1·312in. by 0·260in. The canopy is hung from the ceiling by rods at 3ft. 3in. centres, and, as before mentioned, carries the indicators and half of the connecting plugs and cords. The strips of indicators are fixed in the sides of this canopy, being hinged to allow of their opening outwards for convenience of inspection and repairing.

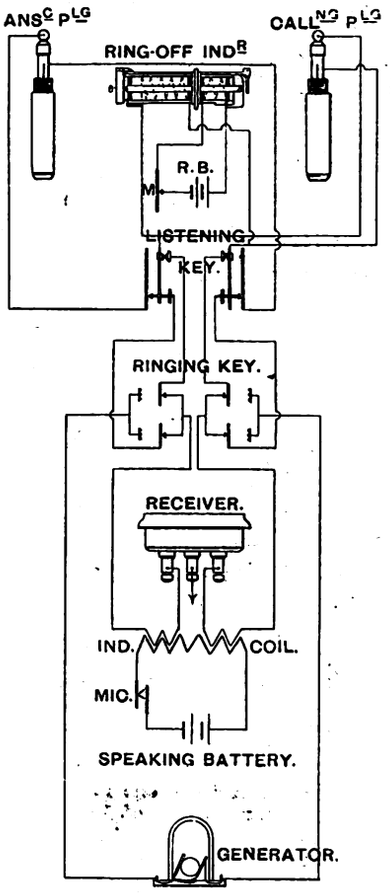


FIG. 6A.—Diagram of Branching System with Self Restoring Indicators

In connection with flat boards I mentioned the call wire, and this introduces us to a system of working telephone exchanges differing largely from any I have previously described. The use of this system has been very much discussed by telephone experts. In the call-wire system each subscriber has, in addition to his direct line to the exchange, the use, in common with a number of other subscribers, of a wire known as the "call wire," which, starting from the exchange, is branched into the offices of, say, 50 subscribers.

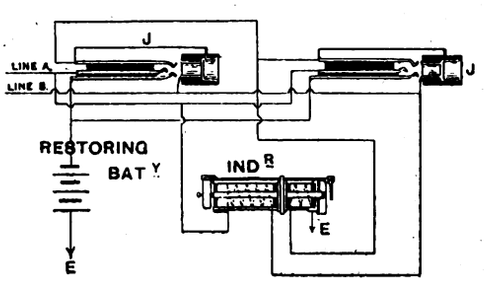


FIG. 6B.—Diagram of Branching System with Self-Restoring Indicators

On this call wire the operator attending the subscribers is continuously listening in the exchange. The subscriber's instrument is fitted with a switch which enables him to place it in connection with the call wire, on which he asks for the subscribers he requires. These, of course, are connected on his direct wire, and are rung up by him, the operator not interfering with the connections until told on the call wire to clear. It will be seen from this that when a subscriber takes a long time to answer

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his bell (and there are many of them who do so, especially in London) he has to explain to the calling subscriber the reason of the delay, which would, in all probability, have been otherwise attributed to the operator. There being 50 subscribers connected to the telephone of each listening operator, it is evident that any number of them may try to speak at the same time; but here, as in all matters of business, common sense, as a rule, prevails, and a subscriber coming on to the call wire and hearing others talking to the operator does as he would do if booking a ticket at a railway office—*i.e.*, takes his proper turn—and so the calling is done without confusion, and more quickly than with the indicator system. It must be clear to everyone who considers the matter that an operator cannot attend to two subscribers at the same time; and, generally, it is quite as satisfactory to a subscriber to listen until he hears that the operator is free, as to ring time after time until the operator is able to attend to his call. It must be obvious, however, that the number of subscribers a call wire will accommodate is limited, and, as hereafter explained, great confusion would arise from overloading it.

I have before now been accused of something like inconsistency in advising in favour of this system in some places, and against it in others. In deciding upon any particular case the local circumstances have to be taken into consideration, and, after a careful study of the subject, the decision I have arrived at is that, given a town where all, or nearly all, the subscribers' lines terminate in one exchange, there is no doubt that the call wire gives the most perfect service. For this reason we have introduced the call wire into Glasgow and nearly all the towns in Scotland. We are also

Fig 7.- View of Operator, showing Breast-Plate, Microphone and Receiver.

introducing it into Manchester. It would, however, be absolutely unworkable in London. The full explanation of this would take more time than can be given to it in a Paper of this kind; but, broadly, it may be said that in a great city like London, where there are a large number of exchanges, and consequently the subscribers lines terminate at a number of different centres, the call wire becomes unsuitable. Let us take an instance. Suppose a subscriber on our King's-cross-exchange, whose office has been fitted with the call wire, wishes to communicate with a subscriber on Lime-street exchange, in the City, he presses his call-wire key and gives the listening operator the number of the subscriber he requires. The operator has then to do one of two things: she has either to cut herself off from the local call wire, in which case the main feature of the call wire, viz., continuous listening, is sacrificed; or to connect her telephone, as well as the call wire with its 50 subscribers, on to a call wire to the city. Other operators in the same exchange may have been asked by their subscribers for subscribers in the City, and may also have connected their call wires to the same City wire. In the event of a connection having to be made through two or three exchanges this trouble would be increased, and it would often be found that operating would be rendered impossible, owing to the large number of subscribers connected together all clamouring for their instructions to be taken first. The effect would be somewhat similar to that of a crowd of people attempting to rush out of a public building, on an alarm of fire, through a doorway too small to accommodate them; they simply get jammed in the doorway, with the unhappy result that they perish in the attempt. In the same way the subscriber at King's Cross might stand at his instrument and perish before he succeeded in getting through to

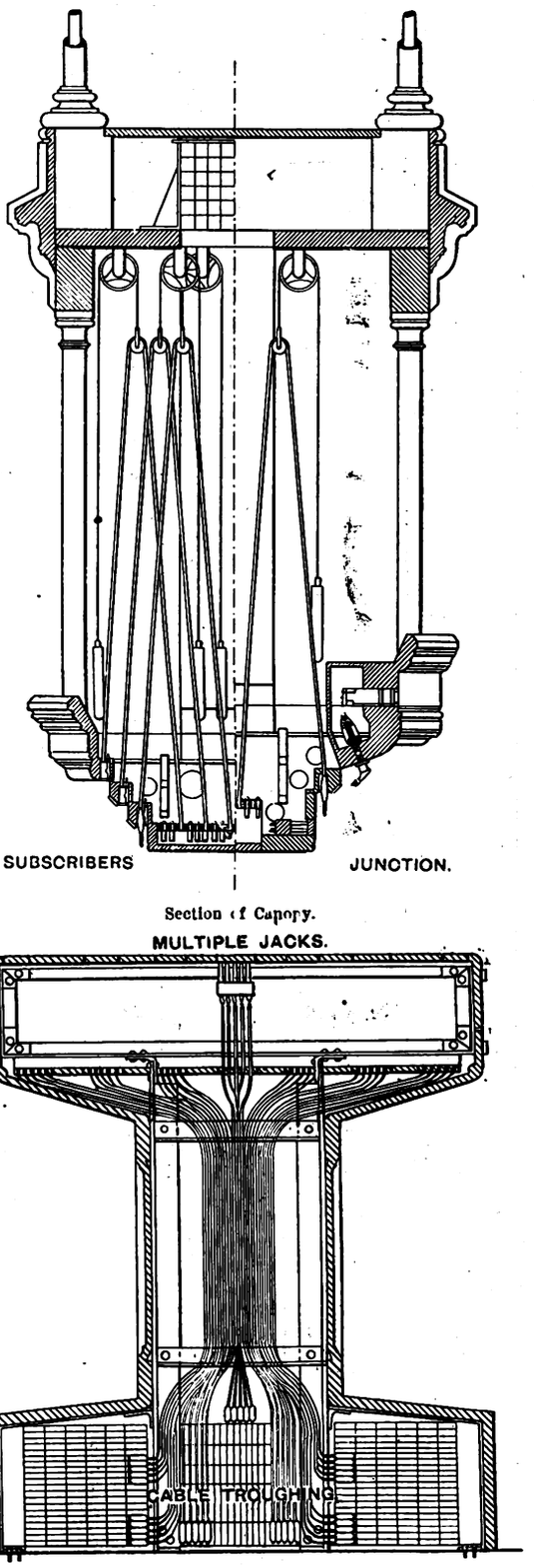

Fig. 8—Manchester Board.

the subscriber in the City. With this explanation it will, I am sure, be apparent to everyone who thoroughly studies the matter how it is that the call wire may be successful at one centre where all, or nearly all, the subscribers' lines are grouped in one exchange, and be a complete failure if introduced into an exchange system like that of London.

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All things being considered, we find that the call wire gives more satisfaction than the indicator system, and it is perhaps to be regretted that it cannot be introduced under all circumstances. We had the indicator system with multiple boards at work for many years at Glasgow, and we changed to the call-wire system. Nine months after the introduction of the new system the subscribers were asked whether they preferred the call-wire or the indicator system previously in use, with the result that 95 per cent. of the subscribers were in favour of the new system; and it was this result that decided the question in favour of its introduction into Manchester.

The call wire has been in use almost since the introduction of telephone exchanges, and here again I find that our friends on the other side of the Atlantic at a very early date saw the advantages to be derived from it, with both the make-and-break and the branching system. It is the latter system which is being introduced at Manchester.

It so happens that at Manchester 90 per cent. of our subscribers have their lines terminating in the central exchange, and, consequently, it is a highly-suitable place for the introduction of the call-wire system. We are now installing it there in connection with a new exchange which is being fitted with flat boards.

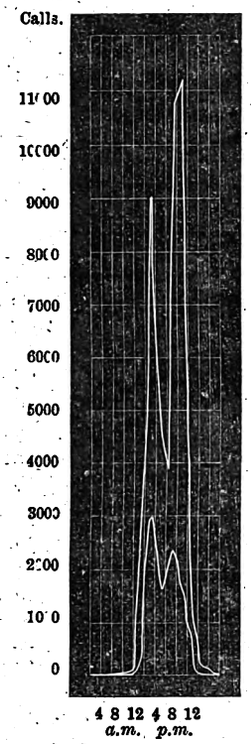

FIG. 9.—Diagram showing Originating Calls. Upper Curve: Liverpool.

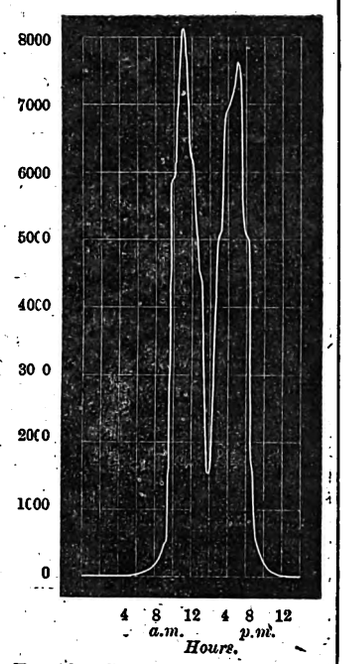

FIG. 10.—Curve showing Calls at Manchester Central Exchange for one day.

The Manchester board is illustrated in the drawing Fig. 8. It will be seen that it differs somewhat in detail from that with self-restoring indicators which has been already described. The board will accommodate 7,200 subscribers' lines, and is now being fitted complete for 4,800, with the necessary trunk and junction wires in addition. The design of the framework has been so modified as to allow the operators to get nearer to the line jacks, which gives greater facilities for operating.

I may now refer to a few load curves (FIGS. 9 and 10) I have prepared showing the number of calls passing through our busiest exchanges. At the top of these we find Liverpool, where the average number of calls per subscriber per day amounts to 18·6. The pressure of the work will, however, be better understood by noticing that at certain hours of the day the number of calls is very high. For instance, between 4 p.m. and 5 p.m. the total was 11,050. I believe this is higher than is to be found in any other exchange of equal size in this or any other country.

An important part of an exchange system in a place like London is the proper arrangement and working of the junction wires between the different exchanges. I have found that the best way to arrange these is to have, in addition to the direct wires, a central juction-wire exchange, between which and every other exchange two or more wires are provided. It will be readily understood that in a system like that of London, where there are 37 exchanges, it would be impracticable to run from each new exchange opened in the suburbs direct wires to all the others. Therefore the central junction exchange becomes a necessity. It is obvious, however, that such a central exchange must introduce extra operating, and consequent delay, into the service; and, therefore, where we have as many as 60 or 70 messages per day between any two exchanges, we provide two direct junction wires. Beyond this, an additional junction wire is provided for each 40 messages per day. Taking the average duration of each call as three minutes, it will easily be seen that, to meet the maximum pressure at the busiest time of the day, so many junction wires have to be provided that the average time each is in use amounts to only two hours out of the 24.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April 3, 1896.*

New York Academy of Sciences.—The third annual exhibition of the New York Academy of Sciences was held on the afternoon and evening of March 26th, and was attended by a large and enthusiastic gathering. This is one of the oldest scientific bodies in America. The department of electricity was the centre of greatest attraction, owing to the exhibition of Röntgen radiographs, the results showing a marked advancement in this absorbing field of investigation. In the evening Prof. Pupin, of Columbia College, gave a formal lecture on the methods of using the Crookes' tube for obtaining Röntgen effects, and after the lecture those who desired were permitted to examine their own bones with the aid of a device produced by Mr. Thomas A. Edison, which that gentleman calls a fluoroscope.

Electric Power on the Brooklyn Bridge.—Everything tends to the ultimate use of electricity as the motive power for the Brooklyn Bridge cars. On March 23rd, at the regular meeting of the trustees, Chief Engineer Martin made a report upon the results of the experiment of using electric motor cars for switching purposes. His report was very favourable, and he recommended that a power plant of larger capacity be built. The proposed plant will have an engine capacity of 2,500 H.P. and electrical generators of about 1,600-kilowatt capacity. It is proposed to do all the switching of trains by electric motors, and in case of failure of the cable, the motor cars will be capable of running four-car trains across the bridge at intervals of 60sec. Mr. Martin's report was approved, and plans for the new power house will be advertised for at once.

Consolidation of Electric Heating Interests.—Last week the consolidation of the various electric heating companies was effected in Boston, the new company absorbing these interests being known as the American Electric Heating Corporation of Boston. The capital stock of the new concern is $10,000,000, and all patents, processes and devices throughout the country that are believed to be of value will be purchased. Mr. James I. Ayer, the well-known electrical engineer and manager, is general manager of the new combination.

Franklin's Will.—The will of Benjamin Franklin was probated in Boston on March 26th as a foreign will. The will was probated in Philadelphia about a century ago, but in view of the legal disposition of the Franklin Fund in Boston, which amounts to several hundred thousand dollars, and which was created by Franklin's will, it was deemed necessary to have the document probated in Boston. The will was drawn up on July 17, 1788.

The Edison Fluoroscope.—Mr. Edison, who has been extensively experimenting with the Röntgen fluorographic screen, has finally devised a practical apparatus for its application. The instrument is intended more particularly for the use of surgeons and physicians. It is a very simply-constructed device and has been named by Mr. Edison the fluoroscope. It consists of a tube about 8in. long, larger at one end than at the other. The smaller end is so arranged as to fit closely about the forehead and eyes; the larger end is covered by a piece of cardboard, on the inner side of which is a piece of white cloth coated with tungstate of calcium crystals. A handle placed on one side enables the observer to hold the instrument. The vacuum tube is placed in a wooden box and the hand or object

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to be examined is laid on top of the box, over the tube. The observer then fits the fluoroscope to his eyes, and looks down. If Röntgen rays are being emitted from the tube the tungstate crystals fluoresce, and the observer can plainly see the shadow of the object being examined. Any motion of the object is perfectly visible through this instrument.

Nikola Tesla's Investigations.—During the past week interviews with Mr. Nikola Tesla have been published in several of the New York daily newspapers, and prominent articles have been printed as coming from him under such headings as "May Signal the Stars," "We may Signal to Mars," &c. The gist of all the gush so printed is that Mr. Tesla has revived his old experiments of communicating intelligence from one part of the earth to another part without the aid of wires, using as a means therefor the principle of propagation of electric waves. "Now, why is it not equally conceivable that a disturbance on the earth's surface should produce some tangible effect on other planets?" asks Mr. Tesla.

LEGAL INTELLIGENCE.

Re The Coventry Electrical Engineering Company (Limited).

At the Coventry County Court, on Wednesday, Mr. Walter Browett applied on behalf of the Northern Electric Wire Company, of Sedburgh Mills, Halifax, electric wire and cable manufacturers, for the withdrawal of their petition for the compulsory winding-up of the Coventry Electrical Engineering Company. Counsel stated that terms had been agreed upon between the debenture-holders and the petitioning creditors. Mr. Maddocks for the debenture-holders, Mr. Wilks for the Company, and the liquidator (Mr. S. T. Peirson) consented to the application, which his Honour granted.

Walter v. Central News (Limited).

The hearing of this case (referred to in our issue of April 3rd) was resumed on Tuesday. The re-examination of Mr. Moberley Bell was continued. He had since the adjournment edited the telegrams supplied by the Central News. It was not permissible in editing telegrams to invent or add facts. He had counted the words in 24 telegrams supplied by the Central News, leaving out the dates and addresses. He had also counted the words in the telegrams as edited by himself. The original telegrams comprised 1,264 words. By liberally editing them he had added 793 words, or 63 per cent., making 2,057 words in all. These telegrams, as expanded by the Central News, contained no fewer than 7,947 words, representing an increase of 529 per cent. over the original number of words. The payment of 6d. a line was consistent with the Central News making a considerable profit. There were at least 100 daily papers. In addition to these they supplied news to American papers. With the expansions made by the Central News they might make out of each paper the whole cost of the telegrams. They received from the Central News a telegram briefly announcing the battle of Ping Yang. On the same day they received a letter from them, in which they said they had a telegram of 700 words describing the battle, and desired to know whether *The Times* would like to have it for their second edition. The telegram was accepted, and published in the paper. He had not been able to find any original telegram corresponding to those 700 words except that of 75 words. There were 17 telegrams supplied to *The Times* for which they were unable to find that any corresponding telegrams had reached the Central News.

At this point a conference between counsel took place, and it was announced that an arrangement had been come to by which a verdict was to be entered for the plaintiffs, with damages fixed at £5, with costs on the higher scale.

The Court approved this arrangement, and a verdict in these terms was accordingly given.

In reference to the above case *The Times* of yesterday contains the following: "In reference to a statement circulated by the Central News and printed by some of our contemporaries yesterday but not sent to *The Times*, it is sufficient to point out that the reports of the case published by the entire Press show that the assertion of the Agency that we accepted the readiness of the plaintiff to close the action is the direct reverse of the truth. The proposal to agree to a verdict against themselves, before our case was closed and before any evidence was offered for the defence, was made by Mr. Carson on behalf of the Central News and accepted by *The Times*."

BOOKS RECEIVED.

"The Volunteers and the National Defence." By Spenser Wilkinson. (London: Archibald Constable and Co.)

"Les Rayons X et la Photographie a Travers les Corps Opaques." By Ch. Ed. Guillaume. (Paris: Gauthier-Villars et Fils.)

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

TENDERS INVITED.—The Corporation of Sunderland are prepared to receive tenders for an evaporative tubular surface condenser, with air and circulating pumps. Specifications, &c., may be obtained at the office of the borough electrical engineer (Mr. C. S. Vesey Brown) at the electric supply station, Dunning-street, and tenders addressed to the Town Clerk (Mr. Fras. M. Bowey), Town Hall, must be in by 5 p.m. on Wednesday, the 29th inst. Our advertisement columns contain further particulars.

——— The Vestry of St. John, Hampstead, invite tenders for the supply, delivery and erection at the Central Station, Stoneyard, Lithos-road, Finchley-road, N.W., of a steam alternator, switchboard, steam and exhaust pipes, feed water heater, tank, and appurtenances, and these can be tendered for either as a whole or in part. The specification, &c., may be obtained after the 11th inst., at the offices of Mr. Arthur P. Johnson, Vestry Hall, Hampstead, to whom tenders must be sent not later than 4 p.m. of the 27th inst. Further particulars are given in our advertisement columns.

——— The Public Lighting Improvement Committee of St. Helier, Jersey, invite communications from persons wishing to establish a lighting station in that town for the supply of electric, gas, or other forms of light for both public and private purposes. Communications should be sent to Mr. P. Baudains, Ecr. Constable, Town Hall, St. Helier, Jersey. Some further essential particulars will be found in our advertisement columns, and other information can be obtained on application to the Town Hall.

——— Tenders are required for the provision and fixing of electric bells, telephones, fire alarms, &c., at the Brook Fever Hospital, Shooter's Hill, S.E., for the Metropolitan Asylums Board. Copies of the specification (which has been prepared by Prof. Alex. B. W. Kennedy), forms of tender, &c., can be obtained at the chief offices of the Board, Norfolk House, Norfolk-street, W.C. Tenders must be delivered at the offices by 2 p.m. on Wednesday, May 6th. Further particulars are given in our advertisement columns.

——— Tenders are invited for the purchase of about 45 tons of old copper, a large quantity of other metals, india-rubber, and other old telegraph stores, some particulars of which will be found in our advertisement columns. The necessary form of tender can be obtained of Mr. Chas. E. Stuart, Controller of Stores, General Post Office, London, E.C. Tenders must be sent in by 10 a.m. of Monday, May 4th.

——— The Electric Lighting Committee of the Coventry Corporation invite tenders for the supply and erection of (*a*) boilers and fittings, mechanical stokers and economiser, feed pump, &c.; (*b*) steam engine, alternator, oil filter, fittings, &c., steam, exhaust, feed, blow-off, and sundry pipes, valves, &c. Plans and specifications can be obtained from the consulting engineer, Mr. Robert Hammond, Ormond House, Great Trinity-lane, London, E.C., on and after the 24th inst., and tenders, addressed to the Town Clerk (Mr. Lewis Beard), St. Mary's Hall, Coventry, must be in by Tuesday, the 12th inst.

——— The Commissioners of the township of Rathmines and Rathgar, Ireland, require tenders for the electric lighting of the new Town Hall and offices, for which about 250 lights with the necessary generating plant will be required; also for an installation of telephones and electric bells. Tenders to Mr. F. P. Fawcett, Town Hall, Rathmines, by 10 a.m. of Monday next.

——— The Town Commissioners of Bray (Ireland) invite tenders for the supply of electrical stores and fittings for their generating station for twelve months. Tenders to the Town Clerk (Mr. P. Macdonnell), Bray, by Monday next.

——— The Bedford Urban Sanitary Authority invite tenders for the supply and delivery of vulcanised rubber cables. Tenders must be sent in to the Clerk, Mr. T. S. Potter, Town Hall, Bedford, by Tuesday next.

——— The Brighton Corporation require tenders for the supply and delivery of cast-iron and drawn steel bracket posts for suspending arc lamps. Tenders to the Town Clerk (Mr. F. J. Tillstone), Town Hall, Brighton, by the 20th inst.

——— Tenders are required for the erection and completion of general offices and house at Messrs. Willans and Robinson's new engineering works at Rugby. Tenders to the Secretary, Messrs. Willans and Robinson (Limited), Picton House, Thames Ditton, Surrey, by the 30th inst.

——— The Royal Company of Portuguese Railways require tenders for the supply of electric light stores. Particulars from the offices of the Company, 28, Rue de Châteaudun, Paris, and tenders, addressed to the Ingenieur Chef du Service des Magasins,

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Compagnie Royale des Chemins de Fer Portugais, Santa Apolonia, Lisbon, by May 6th.

TENDERS INVITED.—Tenders are invited for an electric light installation (about 180 lights), including the supply and erection of the necessary generating plant, at Ferniehurst, Baildon (Shipley Station).

——— The French Admiralty Authorities at Brest invite tenders for the supply of three steam dynamos, required in connection with the electric lighting of the French cruiser "Gaulois."

——— The London County Council require tenders for engineers' goods and stores, tools, implements, &c. Tenders must be delivered at the County Hall, Spring Gardens, by May 5th.

TENDERS ACCEPTED.—The Sunderland Corporation have accepted the following tenders for the supply of additional plant for their electricity supply station:—

Thomas Parker (Limited)	Two continuous current dynamos and Bellis steam engines, steam pipes and switchboard connections.
Babcock and Wilcox (Limited)	Two boilers.
E. Green and Son	Fuel economiser.
H. Tonkinson	Cast-iron water tank.

——— Thirty-five tenders were received for fitting up an electric light installation at the Prince of Wales Hotel, Harrogate, including the supply of the generating plant, fixing telephones, bells, &c. The tender of the Liverpool Gas Fittings Company for the sum of £1,293 has been accepted. Mr. Walter Leake is the consulting electrical engineer.

——— The Yarmouth Town Council have accepted the tender of the General Electric Company for the supply of arc light carbons for the ensuing twelve months, at £6. 12s. per 1,000 pair, and £3. 3s. per 1,000ft.

——— The Cheltenham Town Council have accepted the tender of the Callender Company for the supply of service cable required during the remainder of the year.

——— In connection with the tenders recently invited for works required in the erection of the new electricity supply station for the Bradford Corporation, the builders', carpenters', plumbers', &c., work has been let to Bradford firms. The wood-block flooring will be executed by the Wood Block Flooring Company, of 11, Queen Victoria-street, E.C., and gates and railings will be supplied by the Coalbrookdale Company. The reservoir and tank by Messrs. A. Broxup and Sons, of Great Heorton, Bradford. The tenders for plant (batteries, surface condensing plant, cables, travelling crane, and steam and exhaust pipes) were given in our last issue.

——— The Edinburgh Town Council have accepted the tender of Messrs. Lowdon Brothers, of Dundee, for wiring the City Chambers for the electric light at £188. Eighteen tenders were received.

APPOINTMENTS VACANT.—An assistant is required for the Physical Department of the City and Guilds Central Technical College, Exhibition-road, S.W. Salary £100 per annum. Applications to Prof. Ayrton.

——— The Blackpool Corporation invite applications for the position of resident working electrical engineer to the Corporation, in succession to Mr. John Hesketh, who has been appointed electrical adviser to the Queensland Government. Further particulars are given in our advertisement columns, and applications must be sent in to the Town Clerk (Mr. T. Loftos), Town Hall, Blackpool, by the 27th inst.

BUSINESS NOTICES.—The Jackson and Sharpe Company of Wilmington, Del., U.S.A., builders of passenger and tramway cars, &c., have opened London offices at 13, St. Ermin's-mansions, Westminster, S.W.

LIQUIDATIONS.—A meeting of the principal unsecured creditors in the matter of Woodhouse and Rawson United (Limited) will be held at 33, Carey-street, London, W.C., on Tuesday, the 21st inst., at 12 o'clock, to consider what action, if any, should be taken in the interests of the unsecured creditors in connection with certain claims which counsel has advised that the liquidators can enforce against the directors and auditors, and which claims are now offered for sale by tender.

——— A meeting will be held on May 14th, at 24, Fulham-road, London, S.W., for the purpose of receiving an account of the winding-up of the Domestic Telephone Company (Limited).

——— Notice is given of the release of the liquidator (Mr. G. S. Barnes, 33, Carey-street, W.C.) in the liquidation of the Ford-Lloyd Manufacturing Company (Limited).

——— All attempts to dispose of the patent of the International Electric Subway Company (practically its only asset) have proved unavailing, and Mr. C. W. Grimwade, the liquidator, informs us that there are no assets whatever to set off against the Company's liabilities.

BANKRUPTCY.—Mr. James Nicoll, C.A., Greenock, has been appointed trustee in the bankruptcy of John H. Cox, electrical engineer, of Greenock. Claims by May 8th, and meeting of creditors at the Court House, Greenock, on May 29th, at 11:30 a.m.

PRESENTATIONS.—Mr. W. B. Edgar was presented by the electrical staff of the Crichton Royal Institution, Dumfries, with a gold chronograph on the occasion of his leaving the Institution, where he has acted as Dr. Bottomley's assistant. Mr. Edgar joins Messrs. Johnson and Phillips' staff at Charlton.

——— Mr. E. Thomas, manager of the Cork District of the National Telephone Company, was on Monday presented with a gold watch, chain and pendant by the *employés* of the Company on his promotion as local manager of the Dublin district. Mr. Thomas has been in the Company's service at Cork for five years.

PERSONAL.—Mr. W. S. Graff Baker announces that he has severed his connection with the General Traction Company (Limited), and has taken offices at 13, Austinfriars, London, E.C.

TELEGRAPH WIRE AND APPARATUS EXPORTS.—The value of the telegraph wire and apparatus exports for March amounted to £21,238, against £109,840 in the preceding month, and £19,598 and £113,423 in the corresponding months of 1895 and 1894. The figures for the quarter, however, show a considerable improvement compared with the same period of last year, the totals being £167,064 and £44,604 respectively.

EXPORTS TO SOUTH AFRICA.—Under the classification of "electrical" the value of goods exported from this country to South Africa for the week ended April 4th was £1,849, made up as follows:—Cape Town, £831; Algoa Bay, £142; East London, £242; Natal, £49; Delagoa Bay, £585.

NEW GLOW LAMP PRICE LIST.—We have received from the Sunbeam Lamp Company (Limited), of Gateshead-upon-Tyne, their latest illustrated price list of glow lamps. Among the various types we notice high-voltage lamps for pressures up to 230 volts with either single or double filaments. The list is well arranged, and gives, besides the prices for lamps and a few accessories, some views of departments in the Company's factory.

ELECTRIC LIGHT REQUISITES.—Messrs. Sunderland, of Halifax, have just issued a catalogue of electric light requisites, &c.

PRIVATE TELEPHONES.—The National Telephone Company notify that they are now prepared to erect and sell outright telephone instruments, wires, and complete installations for warehouses, offices, institutions, &c., and call attention to the low price at which instruments are now provided by the Company for these purposes. A list of many well-known establishments so fitted is given. Catalogues and estimates can be obtained on application to the Company at the District Manager's office, 58 and 59, London Wall, E.C.

AYR.—The Special Tramways Committee of the Town Council have presented a report on the question of the proposed construction of a system of tramways from Prestwick, through the town of Ayr, and on to the Burns monument. The Committee recommend the Council to proceed with the scheme, and to employ electricity as the motive power. After discussion the Council decided to remit the report to the Bills Committee.

BANGOR.—Major Philip Cardew, R.E., held a Board of Trade inquiry on Wednesday into the application of the City Council for a licence to supply electrical energy. The application was opposed by a section of the ratepayers. The applicants were represented by Mr. Marshall, while Mr. E. J. Griffith, M.P., appeared for the objectors. After evidence in favour of the scheme had been given by Councillor H. Lewis, Mr. Marshall called several influential ratepayers who were willing to take current if it were available. The first of these was the Bishop of Bangor, who said that at present he paid £20 a year for gas for the Palace and about £80 for the Cathedral. He was favourable to the scheme, and would have the electric light at the Palace at any reasonable cost, and he understood it would also be adopted at the Cathedral and the Training Colleges. By way of cross-examination, Mr. Griffith, M.P., asked "Do you know that the electric light would cause noise, smoke and vibration?" His Lordship replied: "No. I know that the manufacture of the electric light might cause noise, smoke and vibration, but not the light itself," an answer which evoked considerable laughter. Mr. E. A. Young (quarry manager for Lord Penrhyn) said he had made up his mind to put down an independent installation if he could not obtain current from the Corporation. He had Lord Penrhyn's permission to support the scheme; at present he took about 1,000,000 cubic feet of gas per annum, but the quality was very poor indeed. The Chairman of the Electric Lighting Committee (Dr. Edwards) said they had already received definite promises to take over 3,000 lights, and if the present application was not granted the Council would have to apply for a Provisional Order, and this would delay the introduction of the electric light till 1898. The present gas supply was so bad and so insufficient that the need for the electric light was urgent. Principal Reichel, of University College, and Mr. R. Davies (Chairman of the Pier and Ferry Company) also gave evidence in support of the application, while Messrs. F. H Medhurst and Fawcus gave technical details of the scheme.

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Amongst the witnesses called by Mr. Griffith was Alderman T. Lewis (Chairman of the Water and Gas Committee), who was surprised to hear that the gas was bad. It was inconceivable that the proposed scheme could be anything but a failure! He thought that Bangor was one of the best lighted town, in Wales. The Gas Manager (Mr. J. Smith) and one or two other witnesses also opposed the scheme.

BELFAST.—At a recent meeting of the Electric Light Committee, the borough electrical engineer (Mr. Victor A. H. McCowen) submitted a report on the progress and development of the electricity works. After discussion it was decided to instruct Mr. McCowen to examine and report upon sites available for the erection of a generating station capable of considerable extension and of meeting the city's requirements for some time to come, in order that, should the Council decide to enlarge the producing capacity of the works, the Committee would be in a position to carry out these extensions.

BLACKBURN.—At the last meeting of the Gas Committee it was decided to increase the salary of the borough electrical engineer (Mr. A. S. Giles) by £50 per annum. It was also decided to recommend the Town Council to make application to the Local Government Board for sanction to borrow £3,000 for providing an additional steam dynamo, &c., at the generating station.

BLACKPOOL.—At the last meeting of the Town Council the minutes of the Street Lighting Committee recommended that additional gas lamps be erected in the Lytham-road. The Chairman of the Electric Lighting Committee took exception to this, and moved an amendment that electric arc lamps be substituted. After a long discussion the amendment was carried by nine votes to seven.

BOLTON.—The Gas Committee of the Town Council, at their meeting on Tuesday, considered the applications received for the appointment of borough electrical engineer, in succession to Mr. J. H. Rider. There were about 50 applications in all, and the following were elected to appear before the Committee on Wednesday next, when the final selection will be made:—Messrs. N. Applebee, Cardiff; H. W. Couzens, Taunton; E. W. Dickinson, Bolton; A. Ellis, Southport; F. Teague, Coatbridge; and J. Pilling, Bolton.——From the financial returns which have just been presented it appears that the receipts for the Electricity Department for the month of March were £1,541, against £461 in the corresponding month of 1895.——For some time past complaints have been made as to charges made for electric current. Under the present system large consumers are entitled to discounts, and it is contended that this presses unduly on the small consumer. At the last meeting of the Committee the electrical engineer (Mr. J. H. Rider) submitted a report as to the charges made in other towns, including Brighton. In order to furnish a practical example of the effect of the Brighton scale, the electrical engineer was authorised to arrange for a demand indicator being placed in one of each of the following description of premises, viz., private dwelling house, shop, mill and works. It was also reported that there were 117 customers connected to the mains, with an equivalent of 9,525 8-c.p. lamps. A continuous supply of current is now available.

BRADFORD.—A Local Government Board inquiry will be held at Bradford on Tuesday next in connection with the application of the Town Council to borrow £40,000 for electric light extension purposes.

BRANDON.—The District Council are at present considering a proposal from Messrs. Straker and Love to supply electric current for lighting the greater part of the district by means of 16 c.p. incandescents at 33s. per lamp per annum, the Council to find and erect poles, wires, lamps, &c.

BRIGHTON.—In the abstract of Mr. Wright's report in our last issue, we gave some figures showing the increase in the demand for electric current in this town. We, however, omitted to state that the figures represented the number of units sold in the first two months of the years 1894, 1895 and 1896 respectively.

CHELTENHAM.—Mr. Kilgour's report to the Town Council states that there is now an equivalent of 6,150 8 c.p. lamps connected, while about 700 wait connection.

CHURCH LIGHTING.—It has been decided to wire the Duncansburgh (Inverness-shire) Established Church for the electric light.

COMMISSION OF SEWERS (LONDON).—At the last meeting of the Commissioners an application from the National Telephone Company for permission to lay telephone wires under certain thoroughfares was referred to the Streets Committee for consideration and report.

DARWEN.—A Committee has been appointed to consider and report upon the advisability of the Council applying for a Provisional Electric Lighting Order.

DOCK LIGHTING.—The Graving Dock Committee of the Tees Conservancy Commissioners are considering the question of lighting the dock electrically.

DUDLEY.—The Town Council appear to be dissatisfied with the manner in which the streets are at present lighted, and a committee has been appointed to consider and report upon the matter. Electric light has a good chance here.

DUNDRUM.—Mr. W. B. Barrington recently held an inquiry at Dundrum on behalf of the Board of Works, Dublin, into the application of the Rathmines, Dundrum and Blackrock Tramways Company for powers to construct a tramway on the overhead trolley system between Rathmines and Dundrum. Mr. Barrington said the inquiry only concerned the undertaking from an engineering point of view. Mr. Drury, on behalf of the Rathmines Commissioners, raised an objection to the jurisdiction of the inquiry, and contended that the plans, &c. submitted by the promoters' engineer (Mr. Fuller) should be altered so as to meet the views of the Commissioners. The Company acquiesced in this view and the inquiry terminated.

EDINBURGH.—At the fortnightly meeting of the Town Council on Wednesday Mr. Treasurer M'Crae submitted the draft provisional estimates of expenditure for the next financial year. He stated that the accounts of the Electric Lighting Committee were extremely satisfactory. Whereas last year they expended an excess of income of £1,260, this year it was estimated that a surplus would result of £7,490. This was after giving effect to the contribution from the Lighting Committee at the reduced rate of £18 per lamp, showing an actual increase of £8,750 over last year's figures. A proposal to construct a circular tramway at or near the proposed extended boundary of the City was afterwards discussed, and it was remitted to the Lord Provost's Committee to consider whether this should be worked by electric or other motive power. The Electric Lighting Committee are considering the charges to be made for electrical energy as from May 1st next.

EXETER.—At the meeting of the City Council on Wednesday last the special Electric Lighting Committee reported that the Local Government Board had sanctioned the transfer of the undertaking of the Exeter Electric Light Company, and had also sanctioned the Council's application to borrow £7,500 to complete the purchase, the loan to be for a period of 15 years.

GREAT YARMOUTH.—The municipal electric light works continue to progress in a satisfactory manner. From the report of the surveyor for the month of March, it appears that the income for the month was £180. 16s. 8d. and the expenses £142. 8s. 11d., leaving a balance of £38. 7s. 9d. towards interest, sinking fund, charges, &c., which altogether amount to about £100 per month.

HAMPSTEAD (LONDON).—The Vestry have decided to lay an electric light main from Alexandra-road to High-road, Kilburn, for the purpose of supplying current to private consumers in Belsize-road, at an estimated cost of £462.

HARROGATE.—The Town Council have received the formal sanction of the Local Government Board to borrow £25,000 for electric lighting purposes.

HOSPITAL LIGHTING.—At the recent annual general meeting of the Governors of the Norfolk and Norwich Asylum, the quarterly report stated that the subject of the lighting of the hospital, which was unsatisfactory and expensive, had been under consideration for nearly two years. Experiments had been made in one of the wards with the incandescent gaslight, but the Committee who had charge of the matter reported that, although an improvement in brilliancy upon ordinary gas, the system was not suitable for use in the hospital. Inquiries as to the cost of the installation of the electric light were then made, with the result that the estimated capital expenditure was put at £800. The Board, therefore, in view of the superior healthiness, cleanliness and convenience of the electric light, advised that the hospital be wired and fitted up for the electric light, and that an arrangement be come to with the Norwich Electricity Company for supplying current. Mr. J. Holmes said, as to the relative cost of the electric light and gas, with care and economy the cost of the former would be only about £275 a year, whereas the present cost of the gas used for lighting purposes alone was about £300. Sir Peter Eade strongly supported the introduction of the electric light, stating that a hospital required a light that could be localised by means of more or less portable lamps, and from this point, and as to purity and cleanliness, no artificial light could be better suited to the purpose than that of electricity. The Rev. Dr. Barrett stated that a member of a large firm in Norwich had informed him that three years ago he adopted the electric light in his factory. In connection with the firm there was a benefit fund, and during the few years preceding the adoption of electricity benefit was received every year on account of sickness by 11 per cent. of the workpeople, but since the introduction of the electric light the number receiving benefits were only 4 per cent. The recommendations of the report were then agreed to.

ISLINGTON (LONDON).—Although the electricity supply station at Eden-grove, Holloway, was only opened in March last, the Electric Lighting Committee have already, we understand, under considera-

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tion the urgent necessity of an increase in their plant, it being proposed to extend the system from Seven Sisters-road to Highgate-hill, a long stretch of thoroughfare composed of a fairly even mixture of shop and residential premises. The Northern Polytechnic is also to be fitted up for the electric light, and current will be required, as previously noted in these columns, for the lighting of the Agricultural Hall. The Committee have, in fact, already decided to expend about £2,000 in electricity meters and converters.

LEEDS.—At the meeting of the Highways Committee on Wednesday the minutes of the Tramways Sub-Committee recommended that Dr. J. Hopkinson be appointed engineer to supervise the construction of the proposed electric tramway from Roundhay to Kirkstall, terms satisfactory to the Committee having been arranged. The recommendation was agreed to, and Dr. Hopkinson has been instructed to prepare the necessary plans and specifications, and the City Engineer (Mr. Hewson) is preparing plans for the power station.

MERCHANDISE MARKS ACTS.—A general order has been issued by Her Majesty's Customs in reference to discretionary powers granted to Customs officers in regard to certain matters concerning the marking of, and packages for, imported goods. The matter has interest for importers of light goods.

MONMOUTH.—The Local Government Board has sanctioned the application of the Town Council for borrowing £8,115 for electric lighting purposes.

NEWMARKET.—In view of the opposition of the District Council, the Newmarket Electric Lighting Company have decided not to proceed with their application for a Provisional Electric Lighting Order for the district.

PAISLEY.—At the monthly meeting of the Police Commission on Tuesday last, it was decided to proceed with the scheme for establishing electricity supply works in the town. A communication was received from the consulting electrical engineer (Dr. J. T. Bottomley) stating that the cost of the proposed installation would be about £25,750.

PORTISHEAD (SOMERSETSHIRE).—The District Council have decided to instruct their surveyor to make inquiries as to the cost of lighting the district electrically.

PORTRUSH.—The Town Commissioners have decided to sanction the proposal of the Giant's Causeway, Portrush and Bush Valley Railway Company to alter their system of traction from the third rail to the overhead trolley.

SWANSEA.—The Electrical Committee of the Town Council have discussed the offer recently made by Mr. J. C. Howell to take over the Swansea Provisional Order, and have decided to retain their powers for the present.

TAUNTON.—At the meeting of the Town Council on Tuesday last, the Electric Lighting Committee's report recommended that application be made to the Local Government Board for sanction to borrow a further sum of £3,000 for electric light extension purposes. In moving the adoption of the report, Alderman Potter said the balance sheet of the department showed that the expenditure during the year amounted to £3,004. 13s. 3d. and the income to £3,580. 11s. 11d., a profit of £575. 18s. 8d., or more than sufficient to pay a dividend of 3 per cent. if the undertaking were in the hands of a company. Interest amounting to £497 and the balance (£78) had been carried to the sinking fund account, leaving a net deficiency of £350 from the rates. As compared with the previous year they were in a far better position, considerable progress having been made during the year. The report was adopted.

TRAIN LIGHTING.—The North British Railway Company is conducting experiments as to the practicability of lighting their trains electrically. The Company has selected one of the Edinburgh and Glasgow trains for the experiment.

"THE GREAT TRAMWAYS SCHEME."—The *Pall Mall Gazette* on Monday last contained some particulars concerning the scheme for amalgamating into one huge undertaking the tramway service of the metropolis, to which reference was made in our last issue. Our contemporary appears to be much impressed with the particulars it has obtained of this colossal scheme, which, however desirable, must need much more than the consent of the London County Council for its successful execution.

WALSALL.—At the last meeting of the Town Council the Electric Lighting Committee's minutes stated that on March 31st there were 53 customers connected to the Corporation mains, and recommended the Council to carry out various extensions at a cost of £621. 10s. On the motion for the approval of the minutes an unsuccessful attempt was made to get the Council's sanction to the laying of mains in the greater portion of Digbeth. The Committee's recommendation was approved.

WELLS.—The City Council have received a letter from the Local Government Board relative to the proposed purchase of the gas works. It has already been decided to establish electricity supply works in the town, but the matter will be further considered at the next meeting of the Council.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

March 30, 1896.

6,890. S. BERDITSCHEWSKY, called APOSTOLOFF. London. System of distribution of electrical currents.

6,925. H. BIERMANN. London. Electric water-gauge.*

March 31, 1896.

6,943. W. J. FRYER. London. An automatic electric light door switch.

6,953. J. D. BELL. Glasgow. Improvements in controlling gear for electrically-propelled carriages or trucks.

6,980. J. ENTWISLE. Manchester. An improved electric boat-propeller. (S. N. Smith and E. S. Baring-Gould, United States.)*

6,981. J. ENTWISLE. Manchester. Improvements in electric batteries. (S. N. Smith and E. S. Baring-Gould, United States.)*

6,993. R. HACKING. London. An improved coin-freed electric meter.

7,000. L. EPSTEIN and F. MARZA. London. A process and apparatus for decomposing sodium or potassium chloride and generating electricity.

7,005. H. H. LAKE. London. Improvements in electric hammers and the like. (A. S. Barnes and P. S. Skinner, United States.)*

7,013. J. DEVONSHIRE. London. Improvements in electric meters. (C. P. Steinmetz, United States.)*

7,038. H. BÄURLIN. London. Improvements in regulators for electric arc lamps.*

7,054. L. C. WERNER. London. Improvements in electrical signal systems for railways.*

April 1, 1896.

7,074. A. J. BEAUMONT. York. An arc lamp for high voltages.

7,121. A. F. DAVIES. London. A new method of making shades for gas, electric or other lights.

1,151. F. H. NALDER, C. W. S. CRAWLEY and A. SOAMES. London. Improvements in differential automatic switches.

7,161. F. A. CHAPMAN. London. Improvements in or relating to electric light fittings.*

7,162. A. J. BOULT. London. Improvements in or relating to secondary batteries. (J. Julien, Belgium.)

7,166. M. A. SHANAHAN. London. Improvements in electric fire alarms.

SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1895.

5,205. LUCKOW. Secondary battery plates.

8,453. BROCKIE. Electric switches.

9,380. LLOYD and BRANSTON. Electric-firing pistols for gun mountings.

9,442. HARDINGHAM (Felten and Guilleaume). Insulating electric conductors.

9,636. SIEMENS BROS. AND CO. (LIMITED) and BOOKER. Arc lamps.

10,277. SIEMENS BROS. AND CO. (LIMITED) and LAUCKERT. Measuring electric currents.

11,544. BULLERS (LIMITED) and CHAMBERS. Telegraph poles, &c.

21,460. MORGAN. Electric motors.

24,711. DEVONSHIRE (Potter). Electric brakes.

COMPANIES' MEETINGS AND REPORTS.

Chelsea Electricity Supply Company (Limited).

An extraordinary general meeting of the members of this Company was held at the offices, Cadogan-gardens, on Wednesday, Mr. J. Irving Courtenay in the chair, to consider a resolution for increasing the capital of the Company by the creation of 20,000 Ordinary shares of £5 each, the provisions of Article IV. of the Articles of Association of the Company not to apply to the new shares.

The SECRETARY (Mr. S. J. Cluer) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, the object of the meeting to-day is, as set forth in the notice, to obtain the necessary powers for the increase of the nominal capital of the Company, as all the share capital originally authorised has been issued and fully subscribed. At the general meeting on March 4th last, I laid before you fully the position of the Company, and I need not therefore detain you now at the same length, but I shall again call attention to some of the salient points. It is evident that with the growing demand for current in excess of the present capacity of the plant the capital outlay must

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increase, but the experience gained enables the outlay to be made to the best advantage and in the most economical manner. The total number of lamps added this year up to the end of March is 4,573, as against 1,098 last year, or more than four times as many in the first three months. Formal application has been made to the Board of Trade under our Provisional Order for the whole of the remaining portion of the parish of Chelsea, and as it is unopposed we expect that the application will go through in due course. This comprises the extensive district running from Battersea Bridge, along Beaufort-street, and by the Fulham-road to the Western boundary of the parish. The rapid increase in the demand for current in the present area, and this large addition to the district supplied by the Company, necessitate the immediate building of a new generating station, which will be erected on our own freehold property, and adjacent to the existing station in Manor-street, and also substations for the distribution of the current. The site selected for the new generating station has space for plant having capacity for running some 50,000 8-c.p. lamps at one time, but it is only intended to erect and equip works in accordance with the demand as it arises, though the complete arrangement has been designed. The works and plant it is proposed at once to erect and equip will furnish current to about 25,000 8 c.p. lamps fixed, and then there will be the mains and street work, which latter will be laid down with a view to carrying a larger demand as it arises. I desire to call your attention to the fact that the works costs have considerably decreased as the number of units sold have increased. During the last two years there has been a reduction in works costs of 26 per cent., and an increase in the demand for current during the same period of 43 per cent., which agrees with the experience of other metropolitan companies. Upon the general situation I may point out that we have during the past few years been adding to our renewals fund; we have cleared our accounts of some heavy items which might legitimately have been spread over several years in a suspense account, and we have this year created the nucleus of a reserve fund, to which we intend from time to time to make substantial additions. The foregoing remarks are confirmed by the fact that since 1890 the revenue of the Company has about trebled itself, for in 1890 it was £6,080, and in 1895 it amounted to £17,165, while the amount available for interest and dividends (which in 1890 was £597), was, as shown in the accounts to December 31st, 1895, £9,595. The figures for the intermediate period also indicate how the increase of the gross revenue each year has been accompanied by a large increase in the proportion which the net revenue bears to the gross. I trust I have said enough to convince you of the healthy growth of the Company, and to show you that we may expect these conditions to continue in the future. He concluded by moving the resolution.

Mr. EMILE GARCKE seconded the motion.

A brief discussion followed, in which Major R. M. Mackenzie, Mr. A. Andrew, Mr. Thomas Webb and Mr. John Hughes took part.

The CHAIRMAN, in reply, stated that the Directors intended to give the shareholders a preference in the allotment of the new shares over the applications sent in by the public. It would be advantageous to increase the constituency, however, and they could not issue a prospectus to the public, and then confine the allotment of the shares to the shareholders. The Directors had not yet decided how much of the new capital they would require to call up at once, but they would soon come to a decision. He quite agreed with Major Mackenzie as to the advantages of a reserve fund, which the Directors would be most anxious to see increased to a substantial amount. They had not yet decided as to the premium they would ask for the new shares. There was a ready market, he believed, for the Preference shares though not officially quoted; and he was informed that they had changed hands at £7. 10s. to £7. 15s.; that was for the £5 shares. The Stock Exchange had not granted a quotation to the Preference shares as the amount was so small. Until they had issued £50,000 of Ordinary shares, the latter were not given an official quotation.

The motion was carried unanimously.

A vote of thanks to the Chairman and Directors brought the meeting to a close.

County of London and Brush Provincial Electric Lighting Company (Limited).

The second ordinary general meeting of this Company was held at Winchester House, London, E.C., on Monday last, under the presidency of the Right Hon. Lord Rathmore, LL.D.

The SECRETARY (Mr. H. B. Renwick) read the notice convening the meeting.

The CHAIRMAN, in moving the adoption of the Directors' report and accounts, said: We have every reason to feel satisfied with the present position of the Company and increased confidence in its future. During the period with which the present report deals we have met with some difficulty and have had to submit to some disappointment and delays, such as are, I suppose, almost inevitable in the earlier stages of such an undertaking as ours is; but already we have, I think, a considerable measure of success to present to you. I am myself never inclined on such an occasion as the present to take too glowing or rosy a view of the situation; but still I think that, speaking in all seriousness and moderation, we may well congratulate ourselves on this—that, although we have been less than two years in existence, we stand to-day on solid ground, that we have established a large and important business, and that we have good reason to anticipate that ere long this Company, in which we have invested our money, will prove a very profitable and lucrative undertaking. Our position, in a word, is this—that the net revenue for the year 1895 has proved to be sufficient to pay in full the dividends upon our Preference capital, and to carry forward a substantial balance to the accounts of the present year, and this revenue has been earned under circumstances of some difficulty, which, although of a temporary and accidental kind, were still such as to give us a good deal of trouble, as I shall presently explain to you. Before I do so, however, I think I had better refer for a moment to one or two items in the statement of accounts as to which you would, perhaps, like some further information. You will find in the balance sheet, under the head of "liabilities," the item of "loans against security." That refers to advances which we have received from our bankers in anticipation of calls upon our Preference issue, and also against the security of certain investments which the Company had made in quoted stocks. Those investments were steadily rising in value, and we thought it was better to postpone selling them until we had received the dividends which were accruing on them. Those investments have since been sold at a considerable profit, which will go into the accounts of the present year, and in order to give honour where honour is due, I think it is right to say that for the success of that operation we are much indebted to your Deputy-Chairman, Mr. Braithwaite. The next item you will see is "sundry creditors," amounting to £12,260, and I may tell you that that sum has already been almost all paid off. Turning to the assets side of the balance-sheet you will see that expenditures are appropriated, £75,911 to the St. Luke's and Clerkenwell Orders, and £40,358 to the Wandsworth Order, the particulars of which you will find in the capital account numbers 4 and 6. As to the circumstances of these undertakings, I shall have a word or two to say presently. Then there is an item of "sundry debtors." That represents mainly debts due, or rather which were due, on management account from sub-companies and for interest on moneys advanced. Practically, all these debts have been received since the beginning of the present year. I will now deal with the working of the Company in our London districts; and first, as to St. Luke's and Clerkenwell, there we have had to confront some difficulties which we had no reason to anticipate when I last had the honour of addressing you. In the first place, objections were taken by the London County Council to the frontage of our St. Luke's buildings. Then we were met by a strike of our contractors' workmen, which lasted a considerable time, and for the time seriously interfered with our business. Then there were difficulties as to our street boxes. I am glad, however, to say that all these obstacles have now been overcome. The whole of the street work has been completed, and connections have been made with our consumers' premises; and by a temporary arrangement for the supply of current we have been able to earn a small profit upon the year. All the cables have now been drawn in. The remainder of the connections with our consumers are being pressed forward as fast as possible, and I may tell you that the amount of current supplied during the first quarter of this year has almost equalled the whole amount supplied during last year, and that it is estimated that at least five times the amount of current will be supplied in St. Luke's and Clerkenwell during the present year as was supplied in the year 1895. Meantime our station buildings, the strike being over, are proceeding, and we trust that we shall have this station completed and supplied with excellent machinery in readiness for the winter lighting. We believe that in this station we shall have one of the best in the metropolis, and we have no doubt that in the cost of running, it will compare very favourably with any other station of similar size. At Wandsworth, too, we had the disadvantage of having to deal with difficulties which were raised by the local authorities in reference to street work, and that involved us in litigation which was rather lengthy, as all the questions raised had to be thrashed out before the Board of Trade and also in the High Courts of Justice. However, we cannot blame ourselves in any way for this, because every question raised was ultimately decided in our favour, and the street work at Wandsworth is now approaching completion on the plans and according to the system we originally proposed. As anyone who travels on the South Western Railway may have observed, our station buildings are also advancing, and we have almost finished what I think will be a handsome generating station at a spot where the river Wandle joins the Thames. We may, therefore, expect that when the winter lighting begins in the present year we shall have in the metropolis two large generating stations—one on the north side and one on the south side. I refer, of course, to St. Luke's and Clerkenwell and Wandsworth respectively, two stations built and equipped with every modern improvement, having a combined power of supplying some 90,000 lamps, and the power of each of them capable of being easily doubled simply by laying down in the existing buildings additional plant and making additional connections for supplying new customers. Under these circumstances I think that, in spite of all the difficulties and delays we have been subjected to, which, as I have explained, were entirely beyond our control, and for which we were not in any way responsible, we may well congratulate ourselves on the satisfactory position in which our ventures for lighting St. Luke's and Clerkenwell on the one side, and Wandsworth on the other side, at present stands. I may add, while on the subject of our London stations, that the Provisional Order for St. Olave's has since this report was published been confirmed by Parliament, and has received the Royal Assent. As you are aware, the Camberwell Vestry has given its assent, and we are in hopes of being able to secure some additional districts in that neighbourhood which could all be easily and economically lighted from one generating station.

So much for our stations in the metropolis. I will now turn to our stations in the provinces. First, as to Bournemouth, the work of our business there has been to some extent interfered with by the change of the machinery from old to new and the rebuilding of the station, which has entailed upon us rather a heavier cost for running expenses than we had anticipated. But, nevertheless, the gross revenue at Bournemouth increased during 1895 by about £600, and the working expenses were a trifle less. I think we may confidently expect that with the rearrangement of the plant which is now being made, and also on account of some improvements which we have been able to introduce into the manage-

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ment at Bournemouth, the cost of production will be still further reduced in the present year, and that the net revenue will be increased. I may mention also that the cost of production was during 1895 three farthings per unit less than it was in the year 1894, and that the amount of current supplied during the first quarter of the present year exceeded by nearly 16 per cent. the amount supplied in the corresponding period of 1895. With regard to Dover, you know that for some time our large and commodious generating station there has been completed, and we have been able since last April to give an uninterrupted supply of current to our consumers. Up to the present time the number of connections that we have is about 4,800 8-c.p. lamps; and Mr. Lawson thinks that that number will probably be doubled by the end of the year. As to Windermere, this time last year I told you we had at that time received the consent of nearly all the local authorities—seven out of nine, I think—to the granting of our Provisional Order. I am sorry to say that the other two local authorities still withhold their consent and, therefore, we have not been able to make progress at Windermere. Then there remains our station at Richmond in Surrey. You may remember that at our last annual meeting I told you that we had just then acquired the controlling influence in the Richmond (Surrey) Electric Light and Power Company, Limited, and I encouraged you to expect favourable results from that investment. I am glad to be able to tell you now that it has come out better than we expected, and we seem to have already well turned the corner at Richmond, for instead of a loss of nearly £1,000, sustained in the year 1894, a certain profit was made during 1895, and sundry charges, the liability for which had been incurred in 1894 and 1895, have been paid for out of revenue. Up to the time at which I am speaking the number of lamps applied for at Richmond is equivalent to 5,913, and 5,800 are connected with the Company's mains; and the units sold in the quarter just ended exceed the number sold in the corresponding period of 1895 by about 19 per cent., while our expenses are considerably lower. A number of lengths of mains were laid down during the year 1895, and some more extensions are now being pushed into other streets to meet the wants of consumers. I think I may encourage you again confidently to expect that before long this Richmond station will provide us with a satisfactory and handsome profit. I do not think that there is anything else in the history of our stations, either in London or the provinces, for me to call your attention to. In October last our manager, Mr. Lawson, was unfortunately stricken down by illness, but Mr. Garcke very kindly stepped into the gap and gave us the valuable aid of his experience. I am pleased to say that Mr. Lawson is now again with us, restored to health, and we now enjoy the advantage of Mr. Garcke's advice and assistance as a member of the Board, to take the place of Mr. Denny, whose resignation the directors have had reluctantly to accept. As stated in my opening remarks, I think we may look with considerable satisfaction at the last year's work, and may look forward with increased confidence to the continued success of the Company. Of course, in our earlier stages heavy expenditure has had to be incurred with only a small resulting revenue. This, however, is only a question of time, and makes our ultimate success the more certain. We shall, without doubt, be able promptly to meet all dividend payments on account of the Preference capital, both present and future, and confidently hope that before long the Ordinary shareholders will also reap their reward. I now beg to move the adoption of the report and accounts.

The DEPUTY-CHAIRMAN (Mr. J. B. Braithwaite, jun.): I have pleasure in seconding the motion, and it will be unnecessary for me to add to the clear and lucid statement of our Chairman. With regard to revenue, our experience is similar to that of the successful City of London Electric Lighting Company, with which I was associated in its early stages. We are fortunate in being able to pay the Preference dividend and to carry forward a substantial sum before either of our London stations are at work. Our provincial stations are doing well, and the outlook from all points of view is extremely satisfactory.

Mr. E. K. SMART referred to an item in the accounts for preliminary expenses.

Mr. CASH desired some information on the subject of Directors' remuneration, salaries and wages, &c.

In reply, the CHAIRMAN said that with regard to the preliminary expenses doubtless the item of £4,000 standing in the accounts might seem large, but the shareholders must remember that the expenses inevitably connected with the issue of capital were necessarily heavy. Their capital issues had been a great success, being subscribed for many times over, and the shares now stood at a considerable premium. With regard to Mr. Cash's question, the charges to which he alluded were always appropriated in proportion between capital and revenue during the period of construction.

The motion was then carried unanimously.

Mr. J. B. Braithwaite, jun., and Mr. A. H. Sanderson, the retiring Directors, were then re-elected, the payment of the interim dividend on the Six per Cent. Preference Shares agreed to, and Mr. R. H. Marsh re-elected auditor.

A cordial vote of thanks to the Chairman and Directors, proposed by Mr. Smart and seconded by Mr. Payne, was carried unanimously, and the proceedings terminated.

Norwich Electricity Company (Limited).

The annual general meeting of the shareholders of this Company was held on Wednesday at the offices, Queen-street, Norwich, Mr. F. W. Harmer presiding. The Directors' report stated that the demand for current, both for lighting and motive power purposes, has continued to increase in a most satisfactory manner, the number of customers showing a considerable increase as compared with 1894. During the year upwards of two miles of new mains have been laid, a new engine and dynamo of 200 H.P. have been added to the generating plant and a new battery sub-station erected. In order to obtain a day load for their machinery the Directors have reduced the price of current for motors run continuously during the day to 3d. per unit for all hours. The Directors anticipate that this will result in an increased and profitable revenue from boot and shoe manufacturers and others requiring motive power. £19,500 Four per Cent. Debentures have been issued during the year for the purpose of paying off the loan from Messrs. Gurney and Co., and to provide for the increased outlay for machinery, &c. The revenue account shows a credit balance of £2847. 3s. 1d., to which must be added £112. 5s. 8d. brought forward from last year, making a total of £2,959. 8s. 9d. From this must be deducted £749. 3s. 5d. for interest on debentures, &c., leaving a balance of £2,210. 5s. 4d. The Directors propose to pay a dividend of 3½ per cent., which will absorb £991. 12s. 10d., to place £1,100 to depreciation account, and to carry forward the balance.

In moving the adoption of the report and accounts, the CHAIRMAN said the income had increased from £3,786 in 1894, to £5,845 in 1895. Their anxiety was not to get fresh customers, but to be able to get machinery to supply them. At present the manufacturers were exceedingly busy; but they hoped to have the additional plant ready to meet next winter's demand. They were gradually extending their mains in all directions, and they had other projects in hand which would, no doubt, be profitable, and give them abundant work for the next year. Referring to the financial position, the Chairman said that at the time of the last meeting they were £15,000 in debt, with over £10,000 expenditure in prospect, but the Directors had such confidence in the future of the Company that instead of borrowing money at the rate they would have had to pay they obtained it on their own responsibility without applying to the public to take up shares until they felt they could show the enterprise was going to prove a financial success. As to the establishment of a sub-station on the Newmarket Road, that was constructed principally in view of the proposal to introduce the electric light at the Hospital, which had just been decided upon by the Board of Management. Repeated applications for current had been made by people in the suburbs, and in time they would be able to supply the demand; but he considered it was better to occupy themselves with the nearer territory, which was more profitable. In the Market Place and London-street there were few shops which contained the old-fashioned system of lighting by gas; in fact, they had practically driven gas out of the principal streets of the city. At the end of 1894 they had 297 customers, and an equivalent of 6,800 8 c.p. lamps were connected; at the end of 1895 they had 450 customers and an equivalent of 9,880 lamps.

The report and accounts were then passed, and a dividend at the rate of 3½ per cent. declared.

Richmond (Surrey) Electric Light and Power Company (Limited).

At a private meeting of this Company held yesterday (Thursday) at the offices, Moorgate-court, Moorgate-place, E.C., the following report of the Directors was presented:—

During the year a further sum of £2,906. 13s. 7d. has been expended on capital account for mains and meters, and for electrical instruments in the station, the necessary funds having been obtained by loan from the County of London and Brush Provincial Electric Lighting Company (Limited). The revenue account for the year to December 31st shows a profit of £230. 7s. 1d., as against a loss of £978. 19s. 8d. in 1894, while legal charges in connection with the adjustment of contractors' claims, amounting to £131. 16s. 2d., liability for the greater part of which had been incurred in the previous year, have been paid out of revenue. The total number of lamps connected was equivalent to 5,486 8 c.p., an increase of 1,746 since 1894, and a considerable additional number have since been applied for and connected in the enlarged area of supply in which mains were laid towards the end of the year. The Richmond Corporation have consented to the Company's application for power to still further increase the area of supply, and mains will be laid during the current year in several of the better residential streets. The generating plant is in excellent working order, and as the capacity thereof is sufficient to meet a greatly increased demand, no further expenditure for plant will be required this year.

Indo-European Telegraph Company (Limited).

The Directors' report for the year 1895, which will be submitted to the meeting to be held at Winchester House, London, E.C., on the 29th inst., at 12:30 o'clock, states that the revenue for 1895 amounted to £123,734 1s. 7d., compared with £119,117. 18s. 3d. for 1894. The expenses were £67,820. 10s. 4d., against £64,838. 13s. 1d. for 1894. Deducting the expenses, taking credit for £5,789. 2s. brought forward and debiting income tax, there remains the sum of £59,371. 17s. 11d., of which £10,000 has been placed to reserve, and £10,625 has been paid as interim dividend, leaving a balance of £38,746. 17s. 11d. The Directors now propose a dividend for the six months to December 31st of 17s. 6d. per share, making, with the interim dividend, 6 per cent, and a bonus of 2?s. per share, both free of income tax, making 10 per cent. for the year, £6,871. 17s. 11d. being carried forward.

Messrs. L. Delbrück and C. W. Earle offer themselves for re-election as Directors.

The dividend and bonus will be payable from May 1st. The transfer books are closed from the 15th to the 29th inst.

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Oriental Telephone and Electric Company (Limited).

The report of the Directors of this Company for the year ended December 31st last, to be presented at the general meeting at Cannon-street Hotel, London, on Wednesday next at 1 o'clock, states:—

That the revenue account for the year shows a balance to credit of £8,675. 2s., which has been transferred to profit and loss. Including the sum of £706. 5s. 3d. brought forward, there is an amount of £9,381. 7s. 3d. available for disposal. The Company's license from the Government of Ceylon expired on December 31st, the Government refusing to extend it, having resolved to work the telephones through their telegraph department. Having declined either to purchase the Company's plant or to compensate them for the loss of its business, representations were made to the Government of Ceylon which resulted in a very inadequate offer being made for the mere value of the plant. This offer your Directors declined. The Directors then appealed to the Secretary of State for the Colonies, and, ultimately, rather than sacrifice the property of the shareholders altogether, agreed to accept a sum of £2,500, equal to about one-half of the capital expended on the construction. Although the transaction was only completed in January of the present year, your Directors are advised that this item in the capital account must be shown in the accounts now presented.

Out of the revenue of the past year, a dividend is recommended of 5 per cent. free of income tax, which will absorb £8,575. 4s. and leave £806. 3s. 3d. to be carried forward.

The revenues of the Indian subsidiary companies continue to improve, although the dividends received by this Company are approximately the same as those received last year. The expenses of the Bengal Company for the past year were temporarily increased owing to a change of manager. That Company has, after payment of the same dividend as in the previous year, carried to reserve and depreciation undivided profits to the extent of Rs.23,000. The Telephone Company of Egypt has declared a dividend of 6 per cent. as usual on the Preferred shares. The China and Japan Telephone Company has had a better year, and the accounts point to an increased surplus over the previous year after payment of debenture interest. The Directors have agreed to extend the time for the payment of the debentures held in this Company, which fell due on December 31st last, for a further period of five years. The turnover by the electric lighting branch in India has more than doubled that of the preceding year, but the expenses incident to sending out an assistant and advertising have again caused a loss on the year's operations. The Directors believe there is room for development in this branch, but have deemed it desirable to write off all initial expenses such as those referred to which are usually spread over a term of years.

Mr. B. St. John Ackers and Mr. G. B. Frost offer themselves for re-election as Directors, as do the auditors, Messrs. Deloitte, Dever, Griffiths and Co.

NEW COMPANIES, STATUTORY RETURNS, &c.

ALTRINCHAM ELECTRIC SUPPLY (LIMITED).—The annual return to April 6th has just been filed. 25,000 shares have been taken up out of a capital of £50,000, in £1 shares, and calls amounting to 15s. per share have been made.

BIRMINGHAM ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return to March 25th has been filed. The capital is £200,000, in £5 shares, of which 30,000 have been taken up. The full amount has been called on 20,000, and £2 per share on 10,000 shares.

CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).—The annual return to March 18th has been filed. The nominal capital is £100,500, in 14,000 Ordinary and 6,000 Preference shares of £5 each, and 500 Founders' shares of £1 each; 6,666 of the Ordinary and the Founders' shares have been issued as fully paid. The full amount has been called on the remaining 7,334 Ordinary and 6,000 Preference shares.

CITY OF BATH ELECTRIC LIGHTING AND ENGINEERING COMPANY (LIMITED).—The annual return to March 21st has been filed. The nominal capital is £60,000, in 5,500 Ordinary shares of £10 each, and 50 Founders' shares of £100 each. 3,384 Ordinary and all the Founders' have been taken up, and 2,250 Ordinary and the Founders' have been issued as fully paid. The full amount has been called on 1,134 shares.

EASTBOURNE ELECTRIC LIGHT COMPANY (LIMITED).—The annual return to March 30th has been filed. 1,025 Ordinary and 40 Preference shares have been taken up out of a capital of £50,000, in £10 shares, and the full amount has been called and paid.

HOVE ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return to March 18th has been filed; 6,633 shares have been taken up out of a capital of £40,000, in £5 shares. The full amount has been called on 6,221, and £2 per share on 412 shares.

OXFORD ELECTRIC COMPANY (LIMITED).—The annual return to March 20th has been filed. Out of a nominal capital of £100,000, in £5 shares, 6,586 shares have been subscribed for, and the full amount has been called and paid.

SYNDICATE OF ELECTRICAL ENGINEERS (LIMITED).—The annual return to March 30th has been filed. Out of a nominal capital of £10,000, in 1,900 Ordinary and 100 Founders' shares of £5 each, the Founders' shares have been issued as fully paid, while £4 per share has been called on 1,007 Ordinary shares.

CITY NOTES.

MEMORANDA.—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 30⅞d. per oz. (April 1st). Consols (2¾ per cent.) 110⅞–111 for money, 110⅞—111⅛ for account; 2½ per cent. 105—105½ (April 16th). Stock Exchange Settling Days: Consols, May 4th; Stocks and Shares Continuation Day, April 27th; Ticket Day, April 28th; Pay Day, April 29th; Mining Share Carry-over Day, April 25th.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended April 12th were £868, against £779 in the corresponding week of 1895, an increase of £89. The total receipts for the half-year amount to £14,339, against £14,362 for the corresponding period of 1895, a decrease of £23.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The accounts to December 31st last show, subject to audit, a balance profit of £210,579 after payment of three dividends. The Directors now propose to distribute on the 30th inst. a final dividend of 2s. 6d. per share, together with a bonus of 4s. per share (or 2 per cent.), making a total distribution of 7 per cent. for the year. The Share Register will be closed from the 22nd to the 29th inst., inclusive.

GAS, WATER AND GENERAL INVESTMENT TRUST.—The ordinary general meeting of the shareholders in this Trust was held on Wednesday last. The Chairman (Mr. Thomas Salt) in moving the adoption of the report and accounts, referred to the connection of the Trust with the Salt Lake and Ogden Gas and Electric Light Company, and to the circumstances under which they acquired such a large holding in that Company. The Directors, however, looked forward to the future with hope. The net earnings of the Company were in 1893 £20,000, in 1894 £18,000, and in 1895 £19,000, and in the latter year the profits would have been much larger if it had not been for the unfortunate opposition which they had to contend with. The estimated net profits of the Company during the present year were £35,000. We are earning sufficient and more than sufficient to pay the dividends on the bonds. With regard to the difficulties that have arisen, I would remind you that all purchases of this kind are liable to unexpected difficulty. The motion was adopted, and a resolution enabling the Trust to hold the amount of stock possessed in the Salt Lake and Ogden Gas and Electric Light Company was afterwards passed.

GREAT NORTHERN TELEGRAPH COMPANY.—The net receipts of this Company during 1895, including the balance (£43,170. 17s. 8d.) brought forward from 1894, amount to £381,583. 2s. 8d. Deducting £85,916. 13s. 4d. towards interest on and amortisation of debentures and interim dividends (£75,000 already paid), the Board propose to distribute the balance as follows:—Final dividend (making the total dividend for the year 10 per cent.), £75,000; reserve and renewal fund, £83,333. 6s. 8d.; pension fund of the staff, £2,777. 15s. 7d.; directors' remuneration, £1,500; leaving to be carried forward, £58,055. 7s. 1d.

IMPERIAL CONTINENTAL GAS ASSOCIATION.—The Directors of this Association recommend the payment of a dividend of 5 per cent., together with a bonus of 1 per cent. for the half-year ended December 31st last.

LAZARE, WEILLER AND CIE.—An extraordinary general meeting of the shareholders of this Company was held in Paris on the 11th to confirm the resolution passed on October 28th last, increasing the capital of the Company by one million francs.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 12th inst. amounted to £1,469. The amount for the corresponding week last year was £1,243. Increase £226.

PONTYPOOL ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The annual meeting of this Company was held on the 27th ult. at Pontypool. The Directors' report stated that the Company had obtained a Provisional Order, which gave them an extended lease of their undertaking for 42 years, but the local authority had liberty to purchase at the end of each seven years of the term. In order to provide for the cost of the Provisional Order, and to get rid of the adverse balance standing to the debit of capital account at the end of last year, it became necessary to raise additional capital. It was accordingly resolved to issue 15 debentures of £100 each, carrying interest at £5 per cent. per annum. These debentures were taken up by the Directors. Several new customers had been added to the Company's mains during the year, there being 54 customers connected, and the Directors consider that the outlook of the Company is promising. After putting £67. 10s. to renewal account there was a balance of net profit, together with the sum brought forward from last year, of £230. 4s. 3d. The Directors recommend that £50 be carried to reserve, that a dividend of £3 per cent. be declared, and that the remainder be carried forward. Mr. W. Pegler, jun., who presided, moved the adoption of the report and accounts, and gave an account of the progress made during the past year. The report and accounts were after a short discussion adopted.

STOCK EXCHANGE NOTICES.—Application has been made to the Stock Exchange Committee to allow 22,500 Six per Cent. Cumulative Preference shares and 22,500 Ordinary shares of Willans and Robinson (Limited) to be quoted in the Official List.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—The sale of electric current for the quarter ended March 25th (at 6d. per unit) amounted to £16,862, against £13,907 (at the same rate per unit) for the corresponding period of 1895.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended April 10th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,375.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share	Last Dividend.	Name	Previous Week's Price, Apr. 8.	Price Wednesday, Apr. 15.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Apr. 11. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	18 0	Anglo-American ..... xd	48 50	49 51	4 18 0	Jan., Apr., July, Oct.	..	..
£2,993,560	Stock	36 0	Do. Preferred ..... xd	9½ 9⅝	9⅞ 9⅞	5 7 6	" "	9⅞	9⅞
£2,993,560	Stock	5/0	Do. Deferred	9½ 10	10¼ 10½	..	..	9⅞	9⅞
£173,400	100	4%	*African Direct Teleg. 4% Deb. (Reg. & Bearer)....	100 104	100 104	3 17 8	January and July ..	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	10⅜ 11	10½ 11	..	..	..	..
180,000	£10	3/0	Brazilian Submarine	14⅛ 14⅜	14⅛ 14⅜	4 14 11	Mar., June, Oct., Dec.	14⅜	14⅛
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1906)	112 116	113 117	4 6 5	June and December	..	..
10,000,000	$100	$ ⅔	Commercial Cable Capital Stock	160 170	160 170	4 2 4	Jan., Apr., July, Oct.	167	..
16,000	10	8/0	Cuba Submarine	12½ 13½	12½ 12¾	5 14 4	February and August	13½	1 ⅛
6,000	10	10%	Do. Preference 10 per Cent.	20½ 21½	20½ 21½	4 13 0	.. ..	..	..
12,931	5	2/0	Direct Spanish (fully paid)	4 5	4 5	4 0 0	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 3	" "	10⅜	..
£80,000	Stock	4½%	Do. 4½% Debentures of £50 each	106⅞ 109⅞	106⅞ 109⅞	4 3 6	.. ..	..	..
60,710	20	2/0	Direct United States Cable, 1877 ..... x1	9½ 10	9⅝ 10	4 0 0	Jan., Apr., July, Oct.	9⅜	9⅛
400,000	10	2/6	Eastern ..... xd	17 17½	17 17½	3 14 4	" "	17⅛	17⅛
70,000	10	6%	Do. 6 per Cent. Preference ..... xd	18 18½	18 18½	3 4 10	" "	18⅛	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	130 133	130 133	3 1 1	May and November	131	130
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899.....	105 108	106 109	4 13 10	February & August	108½	..
250,000	10	2/6	Eastern Extension	17⅜ 18⅛	17⅜ 18⅛	3 16 9	Jan., Apr., July, Oct.	18⅛	18⅛
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128 131	128 131	3 1 5	February & August	128½	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900	101 105	101 105	4 18 7	January and July ..	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb.,1900	101 105	101 105	4 18 7	" "	..	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) ..	105 108	105 103	3 14 9	February & August	..	..
£200,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112⅞ 115⅞	112⅞ 115⅞	3 10 11	May and November	1 2	..
180,227	10	1/6	Globe Telegraph and Trust..... xd	10½ 10⅝	10⅜ 11	4 1 10	Jan., Apr., July, Oct.	10½	10½
180,042	10	6%	Do 6 per Cent. Preference ..... xd	16⅜ 17½	16⅜ 17½	3 9 7	" "	17⅛	16⅞
150,000	10	5/0	Great Northern.....	23⅞ 28½	23 28½	3 8 2	Jan., April, and July	24⅛	22⅛
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue.....	104 107	104 107	4 13 11	March & September	..	..
17,000	25	12/6	Indo-European	48 51	49 53	4 16 2	May and November	50⅜	..
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	107 1 0	108 111	5 8 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942..	108 111	108 111	3 12 9	.. ..	..	..
11,839	8	4/0	Reuter's	5 6	5 6	..	April and October ..	5	..
3,331	£100 Cert.	£3	*Submarine Cables Trust 6 per Cent.	124 130	123 128	4 8 3	" "	136	..
15,609	10	2/0	West African Telegraph	5⅛ 6⅛	5⅛ 6⅛	..	January and July ..	..	..
£233,300	100	5%	* Do. 5 per Cent. Debentures (red.)	101 104	102 105	4 15 8	March & September	..	..
30,000	10	2/0	West Coast of America	1 2	1 2	..	January and July ..	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	95 100	96 101	8 1 6	June and December	..	..
38,321	10	1/3	West India and Panama	1 1½	1 1½	..	..	1⅛	..
24,563	10	6%	Do. 6 per Cent 1st Preference	10⅞ 11½	11 11½	5 4 4	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9 10	9½ 10½	5 14 8	" "	..	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108 111	108 111	4 11 1	June and December	..	..
64,248	15	8/0	Western and Brazilian	8½ 9	8½ 9	5 5 8	May and November	8⅞	8⅞
33,129	7½	3/0	Do. 5 per Cent. Cumulative Preferred	6½ 6⅞	6½ 6⅞	..	..	..	..
33,129	7½	1/6	Do. Deferred Ordinary.....	2¼ 2⅝	2¼ 2⅝	..	..	2½	..
£165,200	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 107	104 108	5 12 2	February & August	..	..
£206,400	100	6%	Do. 6% Mort. Debs., Series "B" 1910	103 107	104 108	5 12 2	" "	..	..
$1,177,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds....	118 118	118 118	6 2 3	May and November	..	..
£164,300	£100	6%	Do. 6 per Cent. Sterling Bonds (red.)	102 105	102 106	5 14 0	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chill Telephone (fully paid)	3 3½	3 3½	..	..	..	..
224,850	10/0	1½d.	Consolidated Telephone Const. & Maintenance ..	1/16 1/8	1/16 1/8	..	May and November	⅛	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid).....	1/16 1/8	1/16 1/8	..	Yearly	..	..
484,597	5	3/0	National	6⅞ 7	6⅞ 7⅛	3 17 2	June and December	7	6⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	17⅛	..
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)....	16⅛ 17⅛	16⅛ 17⅛	3 8 7	" "	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅜ 6⅝	6⅜ 6⅝	3 12 9	.. ..	6⅝	6⅛
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	106 109	106 109	3 4 8	January and July ..	103⅛	103⅛
53,000	5	3/0	United River Plate	3½ 4	3½ 4	..	" "	3 1/16	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.)	96 101	96 101	5 0 6	" "	93	93
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	10/0	City of London Electric Lighting (fully paid)	14½ 15½	14½ 15½	3 4 6	—	15½	..
40,000	10	6/0	Do. 6% Cumulative Pref. (fully paid)	15½ 17	16½ 17	3 10 7	—	16⅜	16⅜
£100,000	Stock	5%	* Do. 6% Debenture Stock (red.)	134 138	134 138	3 13 3	June and December	..	..
19,900	£5	..	Electricity Supply Co. for Spain.....	.. ..	.. ..	..	—	..	..
£30,000	£5	3 0	Charing Cross & Strand Electricity Supply Corp..	7⅛ 7½	7⅛ 7⅜	..	—	7⅜	7⅛
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	.. ..	.. ..	..	—	..	..
21,475	£8	..	County of London & Brush Prov. Ord. (fully paid).	8 9	8 9	..	—	..	..
10,000	£10	3/0	Do. Pref. (£8 paid)..... xd	12½ 13½	12½ 13½	..	—	..	..
8,322	£5	..	House-to-House Electric	.. ..	.. ..	..	—	..	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	.. ..	.. ..	..	—	..	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid).....	.. ..	.. ..	..	January and July ..	..	..
45,080	£5	3/0	Liverpool Electric Supply (fully paid)	7⅛ 7⅜	7⅛ 7⅜	3 16 2	—	..	..
111,000	5	..	London Electric Supply.....	.. ..	.. ..	..	—	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid) ..... xd	12⅞ 13½	12⅞ 13	3 1 7	—	13½	..
£150,000	Stock	4½%	* Do. 4½% Debs.	118 120	118 120	3 15 9	June and December	..	..
6,452	£10	4/0	Notting Hill Electric	8⅜ 9½	8⅜ 9½	..	—	..	..
..	..	..	Rand Electric	⅜ ½ prem.	7/16 ½ prem.	..	—	..	..
19,980	£5	5/3	St. James and Pall Mall	9⅜ 10½	10 10½	..	—	10 1/16	..
20,000	£5	7%	Do. 7 per Cent. Preference.....	9⅜ 10½	9⅜ 10½	3 8 4	—	10½	..
59,900	5	4/6	Westminster Electric Supply (fully paid)	9½ 10½	9½ 10½	3 8 4	—	10	9⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1⅛ 1⅜	1⅛ 1⅜	5 8 8	—	..	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅛ 1⅜	1⅛ 1⅜	3 4 0	—	1 3/16	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures.....	110 113	111 114	3 19 4	March & September	..	..
28,480	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref..	2¼ 2⅜	2¼ 2⅜	..	January and July ..	..	..
39,261	5	1/6	Edison and Swan United.....	1⅛ 1⅛	1⅛ 1⅛	..	..	1⅜	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 5 1	—	..	..
£20,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	.. ..	.. ..	..	—	..	..
110,000	2	..	Electric Construction.....	1⅛ 1⅜	1⅛ 1⅜	..	—	1⅛	..
12,346	2	2·93	Do. 7 per Cent. Cumulative Pref.	2⅛ 2⅜	2⅛ 2⅜	5 1 10	—	..	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ½	⅜ ½	..	—	..	..
20,000	5	..	Fowler-Waring Cables (fully paid)	⅜ ½	⅜ ½	..	—	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	20 21	20½ 21½	4 13 0	February & August	20⅞	20⅛
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	.. ..	.. ..	..	March & September	..	..
15,993	£10	..	International Okonite Ordinary.....	.. ..	.. ..	..	—	..	..
16,000	£10	..	Do. 8 per Cent. Preference.....	.. ..	.. ..	..	December and June	..	..
20,000	2	..	Manchester Edison-Swan "A" (£1 5s. paid).....	⅛ ¼	⅛ ¼	..	..	..	..
37,350	12	24/0	Telegraph Construction and Maintenance ..... xd	38 41	38 41	4 7 10	March and July.....	39½	..
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	102 105	4 16 5	January and July .	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)..	.. ..	.. ..	..	—	..	..
41,098	£5	..	Do. Preference (fully paid).....	.. ..	.. ..	..	—	..	..
£100,000	10	10/0	W. T. Henley's Telegraph Works Ordinary..... x1	16½ 17½	16½ 17½	3 8 7	—	17½	16⅜
£30,000	10	7/0	Do. 7 per Cent. Preference ..... xd	16⅜ 17⅜	16⅜ 17⅜	4 0 0	—	..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock.....	107 112	107 112	4 0 9	—	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway Con. Ordy.....	40 42	40 42	2 19 6	May and November	41	..
7,650	10	5%	Do. 5% Perpetual Preference	14½ 15	14½ 15	3 6 8	.. ..	14⅜	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	132 134	132 134	0 3 8	May and November	..	..
37,500	£10	3½%	Liverpool Overhead Railway	14 14½	14 14½	1 8 2	—	..	..
10,000	10	5%	Do. 5% Preference	16⅝ 16⅞	16⅝ 16⅞	2 19 3	—	..	..
125,000	Stock	4%	Do. 4% Debenture	114½ 116½	114½ 116½	3 10 2	January and July ..	..	..

In calculating the yield on this security, allowance has been made for accrued interest, but *not* for redemption.

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THE ELECTRICIAN:

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NOTES.

In another column we publish a further communication, received yesterday morning from Prof. RÖNTGEN. This, like his first famous memoir, is characterised by extreme lucidity and conciseness. The discoverer of X-rays has not as yet discovered any of the more startling properties which have been unearthed by hasty investigators scattered all over the civilised world. Prof. RÖNTGEN can find no difference in the discharge rate of positive or negative electricity, nor in the discharge rate of different bodies; and he makes no mention whatever of X-ray electrification. He has, however, made several additional observations of considerable value. Perhaps the most interesting—and we may add with all due deference to the great experimenter, the most doubtful—discovery, is, that air which has been traversed by X-rays retains the property of discharging electrified bodies. Prof. RÖNTGEN certainly explains his *modus operandi* very clearly; but it is not easy to see how he avoids ordinary convection discharge.

THE Post Office has often been able to prove that Mr. HENNIKER HEATON'S figures are nearly all wrong. He has now let it be seen that his figures of speech are even more so. In a letter to *The Times* yesterday, after stating, among other things relating to the telephone monopoly, that we are confronted with an accomplished fact and have to make the best of it, he proceeds "to contend, first, that the Government should take the mischief in embryo and grapple with the hydra before it is full-grown." For our part we would rather take the hydra in embryo and grapple with the mischief later on. But there really seems to be no call to do either if we are "confronted with an accomplished fact." Mr. HEATON might, however, be pardoned for his looseness of language if he would hold it tight until he understood a little better what he is going to talk about. His statement that there is no choice but to purchase the Telephone Company's rights at a cost of a hundred million sterling, or establish its monopoly in perpetuity, is absurd as well as untrue. Perhaps some of his parliamentary colleagues, whom he threatens to consult, will enlighten him as to what these rights will be worth on December 31, 1911.

IT is difficult to see what useful purpose Mr. A. L. FYFE expects to serve by distributing the following curious communication broadcast to the daily as well as to the technical press:—

"As I have always from practical experience contended that electric light and power can be more efficiently and economically supplied to towns and urban districts within a radius of five or six miles by using continuous currents than high-pressure alternating currents, I was, to settle as far as possible the question of danger, impelled to write to the Board of Trade for information. To my letter of inquiry they have courteously replied as follows:—'In reply to your letter of the 9th inst., I am directed by the Board of Trade to state that they have been informed of nine cases of fatal accidents to *employés* at generating or transforming stations where high-pressure alternating currents are used, but that no instances have been reported in the case of low-pressure continuous currents.' As the information received is of great public interest, I trust you will see the desirability of making this known to your numerous readers."

The regrettable accidents which have occurred in this country in connection with the employment of high-pressure alternate currents afford a ready means to unduly prejudice the public against their use, but it has been reserved to Mr. FYFE to be the first to take advantage of this opportunity. Apart from the graver aspect of this circular, it strikes us as an extremely inconsequential production. Mr. FYFE says that, being convinced that electric light and power can be distributed more efficiently and more economically within a certain radius by continuous currents than by high-pressure alternate currents, he felt impelled to write to the Board of Trade for information with regard to the *danger* of the latter. This is as if one should say: Being convinced of the superior reposefulness and breeziness of travelling by goods-trains, I felt impelled to write to the Board of Trade to inquire how many people have been killed by accidents to those horridly dangerous express trains. The accidents caused to workmen by high-pressure currents should not be burked, neither should they be employed as a means of improperly and unnecessarily alarming the non-technical public.

AN instance of a hastily-drawn inference from inadequate data is afforded by the conclusion at which the *Electric Railway Gazette*, of New York, arrives, viz., that surface railways are superior to underground railways. This generalisation is deduced from the fact that "a comparison of the cost per train mile for two years of two English electric railways, one a surface road and one an underground road, shows a difference of 3·18 cents per train mile in favour of the surface road." We do not wish it to be inferred that we believe the conclusion to be erroneous; but rather that a comparison between the expenses of the Liverpool Overhead Railway and the City and South London Railway does not justify such a conclusion. If

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it ever becomes necessary either in this country or in America to accurately determine the relative merits of elevated and underground electric roads, the ultimate basis of comparison will scarcely be a heavily handicapped line, like that in the south of London, and an overhead line so admirably adapted to its work as the railway at Liverpool. Our American contemporary comments on the cost of working hydraulic elevators on an underground system, and on the freedom from smoke, soot and other discomforts when running overhead; but it has omitted to take into account the liability of overhead traffic to be hampered by bad weather. During one severe winter the repairs and other items of expense on the Liverpool line were very considerably increased by dirty weather, while on some American overhead lines even greater troubles have been encountered from this cause. There are distinct advantages in either method of construction, and each will probably find favour in this country for its special sphere of work; but their rival claims to general superiority are not to be settled off-hand by a comparison between a single example of each.

One of the most composite systems of electric power generation is that now in use on the Mount Lowe Railway, in California. There are three separate generating stations, each supplying power at a different point. One of these stations is equipped with a 250 H.P. spirit engine, worked with gasolene; another station is worked by water power, the 80 H.P. dynamo being driven by Pelton wheels; while the third station contains a 100 H.P. two-cylinder "Otto" gas engine, the gas being pipe-lined from a gas generator some eight miles away from the station. If only as an instance of how a light electric railway can be run by scraps and odds-and-ends of power, this line is of interest; but it would be of still greater interest to know whether it pays.

A student is sometimes helped to a better comprehension of a science by regarding it from a new standpoint, which, however, would not serve as a basis for a thoroughly scientific exposition. For instance, in order to avoid the primary difficulties involved in the conception of magnet poles, he might study the phenomena of magnetism from the point of view of magnetic moments; yet neither this nor the conception of poles would be the most scientific basis for the science of magnetism. In an article on "Fundamental Magnetic Units," which we publish this week, Mr. H. N. Allen seeks to assist students by expressing the elementary facts of magnetism in terms of a unit of magnetic moment. We notice, however, that Mr. Allen, in deriving his primary laws, has omitted to explain what he means by the *axis* of a magnet, and what is meant by "broadside on," although he bases his laws on these terms. Having discarded the conception of a magnet pole, it becomes necessary to define these terms independently of polarity. We suggest that he might define them in respect to the magnetic field of the magnet, as evidenced by iron filings; but we fear that in so doing he would introduce a greater number of ideas than he gets rid of.

Argon and helium appear to be still fields of research for anomalous and peculiar properties; and the latest investigations in their behaviour when submitted to electric discharge do but widen the breach which seems to exist between these and what we may term ordinary elements. In another column we give an abstract of a Paper read before the Royal Society, in which Drs. Collie and Ramsay describe their researches in this direction. We have in general refrained from leading our readers into the thick of the fight which has taken place around these two recently-discovered elements, because the battle has usually been fought on purely chemical and non-electrical grounds. Now, however, we are confronted by two or three properties of these gases of an electrical nature, which, as Drs. Collie and Ramsey observe, are somewhat inscrutable. For example, it is found that "a tube like those termed Plücker's tubes need not be filled with helium at a low pressure, but shows all the phenomena of a vacuum tube at ordinary atmospheric pressure." Again, the enormous length of spark which is produced in helium, and the unusually long though less lengthy sparks in argon, differentiate these elements quite inexplicably from ordinary gases. Yet, while at ordinary atmospheric pressure a discharge passes most readily through helium, at very low pressures the discharge passes more readily through any other gas than through helium; and a mixture of argon and helium, at low pressure, apparently will conduct the discharge almost exclusively through the argon. More will have to be discovered, as to the atomic mechanism of the electric discharge in gases, before these facts can be explained; but as it is they indicate that in argon and helium we have elements the electro-chemical properties of which are decidedly anomalous.

Horseless Carriages.—The full conditions of the *Engineer* road-carriage competition are published in its issue of the 17th inst.

Cable Interruptions and Repair:—

	Date of Interruption.	Date of Repair.
Assab—Massowah.....	March 29, 1896. ...	April 18, 1896.
Puerto Plata—Martinique	December 19, 1895. ...	—

Personal.—Mr. George G. Ward, of the Commercial Cable Company, leaves the States to-morrow for England. He takes part in the forthcoming Telegraphic Conference at Buda Pesth, which begins on June 16th.

The Centenary of the Voltaic Cell.—Como, the native town of Alessandro Volta, is going to celebrate the hundredth anniversary of the invention of the voltaic cell by an electrical congress and an electrical industrial exhibition.

The Use and Economies of Rectifiers for Arc Lighting.—A Paper on this subject is announced as being down for reading by Mr. John Hesketh, at the meeting of the Northern Society of Electrical Engineers, on May 11th.

Lord Kelvin's Jubilee.—Mr. T. C. Martin, one of the editors of the *Electrical Engineer* of New York, has been appointed to represent the American National Electric Light Association at the forthcoming jubilee of Lord Kelvin's professoriate at Glasgow.

Forthcoming Books.—*The Electrician* Company will publish shortly a New Edition of Vol. I. of Dr. J. A. Fleming's "Alternate-Current Transformer, in Theory and Practice." The first week in June, Mr. H. D. Wilkinson's book on "Submarine Cable Laying and Repairing" will be published by the same publishers.

Electric Tramways in Zurich.—The Swiss Federal Council has just sanctioned the construction of six electric tramways in Zurich and suburbs. Four of the concessions have been given

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to the municipality of Zurich, one to Oerlikon and one to a private person. The system to be employed will be on all the lines the overhead trolley.

Transformer Patent Litigation in Italy.—The Corte d'Appelo of Florence, in the action of Zipernowsky-Déry-Bláthy *v.* Siemens and Halske, handed down on March 30th a demand for the examination of the translations of all foreign documents produced by Messrs. Siemens, and appointing for the examination of the same a committee composed of the following experts:—Prof. Rinaldo Fernini, professor of electrical engineering in the Polytechnic in Milan, Prof. Pietro Blaserna, professor of physics in the University of Rome, and Sig. Riccardo Arnò, instructor in electrical engineering at the Museo *Industriale* in Turin.

Röntgeniana.—So great has been the interest and curiosity aroused in Newcastle by the Röntgen phenomena that Prof. Stroud, who has been giving photographic and fluorescent screen demonstrations in the physical theatre of the Durham College of Science, has had to deliver his lecture three times, and on each occasion the theatre has been filled to overflowing. On Monday very clear slides of cases taken at the College were shown—viz., the hand of a lad containing a shot from a revolver; the wrist, elbow, knee and foot of adults; the leg of a lad who had had the tibia removed some years ago; and an excellent slide of a child's arm and hand showing partial ossification, &c.

The London Tramways Question.—We understand, says the *City Press*, that the Highways Committee of the County Council will bring up an important report on the tramways question either next Tuesday or on the following Tuesday. The offers of the syndicate have not been entertained, but the committee will report that the North Metropolitan and the London Street Tramways have jointly agreed to sell their undertakings to the Council at once, and to pay a sum for the 14 years' lease to be granted to them, equivalent to 9 per cent. on the capital outlay. The committee have also completed negotiations for leasing other tramways, which will return 5 per cent. on the capital outlay.

Electric and Oil Engine Vehicles.—At a stage in the development of horseless carriages when both electric and oil engine vehicles may be regarded as far from perfect, it may not be out of place to claim for electricity that it has at least run one experimental "'bus" about town at irregular intervals during the past ten years or so. We refer to the electric accumulator car invented and run by Mr. Radcliffe Ward. The claims of an oil motor syndicate to possess patents which "rule and control every substantial improvement in horseless carriages" have left electricity a little too completely out of account.

The Glasgow and West of Scotland Technical College.—At the last meeting of the Governors of this College, the subject of a site for new buildings for the college was gone into, and a report in favour of acquiring the site in North-street, coupling this proposal with the idea of retaining the George-street buildings was agreed to. The Chairman (Sir John Neilson Cuthbertson) stated that it was now 100 years since Prof. Anderson, of the university, founded the college. It had been deemed desirable that the centenary of the college should be appropriately celebrated, and it had been suggested that it should take place in June. Owing, however, to the Kelvin jubilee taking place then, it was now proposed that the celebration should take place in October. Lord Kelvin had consented to be of such use to them on the occasion as he could.

Niagara Falls.—Our Niagara Falls correspondent writes that a third 5,000 H.P. generator has been erected in the central station of the Niagara Falls Power Company, making the total capacity of the power house 15,000 H.P. This is to be increased by the addition of seven more generators, each of 5,000 H.P. capacity, which will bring up the total capacity to 50,000 H.P., or just one-half the total capacity of the tail-race tunnel. As yet it has not been decided how these additional generators are to be erected, but it has been rumoured that the Niagara Company has under consideration some suggestions of changes, which may eventually lead to placing the additional dynamos down in the big wheel pit, instead of in the power house, as at present. This method of erection would save the expense of the 138ft. shafts which now connect the turbines with the generators.

Flax Straw as Fuel.—With regard to the use of flax straw as fuel in the electric light plant at Watertown, U.S.A., the manager of the electric light works writes as follows to the *Electrical Engineer* of New York:—

"Our location here, so far from the coal fields of Iowa and Illinois results in transportation charges being so great as to prohibit the use of coal in this business with profit. Soft coal will cost from $3.50 to $6.50 per ton on cars here for the various qualities, from Iowa slack to the high-grade Eastern coals; and wood ranges from $3 per cord for soft wood to $4 for hard on cars. We can buy flax straw in abundance delivered at the plant for $1 per ton, and consider that two tons of straw is equivalent to a ton of the best coal. We have no special arrangement for using the straw The same furnace and boiler are in service, as when burning any other fuel, only that we have constructed sheet-iron chutes to the furnace doors with flaring approaches. By keeping the chutes full of straw and gradually working it into the furnace as consumed, we avoid the necessity of constantly opening and closing the furnace doors. The straw is delivered to us loose, and burned in that same condition. It, of course, requires pretty close attention, yet, after all, does not burn away as rapidly as one would suppose. The fibre in the straw makes an intense heat."

The Government and the Metric System.—In the House of Commons on Monday evening Mr. Arnold Forster asked the First Lord of the Treasury whether, in view of the fact that the metric system of weights and measures had recently been adopted by Turkey, Russia and Japan, and was now in use in all the civilised countries in the world with the exception of the British Empire and the United States of America, and in view of the fact that metric measurements had already been adopted with respect to the ton and for all purposes of pharmaceutical dispensing in the United States, Her Majesty's Government would take immediate steps to give effect to the practically unanimous recommendation of the Committee on the Metric System with the object of placing this country on a level with other civilised nations in the matter of weights and measures. In reply Mr. Balfour said that the recital of facts in the question was, he believed, correct; but he did not think it would be within the range of practical politics to impose by law on the inhabitants of this country so great a change in their ordinary habits as would be involved in giving effect to the recommendation of the Committee on the Metric System.

Electric Traction for Glasgow.—At the last meeting of the Sub-Committee of the Glasgow Corporation on tramway motors, the report upon mechanical motors drawn up by Councillor Crawford and Mr. John Young, general manager of the Corporation Tramways, from investigation on the Continent, was submitted. In carrying out the remit made to them, the two gentlemen named spent three weeks in making an inspection of a number of the chief mechanical methods of tramway traction on the Continent. In their general remarks the deputation report that the overhead system is admitted to be both best and cheapest, and in their opinion the overhead system can be extended over all existing routes in Glasgow without any disadvantage, the one great, and practically the only serious, objection being the appearance of the wires. Starting with considerable sympathy for that objection, the deputies say that what they have seen has quite removed it from their minds. The wires, where the system is carried out in the most approved manner, give only the very slightest offence to the eye, and a few hours' familiarity removes the objection entirely. The report favours the system of span wires across the streets for the support of the trolley wires, fixing the span wires to the buildings where practicable.

The Three-Wire Patent Prolongation.—At the last meeting of the Bradford Electricity Committee the Town Clerk reported that the joint objections of the interested bodies opposing the application for the prolongation of the Hopkinson three-wire patent had been formulated and duly lodged with the Privy Council. The notice of opposition contains ten clauses of objection. In the first place it is contended that the inventor and patentee has already received full and adequate remuneration, or if he has failed to do so has himself to blame. It is also alleged that the invention is not the only method of distributing electricity by three or five wire system, and that the Westinghouse Company acquired the patent "as a trading

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speculation," and not to assist the inventor, and that if they have not received adequate remuneration that affords no ground for the extension sought. The objectors further urge that the Westinghouse Company have already received full and adequate remuneration for the said alleged invention, or if they have not done so, their failure is due to negligence and refusal to grant licences on reasonable terms. It is also asserted that if the petitioners had exacted royalties from or made arrangements with all users, in the same manner or of the same nature as they have exacted from or made with the objectors, they would have realised a very much larger profit than they have. The objectors and others accepted licences under the patent, and paid large sums by way of royalty in respect thereof, on the faith that the term of the patent would expire on July 27, 1896, and they contend that the alleged invention is not of such special or exclusive merit or public utility as to be sufficient justification for any extension of the term granted by the said letters patent.

The Trans-Australian Line.—Referring to a recent temporary interruption of this line the *New Zealand Herald* says: "The cable has been working fairly well for some time, but it may be noted that breaks have occurred at Alice Springs more frequently than at any other part of the whole connection with Europe. Alice Springs is the central station of the line. It is on the edge of the southern tropic, in the McDonnell ranges, at an elevation of above 1,900ft. above the sea level. For a considerable distance the line follows the track of the Australian explorer, John McDouall Stuart. It was in 1870 that the South Australian Government were committed to the completion of a telegraph line, nearly 2,000 miles long, through a difficult and dry country, which was wholly unoccupied by white men for a distance of 1,400 miles. Between Port Augusta and latitude 26deg., a distance of 600 miles, there was practically no serviceable timber. In the unoccupied stretch of country, there were no tracks for the teams, and all the wires, insulators, &c., had to be carted, besides food for the men and building materials for the stations. The construction parties for the most difficult and remote parts of the work started from Adelaide at the end of August, and the party which had to put up the most distant section did not reach the scene of their operations till May 24th of the following year. In the dry country between the Katherine and Daly Waters wells had to be sunk before the cartage could proceed. Then followed a wet season, and the flooded country became impassable. One of the first messages to Adelaide from Alice Springs conveyed the news that the man who was to have had charge of the station had perished for want of water on his way up the country. The work was completed in November, 1872. The cost of the line up to the end of 1883, including replacing the wooden poles by iron poles, was £479,174. The whole of the line is patrolled once a month, and so perfect is the insulation that messages are transmitted between Adelaide and Port Darwin, with, as a rule, only one automatic translation, namely, at Alice Springs. The stations in the interior are substantial stone buildings, well supplied with water. The operators and linesmen have to be supplied with rations from Adelaide, which are sent up every year."

Boiler Explosion at Bankside.—Mr. Howard Smith, barrister, and Mr. J. H. Hallett, consulting engineer, the commissioners appointed by the Board of Trade under the Boiler Explosion Acts, 1880-1892, held an investigation on 15th, 16th and 17th inst., at the Bricklayers' Arms, Southwark, into the circumstances attending the explosion of a boiler at the Bankside station. The Board of Trade was represented by Mr. K. E. K. Gough, and Mr. Forman appeared as counsel for the City of London Electric Lighting Company. About 6 p.m. on February 25th last there was a rush of steam and hot water in the stokehold, whereby Peacock, a fireman, was badly scalded. He died on the following morning at Guy's Hospital. The commissioners found that the explosion was caused by the down-take water circulating tubes having become plugged up at the drum end, whereby the water was prevented from finding its way to the horizontal tubes, which became distorted through overheating, and in consequence a heavy strain was set upon the cast-iron headers, which they were unable to resist; that the boiler was last cleaned out in August, 1895, and was set to work again on October 6th, in the same year, and had, since that date, steamed 881¼ hours, had been banked 1,950½ hours, and had been off for 528 hours. The commissioners were of opinion that the explosion proved beyond all doubt that the boiler was not sufficiently cleaned after August, 1895, and stated that it was clear that it was not safe to work boilers fed with this water without frequent internal examinations unless steps were taken to free it of the solid matter it contained before it was introduced to the boilers. Having regard to the fact that it had been determined by competent engineers, who advised the Company that these boilers should be thoroughly cleaned out after 2,000 hours' steaming, and that in every case they had been subjected to that operation before the 2,000 hours had elapsed, and that the engineers had acted to the best of the knowledge which they then possessed and had honestly acted on the opinion which they had formed, that the period within which they had directed that the boiler should be cleaned was sufficient to allow an ample margin for safety, which opinion was confirmed by that of independent skilled witnesses, the Court found that neither the City of London Electric Lighting Company nor any of their *employés* were to blame for the explosion, and made no order as to costs.

Recent Chemical Progress.—Prof. Dewar prefaced his first Royal Institution lecture on this subject by saying that, as in the past there had been ages which we now describe as the stone age, the bronze age, and the iron age, so in the future the times we live in would be styled the chemical age. The position of a nation could be judged by the progress it has made in the science of chemistry and its applications to the industrial arts, and though Germany was the home of chemistry, Russian chemists were now to be found in the front rank, and no one could say which of the two nations would take the lead. The lecturer then referred to the advances which have been made in the means for obtaining and measuring high temperatures since he had last delivered addresses on the subject in 1879 to 1880, and stated that the crucible invented by Sir William Siemens was the first application of the electric arc to metallurgical purposes. Moissan's electric furnace, which was an improvement on this, enabled us to obtain a temperature of about 3,000°C., or a temperature one-third hotter than could be obtained in any ordinary furnace. With this high temperature carbon could be made to form definite compounds termed carbides with many of the metals with which it was previously impossible to make it combine, and amongst others the carbides of lithium, calcium, strontium, barium, aluminium, cerium, yttrium, thallium, and uranium had been prepared. The appearance of these bodies was not attractive, and in the dry state they were uninteresting. Immersed in water, however, they at once exhibited activity, and gave off hydrocarbon gases. Carbide of calcium was now manufactured by the ton in the furnace, and gave off the new illuminating gas acetylene (C_2H_2), which was eight times more brilliant than coal gas. This gas was first discovered by Sir Humphrey Davy's nephew in 1837, when he was working at the Royal Institution, and was called carburetted hydrogen. At red heat acetylene yielded benzol, the wonderful coal tar product from which we obtained all the aniline dyes and many other useful products. Both acetylene and benzol had hitherto only been formed by long and costly processes, but now by means of the electric furnace we obtained them by direct synthesis. In connection with this manufacture it might be mentioned that the presence of as little as 3 per cent. of magnesium in the limestone hindered the formation of acetylene. Carbide of cerium, which was a very expensive metal, for it cost about eighteenpence a grain, yielded petroleum when treated with water, which seemed to confirm Mendelieff's hypothesis concerning the oil wells at Baku. About 20 years ago Mendelieff was laughed at for suggesting that the continuous flow of the oil was owing to its continuous formation deep down in the earth due to the action of water on the metallic carbides, and to-day we found that the carbide of cerium, which is one of the heavy metals supposed to exist in that situation, *does* yield petroleum when treated with water.

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ELECTROMAGNETIC THEORY.—LXXXV.*

BY OLIVER HEAVISIDE.

(*Continued from page 719.*)

§ 341. In order to convert the operational solution to a series of Bessel normal functions we naturally use in the first place the form (32), involving the convergent functions We are virtually in possession of the unit impulsive function. —that is, by putting $h=pQ$, and developing by the expansion theorem, the result is a formula showing how the charge Q, initially at y, subsequently behaves. But to allow of this development, (32) should be a rational differential equation. Two necessary failures are obvious. First, if $l=\infty$, which does away with the infinite series of reflections, leaving in general only two waves, these waves themselves constitute the practically significant result. The set of normal functions with distinctly separated periods or rates of subsidence no longer exists, although the series of normal functions appropriate when l is finite has its ultimate representative in a definite integral, the limit of the series. Secondly, if either of the terminal operators be irrational, we have a similar failure, and a similar resulting definite integral.

But, assuming that l is finite, and that both the terminal operators are rational (as well as Y, Z in the circuital equations), we may confidently expect that the operational equation (32) contains p the time differentiator rationally, in spite of the presence in the functions concerned of q^m, where m may be fractional, or of $\log q$ in some cases. As a matter of fact, such irrationalities are inoperative by appearing in a suitable manner for cancellation. Thus, in (32) it will be found that r and s both have the factor q^{2m}, whilst I_m has q^m, and I_{-m} has q^{-m}. So the numerator and denominator in (32) both have the factor q^{2m}, and, therefore, (32) is a rational function of q^2, itself a rational function of p.

This being true for any value of m, it follows that in the case of m being integral, when we need to employ the 0/0 form of the K_m function, which brings in the logarithm of q, there is a similar elimination of this logarithm. It goes out in this fashion :—$\log \frac{1}{2}ql - \log \frac{1}{2}q\lambda = \log l/\lambda$. In the results we have only logarithms of numbers.

The alternative form of (32), in terms of I_m and K_m instead of I_m and I_{-m}, is got by using

$$\mathrm{I}_{-m} = \mathrm{I}_m + \mathrm{K}_m \sin m\pi \tag{49}$$

in (32). This brings us to

$$\mathrm{V}_1 = \frac{\frac{1}{2}\pi Zh}{x^m y^m} \frac{(\mathrm{I}_{mx} - f\mathrm{K}_{mx})(\mathrm{I}_{my} - g\mathrm{K}_{my})}{f-g}, \tag{50}$$

where

$$f = \frac{\mathrm{I}_{m\lambda} - \mathrm{A}\mathrm{I}_{m+1,\lambda}}{\mathrm{K}_{m\lambda} + \mathrm{A}\mathrm{K}_{m+1,\lambda}}, \tag{51}$$

and g is got by turning λ to l and A to $-\mathrm{B}$. Here the convergent K_m function may be understood, though the same result is true with the divergent form.

If l is made infinite, it will be found, by using the divergent series, that g becomes either $+\infty$, or $-\infty$ according to the nature of Z_1. In either case Z_1 is impotent, and (50) reduces to

$$\mathrm{V}_1 = \frac{\frac{1}{2}\pi Zh}{x^m y^m} (\mathrm{I}_{mx} - f\mathrm{K}_{mx})\mathrm{K}_{my}, \tag{52}$$

showing just the primary wave and a reflected one. This is the form suitable for simply periodic states when fully established, as to which more later.

The conversion of (50) to normal functions is merely a formal one by the expansion theorem, but there may be a good deal of work needed sometimes to bring the result to a form suitable for calculation by such tables as exist. In general, the roots of the determinantal equation $f=g$ are complex. That is too bad. But there are important cases of a relatively simple nature. Say $\mathrm{L}=0$, retaining R, S, K finite. Then only electric energy is concerned in the "medium," whether with wires or not. If also there is only electric energy concerned at the terminals, the roots (for p) of the determinantal equation are all real and negative.

In like manner, if $\mathrm{S}=0$, retaining R, L, K finite, only magnetic energy is concerned in the medium; and if this is also the case terminally, we have again roots of the same nature. These are two extreme cases of diffusion, with infinite speed v of propagation, though the practical result may be slow enough. Also, if R, K are zero, and L, S finite, we have finite speed of propagation without waste by resistance; therefore undamped vibrations can occur. In this case the roots are $p=\pm\theta i$, where θ is real, and corresponding terms can be paired to make real vibrations. To this may be added that if R and K are not zero, but are properly balanced, we have the last case again, with attenuation due to R and K superimposed. This nearly exhausts all the applications of a relatively simple nature; though if we do away with the terminal considerations, by taking Z_0 and Z_1 to be either zero or infinity, which makes either the current or the potential vanish terminally, we can extend the matter further.

§ 342. In all such cases, it is convenient to convert the functions from I_m and K_m to the oscillating functions J_m and G_m, or perhaps to J_m and J_{-m} instead. The cases of integrality of m are perhaps most common; then it is better to use K_m or G_m, and ignore I_{-m} and J_{-m}.

The oscillating functions are got by putting $q=si$. Thus,

$$\mathrm{I}_m(qx) = i^m \mathrm{J}_m(sx), \qquad \mathrm{I}_{-m}(qx) = i^{-m}\mathrm{J}_{-m}(sx), \tag{53}$$

where

$$\mathrm{J}_m(sx) = \frac{(\frac{1}{2}sx)^m}{\underline{|0}\ \underline{|m}} - \frac{(\frac{1}{2}sx)^{m+2}}{\underline{|1}\ \underline{|m+1}} + \frac{(\frac{1}{2}sx)^{m+4}}{\underline{|2}\ \underline{|m+2}} - \ \ldots, \tag{54}$$

and J_{-m} is the same with $-m$ put for m. When the argument sx is real, this is an oscillating function, the original Bessel function in fact. But the functions involving q are more primitive.

Now as regards K_m. Use the second of (34), with $q=si$. Then,

$$\mathrm{K}_m(qx) = i^{-m}\frac{\mathrm{J}_{-m}(sx) - i^{2m}\mathrm{J}_m(sx)}{\sin m\pi}. \tag{55}$$

Here $i^{2m} = (\cos + i\sin)m\pi$. So we may write

$$\mathrm{K}_m(qx) = i^{-m}\{\mathrm{G}_m(sx) - i\mathrm{J}_m(sx)\}, \tag{56}$$

where G_m is defined by

$$\mathrm{G}_m(sx) = \frac{\mathrm{J}_{-m}(sx) - \cos m\pi\, \mathrm{J}_m(sx)}{\sin m\pi}. \tag{57}$$

Or, if we expand i^{-m} in (55) as well, we get

$$\mathrm{K}_m = \frac{\mathrm{J}_{-m} - \mathrm{J}_m}{2\sin \frac{1}{2}m\pi} - i\frac{\mathrm{J}_{-m} + \mathrm{J}_m}{2\cos \frac{1}{2}m\pi}. \tag{58}$$

But the form (56) is the one to take note of.

So now, by the use of (53), we convert the equation (32) to

$$\mathrm{V}_1 = \frac{\frac{1}{2}\pi Zh}{x^m y^m} \frac{(\mathrm{J}_{mx} - \rho\mathrm{J}_{-mx})(\mathrm{J}_{my} - \sigma\mathrm{J}_{-my})}{\rho - \sigma}, \tag{59}$$

where

$$\rho = \frac{\mathrm{J}_{m\lambda} + \mathrm{A}'\mathrm{J}_{m+1,\lambda}}{\mathrm{J}_{-m\lambda} - \mathrm{A}'\mathrm{J}_{-m-1,\lambda}}, \qquad \mathrm{A}' = \frac{\lambda^n s \mathrm{Z}_0}{\mathrm{Z}}, \tag{60}$$

and σ is got by turning λ to l and A' to $-\mathrm{B}'$ in ρ. We have $\mathrm{A}=i\mathrm{A}'$, and $\mathrm{B}=i\mathrm{B}'$.

Also, by the use of (56), we convert the alternative equation (50) to the form

$$\mathrm{V}_1 = \frac{\frac{1}{2}\pi Zh}{x^m y^m} \frac{(\mathrm{J}_{mx} - \alpha\mathrm{G}_{mx})(\mathrm{J}_{my} - \beta\mathrm{G}_{my})}{\alpha - \beta}, \tag{61}$$

where

$$\alpha = \frac{\mathrm{J}_{m\lambda} + \mathrm{A}'\mathrm{J}_{m+1,\lambda}}{\mathrm{G}_{m\lambda} + \mathrm{A}'\mathrm{G}_{m+1,\lambda}}, \tag{62}$$

and β is got by turning λ to l and A' to $-\mathrm{B}'$ in α.

Observe, comparing the forms of (50) and (61), and of α and f, that the transformation is the same in effect as turning I_m to J_m and K_m to G_m, with the change from A to A'. Similarly, as regards the transformation from (32) to (59). The symbol i does not appear in (50), but when we put $q=si$, it appears in K_m through (56), and therefore in f and g. It cancels out on further reduction, and then the strikingly similar form (61) results. That i ought to cancel out is clear enough, because since (50) is rational in q^2, (61) must be rational in s^2. Nevertheless the way the symbol i goes out is somewhat remarkable, depending, as it does, upon the

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existence of two boundaries. It will not take place when there is only one. Say $l=\infty$, then g^{-1} is zero, and the form (52) results. Put $q=si$, and we do not get a result rational in s^2, and we ought not.

In connection with this, there is sometimes a bit of hocus pocus. If we like we may make the functions J_m and G_m the primary objects of attention, so that

$$V_1=(J_{mx}-\alpha G_{mx})X \qquad (63)$$

is the initial form of operational solution, s^2 having the meaning $-YZ$. Determining α and X by the conditions as regards h and terminally, we shall arrive at the result (61). This may, in fact, be the best way to work, when the ultimate results are to be simply periodic or normal solutions, and the development of waves is not in question. But there is a curious irreversibility sometimes concerned. We can always pass from the primitive I_m and K_m to J_m and G_m, but we cannot always go the other way. For instance, (61) leads to (56), by substituting $i^{-1}q$ for s, only when there are two boundaries. It fails when $l=\infty$.

For example, suppose that the condition at l is that $V_2=0$. Then $J_{mx}-\beta G_{mx}$ must vanish at l, and this shows that β must be J_{ml}/G_{ml}. Introduce some other kind of terminal condition, and we get some other form of β. But how find its value when $l=\infty$? If we have worked entirely with J_m and G_m, and know nothing of I_m and K_m, there is apparently nothing to show what β should be. For J_m/G_m, the ratio of two real oscillating functions when the argument is real, has no particular limiting value when l is infinite. Nevertheless, if we write $J_{ml}/G_{ml}=-i$, we shall come to the proper result. For it is the same as $\beta=-i$, which is correct.

The explanation has been already virtually given. It is the K_m function that is concerned alone when l is ∞; when $q=si$, then $(G_m-iJ_m)i^{-m}$ takes its place; that is, $-i(J_m+iG_m)i^{-m}$, or $\beta=-i$. But, quite independently of this determination of β, a physically-minded man, who was working in terms of J_m and G_m for convenience in the practical application, would arrive at the correct result by considering the flux of energy. In a simply periodic state produced between the source at y and infinity, with no reflection, the flux of energy must be outward. This necessitates $\beta=-i$.

§ 343. We know that the operational solution in terms of the divergent H_m and K_m is equivalent to that in terms of I_m and and I_{-m} or of I_m and K_m. Therefore, the same transformation $q=si$ in the divergent operational formula should lead to a result equivalent to that in terms of J_m and G_m. For distinctness, put a bar over the divergent functions. Then, $q=si$ in H_m, K_m produces

$$\overline{H}_m(qx)=i^m\{\overline{J}_m(sx)-i\overline{G}_m(sx)\}, \qquad (64)$$

$$\overline{K}_m(qx)=i^{-m}\{\overline{G}_m(sx)-i\overline{J}_m(sx)\}, \qquad (65)$$

when $\overline{J}_m$ and $\overline{G}_m$ are given by

$$\overline{J}_m(sx)=\left(\frac{2}{\pi sx}\right)^{\frac{1}{2}}\Big(P\cos+Q\sin\Big)(sx-\tfrac{1}{4}\pi+\tfrac{1}{2}m\pi), \qquad (66)$$

$$\overline{G}_m(sx)=\left(\frac{2}{\pi sx}\right)^{\frac{1}{2}}\Big(-P\sin+Q\cos\Big)(sx-\tfrac{1}{4}\pi+\tfrac{1}{2}m\pi), \qquad (67)$$

in which P and Q are the divergent functions

$$P=1-\frac{(1^2-4m^2)(3^2-4m^2)}{1.2(8sx)^2}\Big(1-\frac{(5^2-4m^2)(7^2-4m^2)}{3.4(8sx)^2}\Big(1-\ldots, \qquad (68)$$

$$Q=\frac{1^2-4m^2}{1.(8sx)}\Big(1-\frac{(3^2-4m^2)(5^2-4m^2)}{2.3(8sx)^2}\Big(1-\frac{(7^2-4m^2)(9^2-4m^2)}{4.5(8sx)^2} \qquad (69)$$

The G_m formula is obtained from the J_m one by turning sin to cos and cos to $-$ sin. When x is large, $P=1$ and $Q=0$, so

$$\overline{J}_m(sx)=\left(\frac{2}{\pi sx}\right)^{\frac{1}{2}}\cos(sx-\tfrac{1}{4}\pi+\tfrac{1}{2}m\pi), \qquad (70)$$

$$\overline{G}_m(sx)=-\left(\frac{2}{\pi sx}\right)^{\frac{1}{2}}\sin(sx-\tfrac{1}{4}\pi+\tfrac{1}{2}m\pi), \qquad (71)$$

show the ultimate nature of the oscillating functions at a considerable distance from the origin. They behave just like $\cos sx$ and $\sin sx$, but with amplitudes varying inversely as the square root of the distance from the origin.

J_m and $\overline{J}_m$ are equivalent when sx is real, and so are G_m and $\overline{G}_m$. The first was proved by Sir G. Stokes; the second I find in Gray and Mathew also, though somewhat difficult to recognise, owing to the use of several forms of the second function. It has been standardised in different ways, some of which are very inconvenient.

If in the H_m, K_m formula (22) we make the changes, according to (64), we shall arrive at (61) above precisely, only with $\overline{J}_m$ instead of J_m, and $\overline{G}_m$ instead of G_m. This alone would not prove the equivalence of the convergent and divergent oscillating functions. For example, if we put $\overline{H}_m=2i^m\overline{J}_m$ in (22), instead of the proper form (64), we shall still arrive at the same result (61).

There is, in fact, an essential difference between the two divergent functions $\overline{H}_m$ and $\overline{K}_m$. Say $m=0$, for instance. This is an important case. We do have $\overline{H}_m=2I_m$ when qx is real and positive. But it is not an equivalence when $q=si$, and sx is real. One makes $\overline{J}_0-i\overline{G}_0$. The other makes $2J_0$. On the other hand, $\overline{K}_0=\overline{G}_0-i\overline{J}_0$, and $K_0=G_0-iJ_0$; and we have $\overline{K}_0=K_0$, both when q is real positive, and when s is real positive.

§ 344. I have given elsewhere an algebraical explanation of the distinction. But it will be more satisfactory here to regard the matter physically. We ought to have the one agreement, and we ought to have the other discrepancy, by consideration of the physics. Go back to (5), for example, expressing the initial waves, and suppose that the source h is simply periodic, and that there is no waste of energy by resistance. This makes $q=p/v$, so that if the frequency of the source is $n/2\pi$, then $q=ni/v$, and $s=n/v$. The wave to the right is then

$$V_2=\frac{K_{mx}}{x^m}E=\frac{G_{mx}-iJ_{mx}}{x^m}e, \qquad (72)$$

when E and e are simply periodic functions of the time. Or, if $e=e_0\sin nt$, then

$$V_2=\frac{G_{mx}\sin nt-J_{mx}\cos nt}{x^m}e_0. \qquad (73)$$

This represents the ultimate result of the periodic source, and the corresponding current is

$$\begin{aligned}C_1&=\frac{q}{Z}x^{m+1}(G_{m+1,x}-iJ_{m+1,x})i^{-1}e\\&=-\frac{q}{Z}x^{m+1}(J_{m+1,x}+iG_{m+1,x})e\\&=-\frac{qe_0}{Z}x^{m+1}(J_{m+1,x}\sin nt+G_{m+1,x}\cos nt).\end{aligned} \qquad (74)$$

Here $q/Z=(Y/Z)^{\frac{1}{2}}=$ constant. These solutions indicate a train of waves travelling outwards. The flux of energy is VC. Its mean value over a period is

$$(VC)_{mean}=\tfrac{1}{2}\frac{qx}{Z}e_0^2(J_mG_{m+1}-G_mJ_{m+1})_x. \qquad (75)$$

This is constant, on account of the conjugate property of J_m and G_m, which is (if the accent is d/dx)

$$J_mG'_m-J'_mG_m=\frac{2}{\pi x}. \qquad (76)$$

That is to say, there is a steady average flux of energy from the source out to infinity, and this is as it should be, because there is no barrier.

In a similar manner, the wave to the left is

$$V_1=\frac{H_{mx}}{x^m}F=\frac{(J_{mx}-iG_{mx})}{x^m}f, \qquad (77)$$

where F and f are simply periodic, and this represents a wave train travelling to the left. The flux of energy will again be found to be constant on the average, and to be directed to the left. But this state of things is an impossible one, regarded as the ultimate state, like the other. It can only exist approximately initially. Say that h is at a great distance, and the frequency is so great that very many wave lengths can exist between h and the left barrier before it is reached. Then the above solution may be nearly true in a great part of the region occupied by the disturbance. But,

* O, in P.M., Part 2.

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whereas there is no barrier on the right side, there must be one on the left side, either at λ, as before, or at the origin itself. When the barrier is reached a new state of things will begin to prevail, first at the barrier, and then travelling out to infinity. Its nature will depend upon the kind of condition imposed at the barrier. It is then generally necessary to consider the second wave equation (8) as well as the first, equation (7), and superimpose them properly.

If the barrier should be such as not to take in energy continuously, the result between the barrier and the source must be a stationary vibration, involving no average flux of energy. The case $m=0$ is peculiar, when the barrier is at the origin. There can be no current there, and no flux of energy. So to the inward wave $H_{0x}.e$ or $(J_{0x}-iG_{0x})e$, add the outward wave $(G_{0x}-iJ_{0x})ie$. The result is $2J_{0x}e$, that is, $2I_{0x}e$. Here $2J_{0x}.e$ represents the ultimate stationary vibration which replaces the preceding state $(J_{0x}-iG_{0x})e$. The operator H_{0x} is valid at first, and then, later, the equivalent $2I_{0x}$, as soon as the origin is reached. We see that we have no right to expect that the property $H_m=I_m+I_{-m}$ should be true when s is real as well as when q is real.

The matter is made plainer by considering h to be steady, beginning at the moment $t=0$. The inward wave from h at y is calculable from H_{0x} until the origin is reached. The result is convergent. But after that, that is, after the moment $t=y/v$, it is only a partial solution, valid between y and the front of the return wave. In the region occupied by the return wave and the primary, we can calculate the wave by $2I_{0x}$ instead of H_{0x}. The two forms of solution become identical at the junction. This matter will be made plainer by one or two special examples. The present remarks are directed to the cause of the failure of $H_m=I_m+I_{-m}$ when $q=si$ and s is real, a cause which is not operative when the K_m function is in question.

§ 345. So long as the barrier at λ is at a finite distance from the origin, there is no interference with the power of imposing any terminal condition $V=-Z_0C$ of the usual nature, because the functions concerned have finite values. But when $\lambda=0$, there are some noteworthy peculiarities. We know that in one special case (viz., $n=0$, or $m=-\frac{1}{2}$), that of plane waves in a homogeneous medium, we may impose any condition at the origin. We have also observed that in another case ($n=1$, or $m=0$), that of cylindrical waves in a homogeneous medium, or of plane waves in a medium in which the constants vary as the first (or inverse first) power of the distance from a fixed plane, the Z_0 condition is impotent, because there can be no current at its place of application under any finite voltage. We have, therefore, to inquire when in general the Z_0 condition is potent, and when impotent. This is to be done by examination of the limiting form assumed by a in (22), or by r in (32) or by f in (50), when λ is made zero, under different circumstances. This is rather tedious mathematically, from the absence of luminosity. But we can throw some light upon the matter physically, and see that the mathematical results are justifiable.

Under what circumstances can there be a current at the origin when under an impressed voltage? Plainly the resistance must not be infinite. Now the resistance per unit length is Rx^{-n}, which is infinite or zero at the origin according as n is + or −. But the resistance per unit length is not (under the circumstances) the same as the resistance of unit length at the origin. The resistance of the length from 0 to x is $\int_0^x Rx^{-n}dx$. This is finite when n is negative, and also when it is positive, up to $n=1$, when it becomes infinite, and remains infinite for all greater values of n. Here the distance 0 to x may be a very little bit at the origin. So we see that there can be no current there when n is 1 or >1. This is true also as regards the source h. The terminal condition, if applied, must be impotent when n is 1 or >1.

Next, consider the permittance of a little bit from 0 to x at the origin. This is $\int_0^x Sx^n dx$, which is finite when n is positive, and also when n is negative, down to $n=-1$, when it becomes infinite, and remains infinite for greater negative values of n. If, then, n is -1 or <-1, no finite charge can raise the potential at the origin above zero. The terminal condition must be again impotent.

Thirdly, when n is between -1 and $+1$, both the resistance and the permittance of the little bit at the origin are finite; V and C may then have any ratio, and the Z_0 condition of the usual kind is operative if applied.

In the first case, we require to use I_{mx} only, when m is +, or $n=$ or >1. This makes C be zero at the origin. In the next case, when n is -1 or <-1, we must use I_{-mx}, m being -1 or <-1. This makes V be zero at the origin. In the intermediate case both functions will or may occur, according to the nature of Z_0; that is, both I_m and I_{-m}, or I_m and K_m, or J_m and G_m, if we use the oscillating functions. The last is rather remarkable, it leads not only to expansions of the form ΣAJ_{mx}, but also the form $\Sigma C(J_{mx}-\alpha G_{mx})$, when the origin is one of the barriers.

(To be continued.)

FUNDAMENTAL MAGNETIC UNITS.

By H. N. Allen (University of Nebraska).

It is possible to avoid the assumption, tacit or otherwise, of magnetic fluids covering the ends of the magnets, by defining the unit magnet and the unit magnetic field without introducing, as a temporary expedient, the idea of a magnetic pole.

The definitions rest on laws determined directly with the torsion balance, the bifilar magnetometer, the vibration magnetometer, or the deflection magnetometer.

The first law is, that in a uniform field the torque on a suspended magnet is proportional to the magnetic moment of the magnet, the field intensity, and the sine of the angle between the axis of the magnet and the direction of the field. The second is that when one magnet is placed "broadside on" to another, the distance between them being great compared with their lengths, the maximum torque acting on the second is proportional to the magnetic moment of each magnet, and inversely proportional to the cube of the distance between centres. If the first is placed end on to the second, the maximum torque, on this latter, is twice as great as in the former case.

The definitions are framed in such a way as to convert the above proportions into equalities, and lead to exactly the same units of magnetic moment, and of field intensity, as are obtained in the ordinary way by means of unit poles.

Definition of Unit Magnetic Moment.—If two very short magnets, of unit magnetic moment, are placed one centimetre apart, with the axis of one of them pointing along the line joining them, and that of the other at right angles to this line, the torque tending to twist the first parallel, but opposite to the second is unity. A couple of magnitude two tends to make the second parallel to the first.

In other words B being broadside on to A, the torque on A is unity, and A being end on to B, the torque on B is two units.

Definition of Unit Magnetic Field.—The unit magnetic field intensity is that of a field in which a unit elementary magnet, with its axis at right angles to the direction of the field, is acted on by unit torque, tending to make it parallel to the field.

The main difficulties about a method of treatment founded on these definitions are to obtain the connection between induction and intensity of magnetisation in a magnetic substance, and to define clearly the idea of magnetomotive force, or difference of magnetic potential.

It is possible, in both cases, to use the electrostatic analogy, defining the unit electrostatic doublet—to correspond to the magnet of unit magnetic moment—and showing how, in the outside field, the tubes of electrostatic force, due to the doublet, are geometrically the same as the magnetic tubes due to a magnet, the moment of which has the same numerical value. It can be shown in this way by assuming that the tubes of magnetic induction form closed circuits, that the induction in the central parts of a long thin permanent magnet is $\mathbf{B}=4\pi\mathbf{I}$, and if a field $\mathbf{H}$ is present in addition, having the same direction as $\mathbf{I}$, $\mathbf{B}=\mathbf{H}+4\pi\mathbf{I}$.

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Problems which have to do with magnetomotive force and magnetic flux may be treated in the same way as similar problems concerning electromotive force and current. This is, of course, the constant practice in the more advanced portions of the subject, and produces just as good results in the simpler cases.

The case of a long straight wire conveying a current C may be taken as an example. The magnetic field intensity at a distance r from the axis of the wire is $\mathsf{H} = \frac{2C}{r}$. If the current is supposed to run down into the plane of the paper, the lines of force will run round the wire in circles in clockwise direction. The flux between two cylinders, concentric with the wire, with radii r and $r + dr$, will be, for unit length of the cylinders, $\mathsf{H}\,dr$.

The reluctance of the wire, calculated just like the resistance of a metal ring for electricity, will be $\frac{l}{dr} = \frac{2\pi r}{dr}$. The specific reluctance is unity for air. Thus the magnetomotive force round the tube, which by the "Ohm's law" of magnetic flux is equal to the flux multiplied by the reluctance, will be $\frac{2\pi r}{dr} \times \mathsf{H}\,dr = \frac{2\pi r}{dr} \times \frac{2C}{r} \times dr = 4\pi C$, which is independent of r. Thus $4\pi C$ planes, radiating from the axis of the wire, with equal angles between them, will represent the surfaces of equal magnetic potential, and the magnetomotive force along the induction tubes, between the successive planes, will be unity.

If a long concentric cylinder of iron surrounds the wire, the induction will be $\mathsf{B} = \mu\mathsf{H} = \frac{2\mu C}{r}$. The flux round the ring described above will be $\mathsf{B}\,dr = \frac{2\mu C\,dr}{r}$. The reluctance of the circuit will be $\frac{2\pi r}{\mu\,dr}$, since μ, the permeability, is the reciprocal of the specific reluctance.

Thus the magnetomotive force, in this case, round the circuit, will be $\frac{2\mu C\,dr}{r} \times \frac{2\pi r}{\mu\,dr} = 4\pi C$, or exactly the same as before.

In case the tube is linked n times with the wire, or is due to n wires conveying the same current, about which it forms a closed loop, the magnetomotive force round the circuit will be $2\pi C n$.

The case of a solenoid may be taken in illustration. Some of the induction tubes, in the interior, will run the whole length of the solenoid, and complete their circuit outside. If there are n turns in the spiral, such a tube will be linked with the wire n times, and the total magnetomotive force round it will be $4\pi C n$. If the solenoid is very long indeed, nearly all of this will be used in sending the tube through the interior of the solenoid, and very little in sending it back outside; for the reluctance of this last part of the magnetic circuit is very small, the sectional area of this part of the tube being enormous. Thus, at the centre of such a long solenoid the magnetomotive force per unit length will be $\frac{4\pi C n}{l}$, or $4\pi C m$, where m is the number of turns per unit length.

Take a centimetre cube, two of the faces of which are magnetic equipotential surfaces. Since the specific reluctance of air is unity, the reluctance of this cube is unity, and the flux through it, being equal to the magnetomotive force divided by the reluctance, will be $4\pi C m$. This flux through a square centimetre in the solenoid is, of course, the magnetic field intensity, so that $\mathsf{H} = 4\pi C m$.

It almost seems as though this method of treating elementary problems would be a help in clearly bringing out the meaning of the term magnetomotive force. The more advanced problems of dynamo design are often somewhat complicated and require approximations which are apt to make the student regard the method as a rough engineer's device which gives results but has not a solid scientific foundation.

While there can be no doubt that the ordinary mode of treatment of magnetic problems, by a temporary assumption of the existence of magnetic poles, is perfectly logical, it seems as though a system, founded on what can be observed directly, and on our real conceptions of the nature of magnetism, must have many advantages, if it is not too complicated. Whether this is the case with the definitions here given, must be left to the judgment of teachers and other interested persons.

ON A NEW FORM OF RADIATION.*

BY PROF. WILHELM KONRAD RÖNTGEN.

As my investigations will have to be interrupted for several weeks, I propose in the following Paper to communicate a few new results.

§ 18. At the time of my first communication it was known to me that X-rays were able to discharge electrified bodies, and I suspected that it was X-rays, not the unaltered cathode-rays which got through his aluminium-window, that Lenard had to do with in connection with distant electrified bodies. When I published my researches, however, I decided to wait until I could communicate unexceptional results. Such are only obtainable when one makes the observation in a space which is not only completely protected against the electrostatic influences of the vacuum tube, leading-in wires, induction-coil, &c., but which is also protected against the air coming from the vicinity of the discharge apparatus. To this end I made a box of soldered sheet zinc, large enough to receive me and the necessary apparatus, and which, even to an opening which could be closed by a zinc door, was quite air-tight. The wall opposite the door was almost covered with lead. Near one of the discharge apparatus placed outside, the lead-covered zinc wall was provided with a slot 4 cm. wide, and the opening was then hermetically closed with a thin aluminium sheet. Through this window the X-rays could come into the observation-box. I have observed the following phenomena:—

(*a*) Positively or negatively electrified bodies in air are discharged when placed in the path of X-rays, and the more quickly the more powerful the rays. The intensity of the rays were estimated by their effect on a fluorescent screen or on a photographic plate. It is all the same whether the electrified bodies are conductors or insulators. Up to the present I have discovered no specific difference in the behaviour of different bodies with regard to the rate of discharge, and the same remark applies to the behaviour of positive and negative electricity. Nevertheless, it is not impossible that small differences exist.

(*b*) If an electrical conductor is surrounded by a solid insulator, such as paraffin, instead of by air, the radiation acts as if the insulating envelope were swept by a flame connected to earth.

(*c*) If this insulating envelope is closely surrounded by a conductor connected to earth, which should like the insulator be transparent to X-rays, the radiation, with the means at my disposal, apparently no longer acts on the inner electrified conductor.

(*d*) The observations described in *a*, *b* and *c* tend to show that air traversed by X-rays possesses the property of discharging electrified bodies with which it comes in contact.

(*e*) If this be really the case, and if, further, the air retains this property for some time after the X-rays have been extinguished, it must be possible to discharge electrified bodies by such air, although the bodies themselves are not in the path of the rays.

It is possible to convince oneself in various ways that this actually happens. I will describe one arrangement, perhaps not the simplest possible. I employed a brass tube, 3cm. in diameter and 45cm. long. A few centimetres from one end a portion of the tube was cut away and replaced by a thin sheet of aluminium. At the other end an insulated brass ball fastened to a metal rod was led into the tube through an air-tight gland. Between the ball and the closed end of the tube a side tube was soldered on, which could be placed in communication with an aspirator. When the aspirator was worked the brass ball was surrounded by air, which on its way

* Second communication. For the first communication to the Würzburg Physico-Medical Society see *The Electrician*, January 24th, p. 415.

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through the tube went past the aluminium window. The distance from the window to the ball was over 20cm. I arranged the tube in the zinc box in such a manner that the X-rays passed through the aluminium window at right angles to the axis of the tube, so that insulated ball was beyond the reach of the rays in the shadow. The tube and the zinc box were connected together; the ball was connected to a Hankel electroscope. It was seen that a charge (positive or negative) communicated to the ball was not affected by the X-rays so long as the air in the tube was at rest, but that the charge immediately diminished considerably when the aspirator caused the air traversed by the rays to stream past the ball. If the ball by being connected to accumulators was kept at a constant potential, and if air which had been traversed by the rays was sucked through the tube, an electric current was started as if the ball had been connected with the wall of the tube by a bad conductor.

(*f*) It may be asked in what way the air loses this property communicated to it by the X-rays. Whether it loses it as time goes on, without coming into contact with other bodies, is still doubtful. It is quite certain, on the other hand, that a short disturbance of the air by a body of large surface, which need not be electrified, can render the air inoperative. If one pushes, for example, a sufficiently thick plug of cotton wool so far into the tube that the air which has been traversed by the rays must stream through the cotton wool before it reaches the ball, the charge of the ball remains unchanged when suction is commenced. If the plug is placed right in front of the aluminium window the result is the same as if there were no cotton wool, a proof that dust particles are not the cause of the observed discharge. Wire gauze acts in the same way as cotton wool, but the meshes must be very small and several layers must be placed one over the other if we want the air to be active. If the nets are not connected to earth, as heretofore, but connected to a constant-potential source of electricity, I have always observed what I expected; however, these investigations are not concluded.

(*g*) If the electrified bodies are placed in dry hydrogen instead of air they are equally well discharged. The discharge in hydrogen seems to me somewhat the slower. This observation is not, however, very reliable on account of the difficulty of securing equally powerful X-rays in successive experiments. The method of filling the apparatus with hydrogen precluded the possibility of the thin layer of air which clings to the surface of the bodies at the commencement playing an appreciable part in connection with the discharge.

(*h*) In highly-exhausted vessels the discharge of a body in the path of the X-rays takes place far slower—in one case it was, for instance, 70 times slower—than in the same vessels when filled with air or hydrogen at atmospheric pressure.

(*i*) Experiments on the behaviour of a mixture of chlorine and hydrogen, when under the influence of the X-rays, have been commenced.

(*j*) Finally, I should like to mention that the results of the investigations on the discharging property of the X-rays, in which the influence of the surrounding gases was not taken into account, should be for the most part accepted with reserve.

§ 19. In many cases it is of advantage to put in circuit between the X-ray producer and the Rhumkorff coil a Tesla condenser and transformer. This arrangement has the following advantages:—Firstly, the discharge apparatus gets less hot, and there is less probability of its being pierced; secondly, the vacuum lasts longer, at least this was the case with my apparatus, and thirdly, the apparatus produces stronger X-rays. In apparatus which was either not sufficiently or too highly exhausted to allow the Rhumkorff coil alone to work well, the use of a Tesla transformer was of great advantage.

The question now arises—and I may be permitted to mention it here, though I am at present not in a position to give an answer to it—whether it be possible to generate X-rays by means of a continuous discharge at a constant discharge potential, or whether oscillations of the potential are invariably necessary for their production.

§ 20. In § 13 of my first communication it was stated that X-rays not only originate in glass, but also in aluminium. Continuing my researches in this direction I have found no solid bodies incapable of generating X-rays under the influence of cathode rays. I know of no reason why liquids and gases should not behave in the same way.

Quantitative differences in the behaviour of different bodies have, however, revealed themselves. If, for example, we let the cathode rays fall on a plate, one half consisting of a 0·3mm. sheet of platinum and the other half of 1mm. sheet of aluminium, a pin-hole photograph of this double plate will show that the sheet of platinum emits a far greater number of X-rays than does the aluminium sheet, this remark applying in either case to the side upon which the cathode rays impinge. From the reverse side of the platinum, however, practically no X-rays are emitted, but from the reverse side of the aluminium a relatively large number are radiated. It is easy to construct an explanation of this observation, still it is to be recommended that before so doing we should learn a little more about the characteristics of X-rays.

It must be mentioned, however, that this fact has a practical bearing. Judging by my experiments up to now, platinum is the best for generating the most powerful X-rays. I used a few weeks ago, with excellent results, a discharge apparatus in which a concave mirror of aluminium acted as cathode and a sheet of platinum as anode, the platinum being at an angle of 45deg. to the axis of the mirror and at the centre of curvature.

§ 21. The X-rays in this apparatus start from the anode. I conclude from experiments with variously-shaped apparatus that as regards the intensity of the X-rays it is a matter of indifference whether or no the spot at which these rays are generated be the anode. With a special view to researches with alternate-currents from a Tesla transformer, a discharge-apparatus is being made in which both electrodes are concave aluminium mirrors, their axes being at right angles; at the common centre of curvature there is a "cathode-ray catching" sheet of platinum. As to the utility of this apparatus I will report further at a later date.

Würzburg, Physikal. Institut. d. Universität.
March 9, 1896.

DISCHARGE PHENOMENA IN RAREFIED METALLIC VAPOURS.*

BY E. WIEDEMANN AND G. C. SCHMIDT.

While the phenomena occurring at the anode and cathode, and in the positive light column in a discharge tube (stratification, dark space, glow light, cathode rays), have been variously investigated for permanent gases, this has hardly yet been done as regards metallic vapours.†

And yet such experiments promise many interesting disclosures. For many metals it has been proved by their vapour densities that their molecules are monatomic. Changes in the spectra of such a metallic vapour are not therefore to be generally explained by the splitting up of the molecules into atoms, but by the different temperatures of the luminous particles, or by different kinds of excitation. It is only under well-determined conditions that we must contemplate the combination of several atoms to large molecules, such as liquidogenic molecules in de Heen's sense.

Arrangement.

The metallic vapours were contained in exhausted glass bulbs, fusible with more or less difficulty according to circumstances. Small portions of the metal were thrown into the bulb, its neck was drawn out, and a piece of soft glass fused in to connect with the pump. The metal was introduced into the neck and the bulb heated during exhaustion to expel moisture and hydrocarbons. Electric discharge was produced in the bulbs by means of two rings R and R^1 (Fig. 1) covered with wire netting about 6cm. in diameter. These were either connected directly with the two terminals of an influence machine kept 2mm. to 3mm. apart, or they formed the terminal condensers of a Lecher wire system. The wire nets were fastened on slides, and could be approached to the bulb or withdrawn from it. The bulb was heated by a flame between the wire nets.

Course of the Phenomena during Direct Connection with the Machine.

If the rings are put into contact with the cold glass bulb, sparks pass, in the first place, between the terminals of the machine.

* *Wied. Ann.* 57, pp. 454-458, 1896.

† A few experiments upon mercury are described by Schuster, *Proc. Roy. Soc.*, 37, p. 318, 1884. E. Warburg, *Wied. Ann.*, 40, p. 12, 1890.

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This discharge of the machine prevents the penetration of the bulb before the conductivity of the glass has been brought by heating to such a point that electricity can be continuously conveyed to the metallic vapour. As the temperature is raised still further, the discharge takes place steadily through the conducting glass. But as soon as the rings R are withdrawn a little from the glass walls, so that sparks pass from the rings on to the glass, the gas flashes out and shows all the characteristic phenomena of discharge (with suitable sparking distances and pressures): first cathode stratum, Goldstein's dark cathode space (second stratum), glow discharge (third stratum), dark separation space, and positive light column. With decreasing temperature, and consequently decreasing pressure, or with a constant temperature and increasing exhaustion, the usually observed phenomena also occur in the case of metallic vapours—increase of thickness of the dark space, stronger development of the glow stratum, recession of the positive light.

The phenomena observed at suitable pressure are shown in Fig. 2. k is the first stratum, more or less developed; g is the glow light. The portion g_1 towards the cathode is often of a different colour from the portion g_2 towards the anode. d is the dark separation space, and p the positive light sheaf, which in many cases appears beautifully stratified. In almost every case the domes of the strata have a different colour from the posterior portions.

That in these experiments we observe in the gas, surrounded as it is by a conducting glass sheet, a passage of electricity and a glow, is consistent with the general behaviour of gases and ordinary conductors under the influence of oscillations.

If the metallic nets immediately adjoin the strongly-heated bulb, a practically constant current passes through the glass walls. On withdrawing the nets a little from the glass, small sparks pass over to it, *i.e.*, an oscillating discharge takes place and passes through the conducting glass to the metallic vapours in the interior and makes the gas glow, or excites the molecules, so that they can glow with absorption of electric energy. As far as other experiments go, when spark-gaps are in circuit, the normal discharge

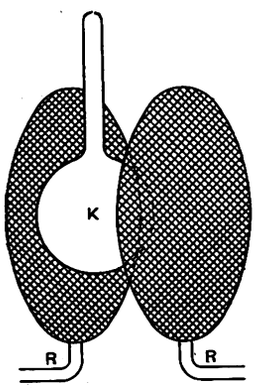

FIG. 1.

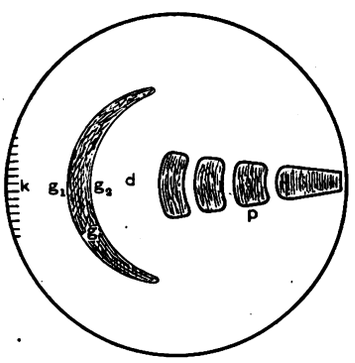

FIG. 2.

phenomena are replaced by irregular confused ones. If all the same the typical appearance is often beautifully presented, this is due to the fact that in consequence of the high resistance of the glass the passage of the electricity to the excited gas takes place so slowly that we can obtain normal discharges.*

The fact that a gas enclosed in the interior of a conductor may be made to glow by means of oscillations, is made possible in any case where the above arrangement is adopted.

In a few cases we used the two-wire net plates as terminals of a bridged Lecher wire system, thus exposing the metallic vapours to the influence of regular slightly damped oscillations; as in all other gases the cathode phenomena appear on *both* sides, and the positive light in the centre.†

We shall now describe the phenomena in detail only for those metals with whom they may be easily obtained, and which show characteristic colourings. Small changes in the colour occur when the quantity of the vapour is changed by different heating. In the main we have the following results:—

Sodium, k orange, g whitish, p yellow.

Potassium, k, &c., whitish, p purple.

Magnesium, all intensely green.

Thallium, k, &c., light blue, p green.

Cadmium, k greenish-blue to violet, g_1 pink, g_2 violet, p green on the whole, the domes green, the further portions violet. The positive light shows the smallest number of lines, next the first cathode stratum, and the glow light the largest number.

Zinc, k blue, g_1 reddish, g_2 purple, p reddish, the domes violet, the posterior portions reddish. The glow light shows most lines.

In zinc and cadmium the colours are very brilliant.

Mercury, differences between anode and cathode are small; in the spectrum of the positive light there is a continuous band in the green already observed by Warburg.

Arsenic, k whitish, g bluish, p green.

Tellurium, everything bluish.

In a number of the monatomic metals among those mentioned, the typical differences between anode and cathode phenomena appear very distinctly. In ordinary discharge tubes with fused-in electrodes A. Schuster has not succeed in observing those with the monatomic mercury. But even in this case difference in the appearance and in the spectrum occurs, as we, and also Warburg, were able to establish some time ago. But they are not very striking, since the colour of the light is nearly uniform.

Summary.

1. In a heated conducting glass bulb, rarefied metallic vapours may be made to glow by oscillating discharges.
2. In metallic vapours the typical discharge phenomena occur, even in monatomic ones. Colour and spectrum of the first and third glow-light strata and of the positive light are essentially different.

* *See* E. Wiedemann, *Wied. Ann.*, 20, p. 760, 1883.

† E. Wiedemann and H. Ebert, *Phys. Med. Soc. Erlangen*, February 8, 1892. *Wied. Ann.*, 50, p. 33, 1893.

EUROPEAN ELECTRIC TRAMWAY STATISTICS.

In its issue for March 10th *l'Industrie Electrique* gives as a supplement a very comprehensive statistical table relating to European electric tramways in operation, in construction, and projected on January 1, 1896. During 1895 the number of lines in operation have increased from 70 to 111, their total length having increased from 700 to 902 kilometres, the total capacity of the power stations in kilowatts has increased from 18,150 to 25,095, and the number of motor cars from 1,237 to 1,747. Germany continues to head the list with 406 kilometres of line, France coming second with 132 kilometres, and the United Kingdom third with 109 kilometres. The overhead conductor system continues to hold its own, being employed on 91 lines, whilst there are only three underground conductor lines and nine central rail lines, eight of which are in the United Kingdom. The total of 111 lines is completed by eight accumulator systems. Below we give a summary of our contemporary's valuable table, which, it will be observed, somewhat anticipates events in the matter of the sister isle:—

Countries.	Kilometres of line.	Power in kilowatts.	Motor cars.
Germany	406·4	7,194	857
England	94·3	4,243	143
Austro-Hungry	71·0	1,949	157
Belgium	25·0	1,120	48
Bosnia	5·6	75	6
Spain	29·0	600	26
France	132 0	4,490	225
Holland	3·2	320	14
Ireland	13·0	440	25
Italy	39·7	1,890	84
Scandinavia	7·5	225	15
Portugal	2·8	110	3
Roumania	5·5	140	15
Russia	10·0	540	32
Servia	10·0	200	11
Switzerland	47·0	1,559	86
Totals	902·0	25,095	1,747

Countries.	Overhead conductor lines.	Conduit lines.	Central rail lines.	Accumulator lines.	Total.
Germany	35	1	...	...	36
England	7	1	8	1	17
Austro-Hungary	6	1	...	2	9
Belgium	3	...	...	...	3
Bosnia	1	...	...	...	1
Spain	2	...	...	...	2
France	11	...	1	4	16
Holland	...	...	...	1	1
Ireland	1	...	...	...	1
Italy	7	...	...	...	7
Scandinavia	1	...	...	...	1
Portugal	1	...	...	..	1
Roumania	1	...	...	...	1
Russia	2	...	...	...	2
Servia	1	..	...	...	1
Switzerland	12	...	...	...	12
Totals	91	3	9	8	111

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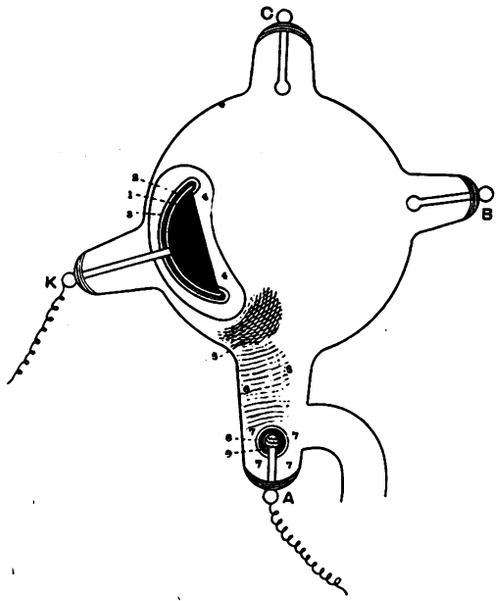
ON A CROOKES APPARATUS.*

BY H. PFLAUM.

To show the difference between the discharges in a moderately and highly exhausted space respectively, Crookes† used two glass bulbs designated by No. 7A and 7B, which were perfectly equal in shape and only differed in degree of exhaustion. While in the first bulb the air had a pressure of several millimetres, it was extremely rarefied in the second. (By Crookes it was said to be exhausted to a millionth of an atmosphere). Three point electrodes A, B, C, and another K, in the form of a concave mirror, were fused in. If, in the bulb 7A, A, B, and C were made the anode in succession, K remaining the cathode, a violet light stream went from the cathode to the anode for the time being. If the same experiment was repeated with apparatus 7B, another phenomenon took place, which was the same whether A, B, or C was the anode. From the concave mirror a beam converged to the centre of curvature of the mirror, diverged from this, and produced vivid fluorescence on the glass wall.

When at the beginning of this year I had an occasion to experiment with apparatus constructed in 1880 for this Polytechnikum, by Leybold, in Cologne, in accordance with Crookes's indications, I observed the same effects again. These bulbs were exhibited at the Physical Exhibition held at Riga in that year. They worked satisfactorily in spite of frequent use by the public. But when I tested the apparatus a few weeks after the exhibition, I found that 7B had become useless. I therefore ordered new specimens of 7A and 7B of the scientific mechanician, F. Ernecke, in Berlin. The bulb 7A did show the phenomenon described; but 7B showed a behaviour differing to such an extent that I feel impelled to publish a description of it.



If K is made the cathode, and A, B or C the anode, a yellowish-grey stratified light extends from the anode to the cathode, while the hollow cathode is completely enveloped in a bluish-white glow. This much is seen with a cursory glance, that the position of the anode is not without influence upon the shape of the light effect. Besides, the green fluorescence of the glass on the plates opposite the cathode is not more intense than at all the other places where it occurs, *e.g.*, behind the cathode, between A and K, or between C and K. The phenomenon in question is quite different from that observed in the moderately exhausted bulb.‡

On close inspection the following details are discernible (*see* Fig. 1). A halo of white light (1), about 0·8mm. thick, immediately surrounds the cathode, at the back of which it is very plainly seen. Then follows a darker layer of the same thickness (2). This is succeeded by a bright white layer (3), 1mm. to 1½mm. thick, and this by a fainter light (4), which continually becomes fainter. It may be traced as far as the wall of the vessel behind the cathode (towards the left in the figure), while in front of the cathode it gets steadily dimmer, and extends to about a centimetre from the surface. Towards the anode this glow is followed by a very dark space (5), evidently the "separation space" (Wiedemann), and this is succeeded by a series of 12 to 15 cloudy striæ of various thicknesses and intervals, concave towards the anode, of a yellowish-grey colour, and vibrating rapidly.* The striæ are bounded on both sides by a very faint violet glow. The striæ towards the anode appear crowded so close together that they appear to pass almost imperceptibly into a faint grey stationary glow, which extends behind the point anode (7). Within this glow lies the anode, surrounded by a brighter layer (8), succeeded by a darker one (9). Just round the anode lies a very bright white halo, the light of which appears disturbed again, as if flickering. If, instead of A, the electrodes B or C are made the anodes, the layers are directed towards B or C. Otherwise the discharge remains the same.

I should also mention the phenomenon observed when K is made the anode, and, say, A the cathode. The concave anode is then, as was the cathode, surrounded by a luminous glow, in which we may distinguish the same parts (*see* Figure, 1—4). But the dark separation space is now succeeded by continuous light, which becomes steadily brighter towards the cathode. The point cathode has now the same appearance as the point anode had in the first experiment, viz., the flickering halo is surrounded by a dark and this by a light space. Stratifications are nowhere to be seen. The fluorescence of the glass remains the same as before. Now and again a small spark bursts from the cathode, accompanied by a momentary brightening of the glow between cathode and separation space. Photographs of the bulbs show less than is seen with the naked eye, and ultra-violet light, which might be expected to play a part in the phenomenon, does not appear on any of the negatives.

Riga, October, 1895.

* *Wied. Ann.*, No. 3, 1896, p. 443.

† *Radiant Matter.*

‡ The conditions of the experiment were the following:—A storage battery of eight cells gave the primary current of 3·9 to 4·6 amperes; the induction current was furnished by a large induction coil with platinum interruptor (74mm. sparking distance). The observations were made in a perfectly obscured place, so as to perceive even the most delicate light details.

* Their situation, distance and number depends upon the strength of the induction current. As the current increases they are drawn towards the cathode, as it diminishes they recede towards the anode.

PUBLIC LIGHTING BY ARC LAMPS.†

BY ANDRÉ BLONDEL.

(*Continued from page* 823.)

Dioptric Methods.

In using dioptric methods we may set ourselves two distinct objects to be attained, corresponding to the two *desiderata* of lighting:—1st. The reduction of the losses of light generally accompanying diffusion. 2nd. The distribution of the light in the most advantageous manner without sacrificing diffusion.

A certain number of inventors have sought to attain one or other, or even both, of these objects, with varying success. They have had recourse to the well-known properties of refraction and reflection, which they have employed each with its own particular object.

Dioptric Diffusion.—The principle of this method consists in covering a globe of transparent glass with a network of small refracting elements, each producing a divergence or expansion of of the rays received by it. The first attempts in this direction were made with ribbed glass, the origin of which is very ancient, and difficult to ascertain. Plain ribs produced a certain amount of spreading of the light in a direction perpendicular to the genatrices of the ribs. Glass of this kind has recently been adopted for the lanterns in the city of London. According to Mr. Preece, they entail a loss of only 21 per cent., but they are very bad from the point of view of diffusion, on which point, however, not much trouble appears to have been taken. Similar glass panes, with horizontal ribs, have been used in lighting the stations of the Midland Railway. They have the advantage of preventing shadows, even at the foot of the pillars. When using globes of this nature Mr. Raffard (in 1881) had the idea, recently taken up again,[39] of placing two such panes with their ribs at right angles to each other, so as to obtain diffusion in both directions. A much better diffusion is obtained with lanterns so fitted than with those fitted in the usual way, though the result is still not perfect. In 1883 Mr. A. P. Trotter,[40] one of the best-versed engineers in photometric questions, attained the same result in a much easier manner by the aid of single glasses, arranging two series of ribs, one on each side of the glass, each rib having an almost circular section.[41] With this arrangement diffusion was still imperfect, and the losses of light considerable, from reasons indicated later.

Dioptric Distribution of Light.—The idea of distributing light according to a given law by the use of refracting rings was first suggested by Fresnel fifty years ago, since which time many similar attempts have been made. But instead of being cut out

† From *La Révue Technique.* Translated by Mr. John Hesketh.

[39] *Société Francaise de Physique*, 1894.

[40] *Proc.* Inst. C.E., 1883.

[41] The arrangement of orthogonal flutings on the same glass seems to have been first pointed out by Messrs. Cooper and Richardson (1870), but without any explanation or theory.

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separately and then fastened together—a very expensive system, which was at first employed—these rings may be made in the form of horizontal grooves or steps on either lantern panes or globes.[42] The profile of these steps or *échelons* is easily determined. In Fig. 39 let P N be the internal shape of the glass which is placed in a predetermined position relative to O, the source of light. The external shape, M *a* N, is determined algebraically or geometrically by the condition that the incident rays of the source O shall be refracted in different directions, so that the illumination on the ground is uniform. The solution of this elementary problem was,

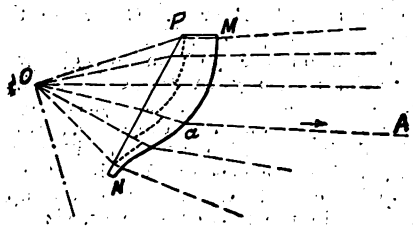

Fig. 39.—Principle of Lenses in *échelon* applied to the Distribution of Light.

I think, given by M. Weissenbruch in 1889. In practice the glass would be too thick if it were made in one continuous section. It may then be divided into several parts, which are afterwards fitted together. In this manner a series of lenses is built up which differs from those in use in lighthouses only in that the rays instead of being emitted parallel, form a diverging cone. But to obtain any desired distribution, account must be taken of the intensity of the incident light in each direction; this naturally changes with the source of light employed. Besides, in the vertical direction,

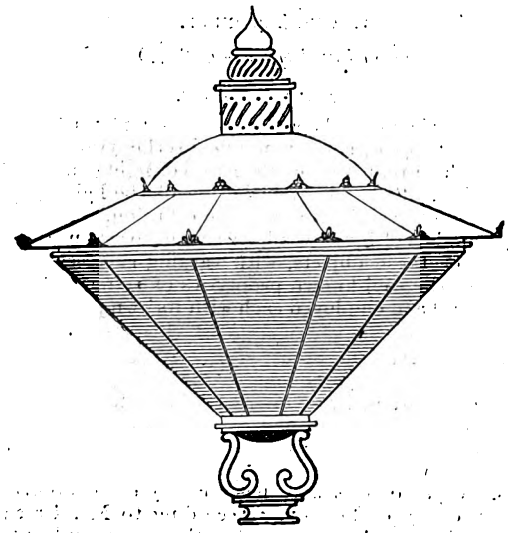

Fig. 40.—Trotter Polygonal Lantern with Reflector and Ribbed Glass.

distribution but not diffusion is obtained, because each rib only sends light out in a single direction, so that an observer at A (Fig. 39) only perceives one groove *a* as luminous, and this one naturally appears dazzling. In addition, these globes absorb a considerable portion of the light by reflection, as will be mentioned later. Mr. Trotter, who in 1883 employed such a system* in the manner shown in Fig. 40, succeeded in minimising its inconveniences

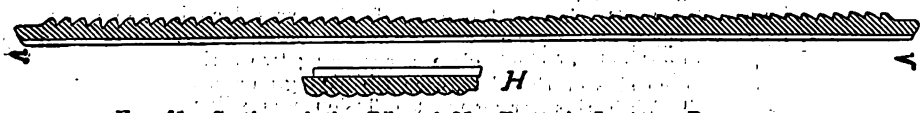

Fig. 41.—Section of the Ribs of Mr. Trotter's Lantern Panes. V. Vertical Section. H. Horizontal Section.

by adding interior ribs to give a certain horizontal spreading of the rays, and giving the purely refracting exterior ribs a profile which rendered them capable of partially diffusing the light. The profiles

* Fig. 39 is taken from Mr. A. P. Trotter's patent. For the description of his system, see his able Paper "On the Uniform Distribution of Light."

[42] This arrangement was first applied to lighthouses by M. Degrand, but owing to the result obtained not being sufficiently accurate it was not successful. The same writer also published a complete set of fittings for public lighting (English patent, 1857), but does not appear to have even carried out his ingenious inventions.

he used are shown in Fig. 41. The ribbed panes are confined to an inverted cone of 45deg.; they receive the light at any angle varying from 15deg. to 90deg. from the vertical, and send it out at an angle of 74deg. The essential end Mr. Trotter had in view was

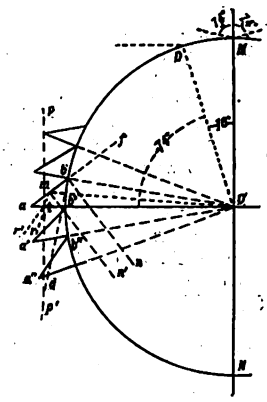

Fig. 42.—Frédureau System of Diffusing Rings.

to obtain uniform horizontal illumination in a circle of a diameter of seven times the height of the lamp; and to this he very closely approximated by calculating most carefully the section of the diffusing glass. The lantern was completed by a silvered

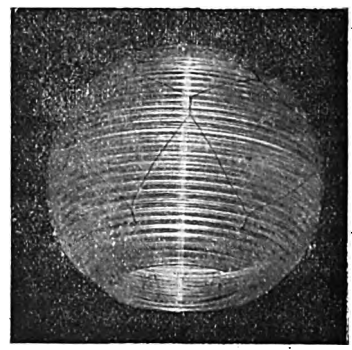

Fig. 43.—Effect produced by Frédureau Diffusing Globe, with 10 ampere Continuous-current Arc.

reflector, which directed all the light emitted above the horizontal on to the cut glass. Owing to its high price this ingenious device did not meet with the success it deserved; its shape and various technical defects, especially the employment of purely refracting

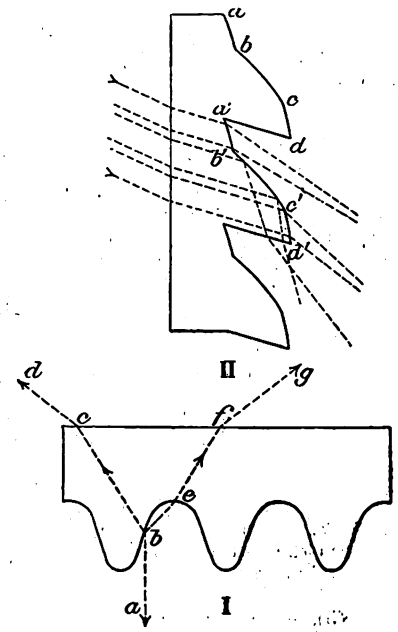

Fig. 44.—I. Average Profile of the Internal Ribs of a Holophane Globe for Public Lighting. II. Typical Combined Reflecting and Refracting External Ribs of the same Globe.

grooves, which do not lend themselves to practical use, and only allow of sufficient diffusion at the risk of losing much light by internal reflection, also militated against it. More recently, M.

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Frédureau reverted to the old system of M. Degrand, and renouncing double ribbing, has constructed globes with simple prismatic or parabolic external zones, simply to reflect as much of the light downwards as possible. Such a globe is shown in Fig. 42. This figure, which is reproduced from *l'Electricien*, shows that each of the steps acts by total reflection like a catadioptric ring, and thus sends a large proportion of the light towards the ground. No particulars as to the results obtained with this kind of globe are at our disposal, so we are unable to say how efficient it would prove for public lighting. The fact that these globes produce a distribution

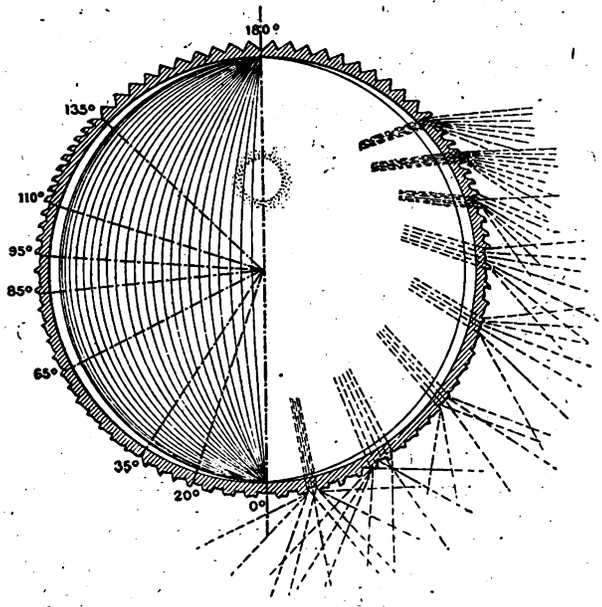

FIG. 45.—Vertical Section of Holophane Globe.

and not a diffusion of the light, is shown by the photograph, Fig. 43. Owing to the excessive internal reflection to which these globes give rise, it will readily be seen that a considerable loss of light results.

Holophane Globes.—This again is a globe with the double ribs used in many of the preceding examples, but with certain special differences. The external ribs differ from all the preceding forms in their profile; each rib is a combination of two independent sec-

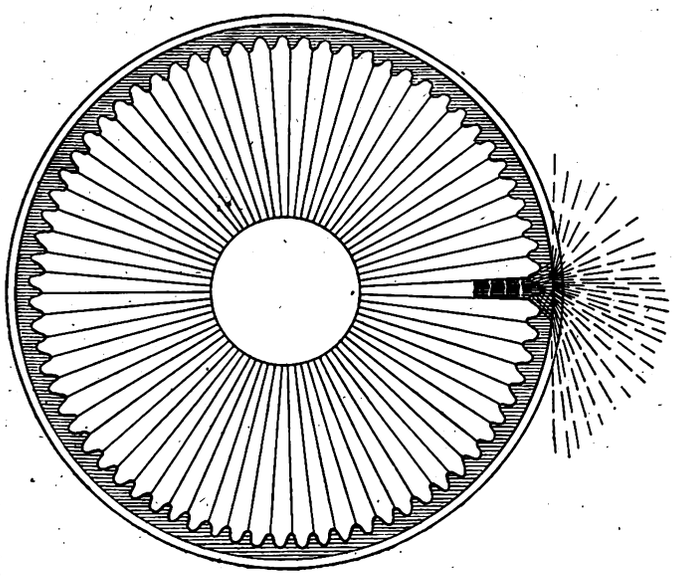

FIG. 46.—Horizontal (centre) Section of Holophane Globe.

tions, one *refracting*, the other *reflecting*, arranged so as to suppress all acute angles, as shown in Fig. 44 II. With this combination a very good diffusion of light can be obtained over a considerable angle without any appreciable loss; the globes themselves appear to be luminous all over, as shown in Fig. 49, and it is on this account that the inventors have given them the name of *holophane* (ολος, entirely; φαινω, to shine). This great diffusion, which the spherical shape of the globe rendered it particularly difficult to attain, makes the globes look as soft as opal globes,[43] and the physiological desideratum is thus satisfied. Moreover, this result is not arrived at in an arbitrary fashion, but by means of calculations too long to be given here, and according to the law of distribu-

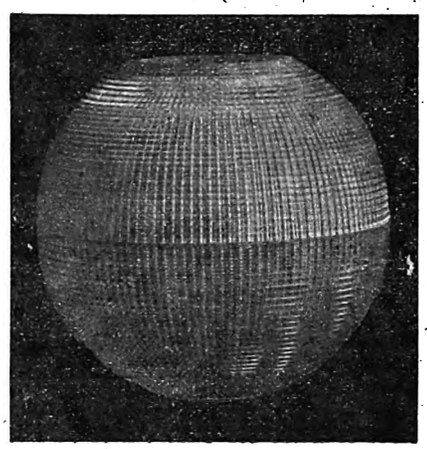

FIG. 47.—View of External Parallel Ribs of Holophane Globe.

tion which seems the most advantageous in each case.[44] The type of holophane globe used for public lighting is 34cm. diameter, so as to fit lamps at present in use. The arc is fixed 10cm. above

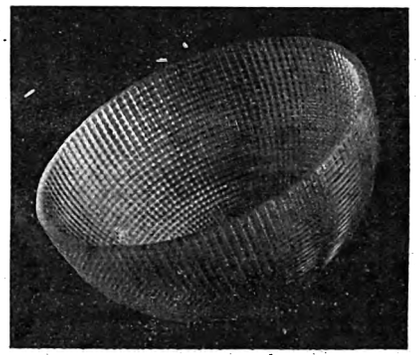

FIG. 48.—View of Internal Ribs of Holophane Globe.

the centre as usual. Figs. 47 and 48 show the external and internal ribs or channels, of which Figs. 45 and 46 are sections. These ribs have been calculated to give definite effects. The average profile

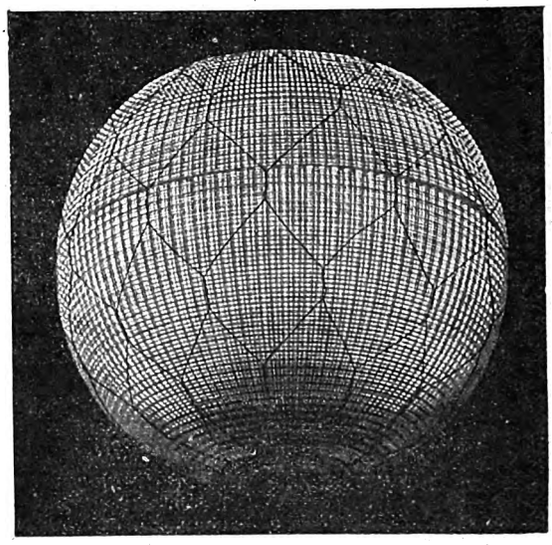

FIG. 49.—Effect produced by Holophane Globe with 10-ampere Continuous-current Arc.

of the internal ribs (Fig. 44 I.) is intended to ensure horizontal diffusion according to the law of cosines; and the external

[43] In reality the luminous surface is formed by an infinite number of small images of the arc, so weak and so close together that the eye completely mixes them up.

[44] Further details will be found in an interesting article in *L'Industrie Électrique* of October 10, 1894, written by M. Claude.

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ribs (Fig. 44 II.) are calculated according to the law decided on for vertical distribution. Fig. 45 shows the result obtained, which result is, moreover, to a certain extent independent of the source of light employed. The law of distribution was discussed in my former article (see *The Electrician*, Vol. XXXVI., November 1, 1895, *et seq.*), and some experimental results are given later. The ribs at the upper portion of the globe are specially designed so as to totally reflect the rays towards the centre of the globe, and yet in such a way as to just escape the carbons. This system of double ribs may be used for almost any system of non-deteriorating reflectors.

(To be continued.)

THE FOUNDATIONS OF THE NEW 1,000-KILOWATT ALTERNATOR AND ENGINE AT DEPTFORD.*

BY J. HETHERINGTON.

A potent factor in the comfortable running of high-speed machinery lies in a massive and trustworthy foundation to which the plant can be securely anchored. Where directly-coupled engines and machines are of such construction and dimensions as to preclude an iron bed-plate, common to the whole, the foundation to which the separate items are fixed has to be answerable for the permanent alignment and consequent smooth running, which would otherwise have been attained by a cast-iron sub-structure, making practically one machine of the driver and driven parts. The foundation, in this respect, being made an integral part of the machinery, its construction, stability and quality are of first-class importance.

An installation in which the above conditions were to be observed was last autumn put into commission in the Deptford generating station of the London Electric Supply Corporation. This station is famous for many unique mechanical and electrical combinations, and the latest unit possesses many interesting peculiarities, which have been fully chronicled in the technical periodicals.

As affecting the question of foundations, there is an engine, some 70 or 80 tons in weight, driving a three-throw crank shaft coupled directly to the shaft of the armature by a rigid coupling. This shaft is over 12ft. long, and carries a revolving armature nearly 40 tons in weight. The field magnet frames for this require a pit 22ft. long, 6ft. wide, and 11ft. deep, and add about 40 tons more. One bearing of this machine is pinned and bolted to the bed-plate of the engine, while the other is aligned with, and connected to, it only by the concrete foundation.

The speed at which the plant is run gives a circumferential speed to the armature bobbins of over 10,000ft. per minute, or nearly two miles. Such weights, moving at this velocity, require, for satisfactory working, perfectly linable bearings, which imply a foundation that will, once the bearings are right, keep them permanently so without vibration or other undesirable movement. Accordingly, unusual care was bestowed on the formation of the concrete block to which the above plant is bolted, with results satisfactory not only to the contractors for the dynamo and engines, but also to the corporation's engineer-in-chief, Mr. P. W. D'Alton, M.I.M.E., under whose directions the foundation was put in by the corporation's own workmen.

The site for the block is on a previously laid concrete floor, planned for 10,000 H.P. direct-driven dynamos (since abandoned), and at a level too low for the general purposes of the station, as well as for the sinking of a pit for the dynamo. On this account the foundation of the new unit is nearly wholly above the floor, being raised 10ft., and is in itself an interesting bit of engineering work.

The first consideration in making the block was a thoroughly efficient bond to the existing concrete floor, which is above 5ft. thick. A clean, fresh surface was obtained by taking off a layer, 1ft. thick, over the whole area to be occupied by the new work, while by slightly undercutting the margin, a dovetail was produced for keying the new work to the old.

A wooden mould, of the shape of the block, was made of 1in. boards, nailed to battens, with vertical timbers 6in. square, at every corner and midway of the long sides. Horizontal timbers of the same section were spiked to the top of these, so as to tie the cross part of the T to the upright part, the plan being in the shape of a hugh letter T, with the engine on the shank and the flywheel armature on the cross. Cross timbers of the same size were fixed on the tops of these to tie in the sides, and on the upper side of these the tipping floor was laid, commanding the whole space below.

On the under side of the cross timbers were arranged supports to take the tops of the bolt cores, so fitted that their accuracy could be checked as often as desired by reference to fixed points outside and altogether independent of the framing itself, and compensation could be easily made for any distortion caused by the dry wood absorbing moisture from the concrete.

Between these points fine lines were stretched, passing through ½in. holes in the pieces A (Fig. 1), a saw cut from the holes to the lower ends of the pieces allowing them to be put on over the strings. Battens 1½in. thick, fixed to the bottoms of these pieces, were bored at the proper places, as determined by the lines, and the bolt cores trimmed to fit the holes at one end and the plates at the lower end. This arrangement being lined so that the strings were in the centre of the holes in the pieces A, any movement could be at once detected and allowed for by the wood-screws above. Only ½in. on each side of the holding-down bolts was allowed in the concrete for grouting in when the engine and dynamo were correctly placed and levelled, and every one of the 42 holes was found to be accurately under the corresponding holes in the bed-plate and bearing blocks. Portland cement of the very best quality was used in making the concrete, finely ground and

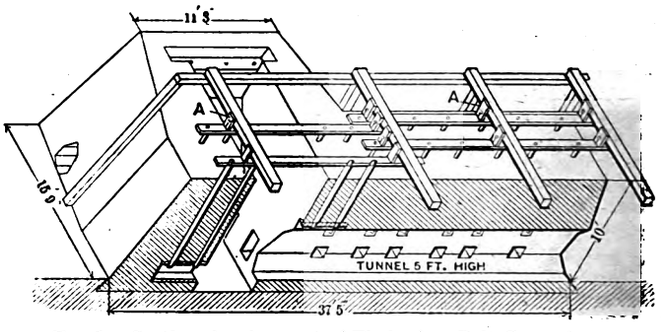

FIG. 1.—Section showing part of Timbering, Bolt Cores, &c.

weighing over 115lb. per striked bushel (1·28 cubic ft.) after quietly filling the measure, and with a tensile strength of 300lb. per square inch after seven days' immersion. It was thoroughly cooled before being used.

The ballast was specially selected from dredgings from the river Thames, and was remarkable for its freedom from any impurities detrimental to the proper binding of the mortar with the aggregate. As brought up it contained too large a proportion of sharp sand, and the whole of it was screened, leaving a heap composed of particles of every size from sand up to flints from 6in. to 8in. long. After careful tests to determine the interstitial space, the sand being somewhat coarse, the following proportions were used:—

Ballast.....	36 cubic feet
Sand	7½ ,,
Cement	6 ,,

This is equivalent to 7¼ to 1, or practically six parts of aggregate to one of matrix. About one-fifth of the total bulk of dredged

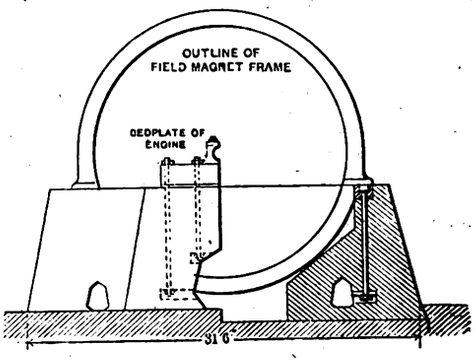

FIG. 2.—End View and Section through Armature Race.

material was left over as surplus sand, in excess of what was required. This was quickly disposed of to builders at current rates. The concrete was turned twice dry and twice wet and was necessarily dropped into the foundation from a considerable height at the beginning, gradually diminished as the work rose in the frame.

As the area to be gone over was very large, the starting point got fairly set before the men worked round to it again with a layer 18in. thick each round, and in order to check the too rapid evaporation of moisture by the hot dry air of the engine room, water was sprayed over the surface of the layers at intervals from a hose pipe laid on for the purpose. Tunnels were moulded in the block to give access to the lower ends of the foundation bolts which connect to cast-iron plates worked in as the concrete rose, and to provide an entrance to the armature race. The total quantity of

* Abstract from *Cassier's Magazine*. For a description of the engine and alternator see *The Electrician*, November 29, 1895, p. 147.

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concrete in the block is 230 cubic yards, weighing about 390 tons, of which close upon 50 tons are cement.

Apprehension was felt that cracks would develop in the work as it hardened, due to the shrinkage of cement, and experienced concrete engineers had predicted that the finished block would not be a monolith. These fears have so far proved groundless, and the most careful examination at the points of weakest section, and where contraction strains were most likely to accumulate, fails to reveal even a hair-wide crack, although the machinery has been daily running for some months. To all appearance the block is as solid as if hewn in rock.

ON THE EFFECT OF THE RÖNTGEN X-RAYS ON THE CONTACT ELECTRICITY OF METALS.*

BY JAMES R. ERSKINE MURRAY.

The experiments described in this communication were made in the Cavendish Laboratory of the University of Cambridge, at Prof. J. J. Thomson's suggestion, in order to find whether the contact potential of a pair of plates of different metals is in any way affected by the passage of the Röntgen X-rays between the plates.

The vacuum bulb and induction coil for the production of the rays were enclosed in a box lined with metal, so that the plates and the apparatus used in measuring their contact potential difference should be screened from any direct electrical disturbances. To measure the contact potential the null method described by Lord Kelvin in his Paper given to the British Association in 1880 was used. The plates were of zinc and tinfoil, the latter being mounted on thin ebonite to keep it flat. They were placed parallel to one another at a small distance apart, so that the rays fell perpendicularly on the back of the tinfoil plate, passed through it and the air space between them, and were absorbed by the zinc. The tinfoil plate was insulated and connected to insulated quadrants of a Kelvin quadrant electrometer. The zinc was uninsulated, and was connected to the uninsulated quadrants of the electrometer. This plate was movable in a direction perpendicular to its plane, and could thus be drawn away from the tinfoil.

Before the rays were turned on, the contact potential of the plates was measured and found to be +0·44 volt, the zinc being positive to the tinfoil. The rays were now turned on. The contact potential, measured while the rays were passing, was about +0·43 volt. But before the plates could be separated to see whether the counter potential applied had annulled the contact potential or not, the charge leaked away as if the insulation of the tinfoil plate were bad. It was also observed that when the plates were not in connection with one another, but only with the electrometer, they seemed to act as though they were connected together by a bad conductor or an electrolyte.

The X-rays were now turned on so as to pass perpendicularly through the tinfoil plate on to the zinc. In a few minutes the deflection indicated −0·50 volt, and remained steady there for several minutes. While in this condition the plates were separated. The deflection increased by a small amount, showing that the electrolytic power of the air while the rays were passing through it had somewhat more than counterbalanced the contact potential of the plates, and had established a slight difference of potential in the direction opposite to that which exists between the surfaces of the plates when connected metallically in air. This was confirmed by a measurement, made immediately after, which gave +0·44 volt for the potential difference between the plates; the rays not being on at the time.

In the experiments described above, the rays had fallen perpendicularly on the plates, passing through the tinfoil. The plates were now placed so that the rays should pass between them in a direction approximately parallel to their surfaces. On breaking the metallic connection between the plates and turning on the rays the electrometer rose to −0·39 volt, and remained steady there. Separating the plates produced no further deflection, which shows that the contact potential difference between the surfaces of the plates has been reduced to zero. This was confirmed by the measurement, made by the null method, of their contact potential, which was now +0·39 volt.

In the above experiment the plates were at about one centimetre apart. The distance between them was now increased to two, then to five, and then to 10 centimetres; but in spite of the fact in the last case the rays must have passed almost entirely through the air between the plates without striking on their surfaces, the electrometer always crept up from zero to −0·39 volt in a minute or two, and remained almost steady at that value.

In order to find whether these phenomena were strictly comparable with the results which Lord Kelvin had got many years ago by connecting the plates through an electrolyte, several experiments were made in which connection was made by a drop of acidulated water. Before doing so, their potential difference was found to be +0·57 volt. Joining the plates by a drop of acidulated water while they were in connection with the electrometer only, the deflection at once rose from zero to −0·54 volt. After a short while the deflection fell to −0·48 volt, which was nearly the value found previously for untarnished zinc and tinfoil in air, showing that the acidulated water had in all probability removed the tarnish, and was now balancing the contact potential between clean surfaces of the metals. The water was now removed, and the contact potential measured by the null method as before. It was still +0·57 volt, for, of course, by far the greater part of the surfaces of the plates was still tarnished as before.

It now occurred to the author that perhaps the electrolytic connection established between the plates when the rays were passing might be through the insulating supports of the tinfoil plate, and not through the air, as hitherto supposed. To test the truth of this idea, several variations were made in the arrangements, all with a view to place the insulators in such a position that the rays could not reach them. When the rays were started the electrometer moved from zero to a position which indicated a difference of potential as great as or greater than any which had been previously observed. This showed that the electrolytic connection had not been at all affected by screening the solid insulators.

The author has observed that the activity of the vacuum bulb seems to determine to some extent the potential difference observed on the electrometer. The conclusions the author draws from these experiments are that (1) the influence of the rays on the zinc and tinfoil plates does not cause any direct or sudden change in their contact potential, but that (2) the air through which the rays pass is temporarily converted into an electrolyte, and when in this condition forms a connection between the plates which has the same properties as a drop of acidulated water, namely, it rapidly reduces the potential between the opposing surfaces of the plates to zero, and may even reverse it to a small extent.

It is interesting to note that this electrolytic property was found by Lord Kelvin ("Electrostatics and Magnetism," Art. XXIII, §§ 412—414) to be possessed by the fumes from a burning spirit lamp. In both cases its cause is probably the same. It is, no doubt, due to a want of electrical equilibrium among and a partial dissociation of the molecules of the gas.

* Abstract of Paper read before the Royal Society March 19th, received March 3rd.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) FRIDAY, April 24th.

PHYSICAL SOCIETY.

5 p.m. Meeting at Burlington House. Papers to be read: (1) "Symbolism in Thermodynamics," by R. A. Lehfeldt; (2) "Adjustment of the Kelvin Bridge," by R. Appleyard; (3) "The Effect of Wave-Form on the Alternate-Current Arc," by J. Frith.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Students' Meeting. Paper to be read: "Underground Conductors," by E. Ray and V. Watlington.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Circulation of Organic Matter," by Prof. G. V. Poore.

MONDAY, April 27th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture I.: "Applied Electro-Chemistry," by James Swinburne.

TUESDAY, April 28th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Papers to be read: (1) "American and British Methods of Manufacturing Steel Plates," by Jeremiah Head; (2) "Four American Rolling Mills," by Samuel T. Wellman.

WEDNESDAY, April 29th.

INSTITUTION OF MECHANICAL ENGINEERS.

7:30 p.m. Ordinary General Meeting at 25, Great George-street, The President will deliver his Inaugural Address. Adjourned discussion on the following Paper: "Notes on Steam Super-Heating," by W. H. Patchell.

THURSDAY, April 30th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture (III.): "Recent Chemical Progress," by Prof. Dewar, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper to be read: "On Railway Telegraphs, wth Special Reference to Recent Improvements," by W. Langdon.

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In a few weeks' time the present stormy and somewhat unsatisfactory session of the Institution of Electrical Engineers will come to an end, and, so far as the average member or associate is concerned, the very existence of the Institution will be temporarily forgotten. To the devotees of *laisser-faire* this is a consummation devoutly to be wished. There is, indeed, a time for all things, even for a policy of procrastination; but we cannot help thinking that the Council of the Institution will be ill-advised in postponing the much-needed emendation of the Articles of Association until after the recess or, as some no doubt wish, until the Greek Kalends. The long-existing feeling of dissatisfaction with the management of the affairs of the Institution has culminated within the past six months in a succession of disagreeable incidents. First of all, the Presidency became a subject of considerable agitation and discussion, and an open battle was only narrowly avoided. Then, at the annual general meeting "held at meeting next previous to Christmas Eve," a determined but unsuccessful attempt was made to secure the appointment of a committee to consult with the Council on matters affecting the welfare of the Institution. Lastly, at a recent meeting, the balance sheet was referred back for amendment. It needs but the most elementary acquaintance with the art of diagnosis to argue from these symptoms that something is rotten in the state of Denmark, and the allegation is that the Council, owing to the slow influx of fresh blood and the dead-weight of the votes of 13 or 14 Past-Presidents, is out of touch with

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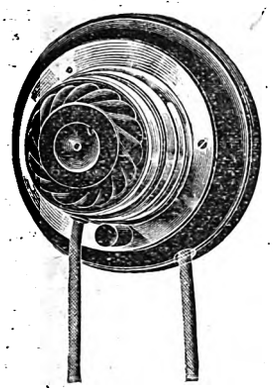

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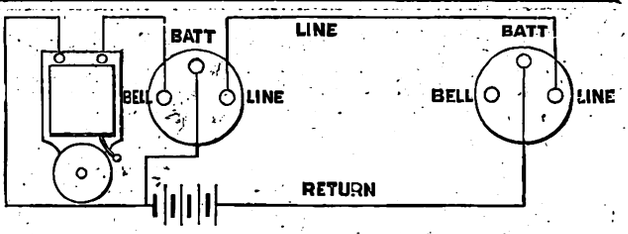

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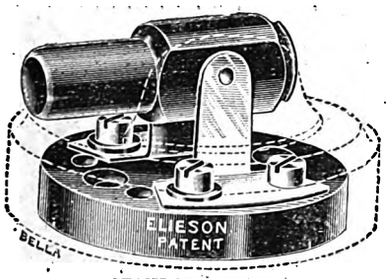

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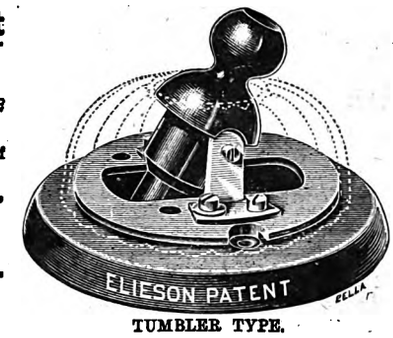

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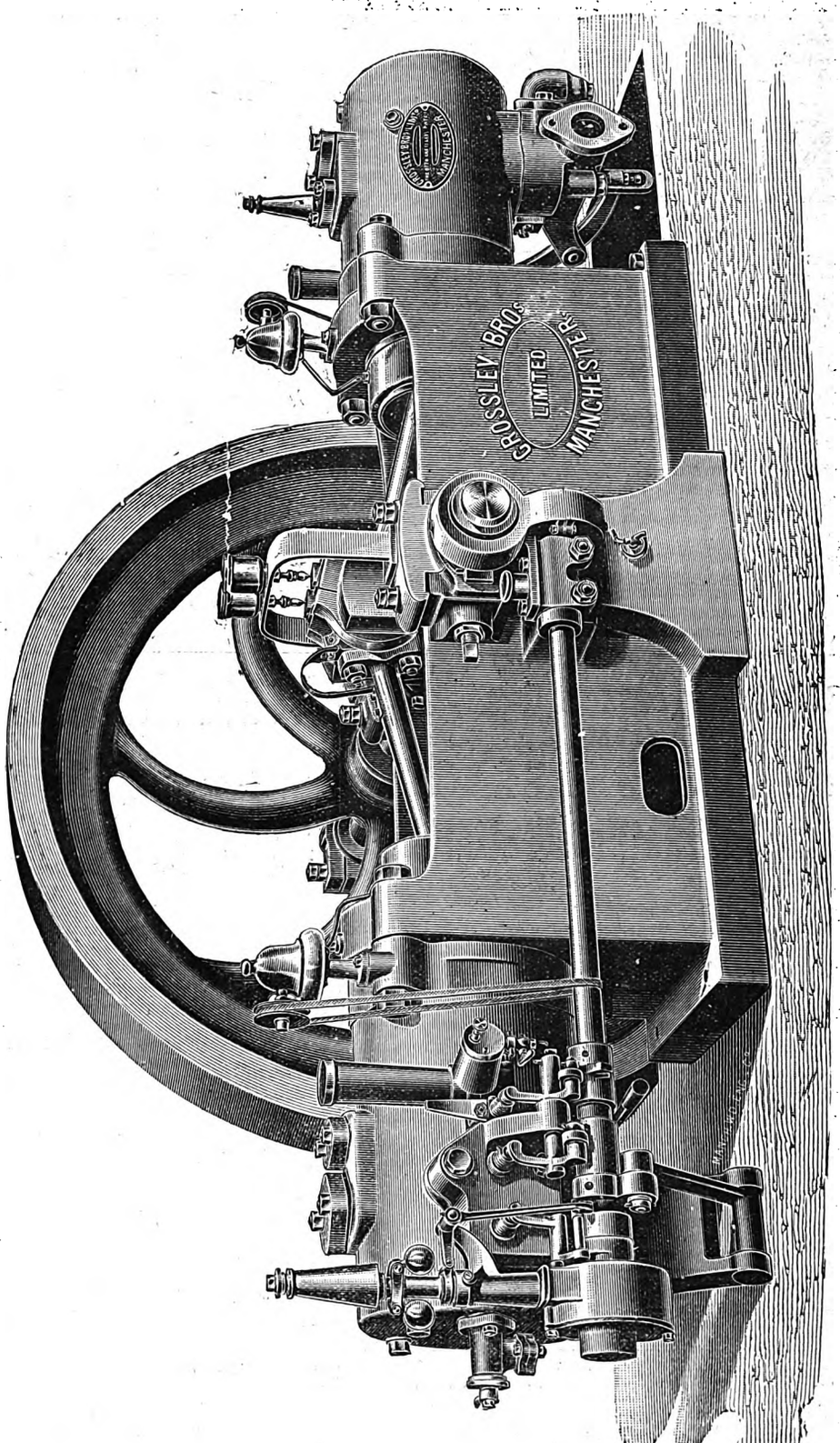

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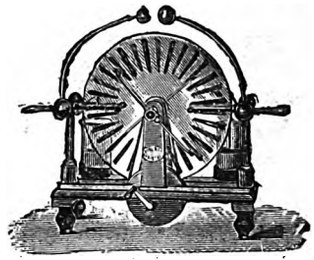

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DISINFECTANTS and APPLIANCES.

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its constituents. As to the correctness of this assertion, we have no desire to be dogmatic; but the unedifying events of December last were certainly symptomatic of a marked divergence of opinion between the Council and the members. Mere alteration of mechanism cannot, of course, by itself entirely prevent the growth of a separatist spirit, the proneness of those in office to treat those outside as children who rarely know what they want, and when they do know ought not to have it, is too natural an instinct for that; but alteration of mechanism would have a distinct tendency that way, and seeing the *tracasseries* which have arisen from this cause, one would have expected that any remedial suggestions would have been welcomed and promptly adopted. No doubt there is much to be said, especially from the Machiavellian point of view, in favour of allowing the "malcontents" to stew in their own juice—to use the not too elegant phrase of an ex-Cabinet Minister—but after what has happened, the balance of statesmanlike advantages surely lies in winding up the present session by making such reasonable alterations in the Articles of Association as will satisfy the reformers. The Institution of Civil Engineers is always being quoted as an example. Well, let us follow it. Not only is its mode of electing Council rankly democratic compared with our own, but a week or ten days ago a number of revolutionary proposals were carried in an afternoon. If the alleged discontent be but the "baseless fabric of a dream," if those who have taken a prominent part in the reform movement are actuated by no other motives except a desire to annoy others and to advertise themselves, if they have no one behind them, the policy of permitting the agitation to fizzle out would be the only one worth considering. Without an open trial of voting strength, a course which in the best interests of the Institution cannot be too strongly deprecated, it is confessedly impossible to tell exactly how far the general body of members are prepared to support any demand for alterations in the Articles of Association: so far as our own inquiries go there would seem to be considerable bottom to the agitation. If that be so, the movement will only fizzle out to flare up later on, and the Council may encounter the awful end of the nigger who sat on the safety-valve. With the voting power of Past-Presidents abolished or greatly diminished, with a more rapid passage of members through the Council, with the election of Council somewhat more in the hands of the members, and the business at the Annual General Meetings, at which the accounts as well as the report should be presented, made less of a time-wasting formality, all will have been done that suitable lubrication can do to make the machinery of the Institution run silently and smoothly.

Assuming that the wishes of the majority of the Council coincide with those of the energetic constitution-mongers who have lately been so much in evidence, an assumption which we have some reason to believe is not without a foundation in fact, what we are going to do with this brand new machine when we get it? Is the net outcome to be merely that a few more self-sacrificing gentlemen will have an opportunity of sitting at the Council Board? Is the pace of the procession through the Council Chamber only to be quickened, and not the pacet of he Institution as a whole? If so, many a "malcontent" of to-day will wonder "*que diable allait il faire dans cette galère.*" The main object for which the Institution exists is, as stated in its Memorandum of Association, to promote the general advancement of electrical science and its applications and to facilitate the exchange of ideas; an object which it is proposed to attain by holding meetings, promoting exhibitions of electrical apparatus, publishing reports of its proceedings, forming a library and making "grants of money, books, apparatus or otherwise for the purpose of promoting invention and research in electrical or telegraphic science or its applications or in subjects connected therewith." It is in the hope that these high aspirations will be more worthily fulfilled than heretofore, that many have set their hearts on improving the administrative machinery. It is true that increased activity will inevitably involve increased outlay, and the question of ways and means will have to be carefully gone into, but with an actual annual surplus of over £1,200, and investments without any earmark amounting to a total of nearly £5,000, there is already a satisfactory fund to draw upon.

Let us consider seriatim the items enumerated in Clause B of the Memorandum of Association. The Institution certainly holds many meetings; but there is a very decided opinion abroad that it does not secure the Papers it should, an opinion not likely to be altered by the Papers presented since November last. A clearer conception on the part of those whose duty it is to glean Papers as to what questions are the "live" questions of the day would tend to improve this state of things, and a little more generosity in the matter of preparing diagrams, a somewhat more lavish outlay on premiums, and a greater energy in securing the attendance of competent speakers would not be amiss. The Royal Meteorological Society in England, and the Société Française de Physique in France, and many other societies at home and abroad, make a great feature of their exhibitions of apparatus; electrical science as in England has as yet not, we are thankful to say, reached the stationary state, and it is permissible to think that such exhibitions held in a suitable manner, in a suitable place, and at a suitable time would be much appreciated. Again, when the Institution has at last succeeded in housing itself, is it too much to expect that an institution laboratory may be founded, in which experiments and tests such as the Institution of Mechanical Engineers, the Iron and Steel Institute and the Society of Arts promote, may be carried out to the benefit of the industry at large? A system of local meetings held simultaneously with those in the metropolis, a system which is in vogue in America, is another departure worthy of a little consideration; it would assist to strengthen the connection between the Institution and its provincial supporters. There is nothing revolutionary, nor indeed particularly original, about any of the suggestions we have thrown out; they have one and all been tried and found—useful. But an institution, to justify its existence, should perform at least one function better than or different, to that performed by any other similar society. What is to be the distinguishing feature of the Institution of Electrical Engineers?

TELEPHONE EXCHANGES AND THEIR WORKING.

The following is an abstract of the discussion on Mr. Dane Sinclair's Paper, which took place at the Institution of Electrical Engineers on Thursday evening last week. Speakers who have returned their proofs are denoted by an asterisk:—

*Mr. J. E. KINGSBURY said Mr. Sinclair brought forward two rather important suggestions with the view of improving the telephone service and to some extent reducing its cost. It was open to some of them to feel that there were other ways of attaining those results, and they might even go so far as to remark that by Mr. Sinclair's methods the results he aimed at were not attained. In the first place he would refer to the call-wire system. Of course the call-wire system was by no means a novelty. It was described in that room by Sir Frederick Bramwell on March 1, 1883, when he said "The Law system seemed to me to work extremely well when I saw it in operation in Philadelphia"; and that opinion was an opinion that was held by a great many others at that day. He did not think he

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had ever come across an advocate of the Law system, which was practically the call-wire system, who had not consistently held that it developed the service. But they had to consider that some experience had been gained between 1883 and 1896, and it had happened that that system which Sir Frederick Bramwell saw at work in Philadelphia was now in process of being discarded. In October, 1883, Mr. T. D. Lockwood was attending a convention in St. Louis. The Law system was under discussion then. Mr. Lockwood said? "About a couple of months ago I was in St. Louis, where the Law system has been in operation for some years. St. Louis, although a city of very large population, has a very small telephonic population. Whether there is any connection between the two things, the Law system and the sparsity of the telephonic subscribers, I am not prepared to say." In looking up that extract a suggestion occurred to him (Mr. Kingsbury) which he followed up. He looked up the English records, and there were some very full records in the Parliamentary Committee's report. Perhaps he expected to find that the English towns were also sparsely populated telephonically, but he found that it was not so. The few towns using the Law system stood at present very well on the list of those towns that had a fair number of telephone subscribers. But he found one set of records in this Committee's report—a statement showing the number of subscribers in the four large Scotch towns during the last five years. Of these towns Dundee and Aberdeen had been using the Law system during that period; one of the towns (Edinburgh) had been using the indicator system, and another, Glasgow, had been using both during the period. Now, the number of subscribers in Aberdeen during the last five years had increased 82 per cent., Dundee had increased 57 per cent., and Edinburgh 140 per cent. Four towns were not, of course, sufficient to afford a conclusive basis of comparison. Still there was the fact. In Glasgow, since the Law system was introduced the proportion of increase had considerably fallen off; but there again the time was not long enough to enable them to judge fairly. In Philadelphia the Law system was now in process of being discarded, and in St. Louis also it was going to be discarded. These were points peculiarly adapted to consideration on the subject of this Paper. Another thing he looked at from the statistical point of view was to find the extent to which subscribers used their telephones on various systems. He found that Glasgow had 6½ calls per day per subscriber, about half the number in Liverpool. That was another point they had to consider, if the Law system was considered useful to subscribers they must consider how much they used it. It appeared that on all the exchanges using the Law system the subscribers did not use the telephone to the same extent they did on the indicator system. Mr. Sinclair referred to the difficulty in connecting between exchanges, of making trunk calls. He supposed the thick and thin advocates of the Law system would say that difficulty did not exist. But they knew that it did, and its existence seemed to him rather a reason for not pursuing the Law system. If they were to indulge in any ideals at all they ought to have an ideal that the communication between towns in the sweet by-and-by would be as easy as the communication between streets of one town now, and if a system involved any difficulty in this direction it seemed to him something of a reason for not pursuing that system. Mr. Sinclair said that 95 per cent. of the subscribers appealed to in a certain exchange preferred the call-wire system to the indicator system previously in use. The weak point about that was that they had not the whole of the material before them to enable them to make up their minds. The question was, what was the indicator system previously in use? When they had that information they could estimate the value of the subscribers' opinions. Personally he attached more value to the opinion of Mr. Sinclair, as that of an engineer; the opinions of the subscribers was rather a weak argument. Subscribers ought to be treated rather as children; they did not know what was good for them. The next important point in Mr. Sinclair's Paper was the question of flat boards. In regard to flat boards Mr. Sinclair remarked somewhere in his Paper that they had been in use previously, and as they were not used for saving spring-jacks it was difficult to see what they were installed for, excepting that they were more easy to operate. That was rather begging the question. He thought it was possible to find another reason for making flat boards without suggesting that they were easier to operate. Flat boards were originally introduced on the Law system before the introduction of the multiple switchboard. At that time it was necessary to have inter-communication by what was called "cross connections" between one set of subscribers and another. Now if they could have a number of plugs along the middle of the table and operators on each side, they could reduce the number of cross connections. That was at first the advantage of the flat board. Subsequently when the Law system was extended so as to use the multiple switchboard, the jacks were reduced to microscopic size, more or less like honeycomb, and the operators were given the whole of the jacks in the exchange. If that pointed to anything it pointed to the difficulty of one operator passing another on the flat board. He would like to point out that the comparisons on paper of the upright board with the flat board had one disadvantage; they assumed one might take anything from the upright position and place it in a flat position and have similar conditions. They had only to consider what would be the difference to them if the diagrams before them were taken down from the wall and placed on the table; they certainly would not be able to see them so well. If they applied the same argument to the blackboard they would be getting very near the conditions with switchboards. If anyone would try to cover that blackboard, lying flat on the table, with chalk marks they would find it impossible. He therefore wanted them to see that the different comparisons of this Paper were not founded on fact, but were based on a wrong assumption, and he would remark that the controlling factor in this matter was not electricity at all, it was simply anatomy. If they would regard the hand as the extremity of a lever of which the shoulder was the fulcrum, they would see that the hand could describe a complete circle moving in a vertical direction, and in a horizontal direction only a semi-circle. The result was the multiple switchboard upright had double the capacity of the multiple switchboard on the flat. That was the governing factor of the whole business. It would be found also that in the upright position they had a maximum of easy work, whilst on the flat they had a maximum of difficult work. The upright board was easy to work, but the flat was difficult, and that resulted in an increased cost of working, and when they got to increased cost of working they got to the crux of the matter. They might save in the cost of construction, but only at the expense of increased cost of working. There were two points which Mr. Sinclair referred to as the most important which induced him to adopt the flat board. One was the small number of jacks and joints, and consequently the fewer faults. He was afraid Mr. Sinclair had in view an obsolete type. With the multiple form of break-jacks (Fig. 5 in the Paper *see* p. 83 of last issue), it was a distinct advantage to reduce the jacks; but that was a reason for not using that apparatus at all. But when they came to the branching system they had a condition of things in which they might multiply their jacks indefinitely, and not incur any real trouble in regard to speaking results. The next point was the possible difficulty in finding room for upright boards and the advantage of putting them on the flat, because they practically only took half the floor space required for upright boards. Well, that applied generally. If they took a multiple switchboard under ordinary conditions, with access to the back of the board, they would have a board running on three or four sides of the room. If they had a multiple switchboard on the flat they would have two operating surfaces for the switchboard. But in no case did they double the capacity of their room. If they really wanted to get a large number of switchboards into the room they must use the upright board! Take Figs. 6 or 8. In Fig. 6 they would see the cable racks went down somewhat deeply in the board. As a matter of fact in Fig. 6 the cable racks were less than one-half the distance across the board, 40in. across and 17in. down. Put that up on edge and another similar board at the back of it, and they would get two rows for less ground space occupied. The difficulties of detail in working the multiple switchboard when installed on the flat were such that it was not necessary to go into them. But there was one question he might go into, the question of an operator on one side having to read in English fashion from left to right, while on the other side the operator would have to read in Arabic fashion from right to left. Repairs were difficult and additions expensive. Then to come more to the practical question of the cost, the comparisons in the Paper were made entirely on what he might call old types. It was the question of an operator attending to 50 subscribers. The first multiple board introduced in England had one operator to 50 subscribers. Now they had boards made for 450 subscribers on the upright worked by three operators. That board was the Western Electric branching board and was established in Christiania. Boards of 360 were quite common on the branching system; that gave 120 subscribers to one operator. This arose from the facility of working, and that really was the crux of the question. They must reduce their operating expenses, taking care, of course, that the apparatus was maintained in the highest state of efficiency. They did it by using upright boards, by making them fast, by giving as many facilities as they could to the operator and reducing their whole expenses. The difference was merely a question of saving the first cost or saving the working expenses.

*Mr. BINSWANGER said he had his doubts, like many others, as to how the public would take to the call system, but from experience, he could endorse everything Mr. Sinclair had said upon the subject. He had had occasion in Manchester of using the call system and the annunciator system side by side; his own experience, and that of most subscribers whom he had consulted, was that the call system was preferable. People felt that they were in more direct communication with the exchange and with the subscribers. They got a much quicker service, but then time was the principal thing. This system also showed that subscribers would not mind doing more work, and the question of putting more work upon the subscriber led to the question whether they could not put still more work into the hands of the subscriber and thereby reduce work at the exchange and make it more automatic. He had heard lately a great deal of automatic exchange systems both in England and America, and understood that one was actually in operation in America, having 200 subscribers. Mr. Sinclair, in his paper, referred several times to American work and American invention. No doubt most of the apparatus and appliances which were used in telephone exchanges had come to us from America. This fact might give the impression to outsiders that American telephone engineers were more ingenious and more enterprising than ours in England, but the true explanation of this fact was that the early proprietors of the telephone patents had killed the industry in England in its early days. They ought therefore to be thankful to Mr. Sinclair for emancipating himself from old practice, and thus only could English manufacturers hope to regain the loss they have had in England as well as abroad.

*Mr. W. H. PREECE said that it was the first occasion on which any representative of the National Telephone Company had had the boldness to come before the Institution and to tell them what the Company was doing. Mr. Binswanger spoke rather strongly of the mode in which the industry in this country had been killed by the early promoters of this particular business. He did not think there was anybody who had ever spoken in severer terms of the management of the National Telephone Company than he (the speaker) had done in that very hall. Its management in the past was unquestionably execrable; but he was happy to say that a complete change had come over the spirit of their dreams in Cannon-row, and now they found this Company, so obnoxious in the past, actually doing all it possibly could to repair the evil that had been done, and they were now working with an energy and a spirit that would, in the course of a few years, bring the telephone industry into a position that would make it compare favourably with that of any land, not leaving out America. He gathered from Mr. Sinclair's Paper that his Company was taking the cream of what was being done elsewhere. In the first place they were

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introducing metallic circuits. He had said over and over again that the telephone without a metallic circuit was an imperfect and incomplete apparatus. Again, they were introducing multiple boards. But he disagreed in regard to these with Mr. Sinclair, for his opinion was that the day of the multiple board for large exchanges was over—he would not say it was quite over, but the multiple board was doomed. The experience in America was that as an exchange grew, so did the difficulties of the multiple board. The experience in America, in Sweden, and in Berlin seemed to be that when they got to 5,000 subscribers the difficulties were so enormous that they must be met in some other way. In the States and in Berlin they were being met by decentralisation; in Chicago particularly, the system Mr. Sinclair had referred to, called the divided board system, had been inaugurated, but in San Francisco there was another system, called the "Express" system, which was also being introduced in Chicago and one or two other places. Up to the present moment the reports received were satisfactory, and it would seem that sooner or later the multiple board in all big exchanges must give place to the "Express" system. Mr. Sinclair in his Paper had spoken a good deal on the question of trunk work and its difficulties. On that point he was not prepared that night to speak. They had only within the last week or two transferred to the Post Office from the Telephone Company the whole trunk system of this country, and it would take some months before it would be thoroughly licked into shape. He hoped by the commencement of the next session they would have in this country the finest telephone trunk system in the world, and he also hoped that the session would be commenced with a Paper written by Mr. Gavey describing that trunk system and how it was being worked. Mr. Kingsbury had criticised a great deal the observations that Mr. Sinclair had made on the call-wire system, or what he called the Law system. The latter system, worked on a large scale, had its difficulties, and he entirely objected to it for the simple reason that it was absolutely unnecessary and not wanted at all. In fact he could not understand, with the experience they had had, the want of any call system or any mode of calling attention whether by the magneto or by the Law system. In the Post Office they never had such a system. Their call was automatic. A man when he went to his telephone and lifted it off the switch hook, called the exchange system, and when he had finished his talk and replaced his telephone on the handle again, there was a ring off. Both the call and the ring off were absolutely automatic. It had only one objection, and that was a very strong objection with those who had not tried it—it was not an objection to those who had tried it—and that was that it involved the use of a continuous current. The idea of having a battery running continuously on a subscriber's line was like a red rag to a bull to an old telephone man. But to a new telephone man and to the Post Office it had no terrors at all. Mr. Kingsbury had also criticised Mr. Sinclair's views on flat boards versus vertical boards. He (the speaker) had an objection to flat boards. There was a certain amount of fascination in the appearance of a flat board; it was certainly attractive, and there was something about it that was enticing. But his objection to it was purely a practical one, and that was the difficulty that an engineer had in removing faults while the operators were at work, and the difficulty of making any changes behind the board. With a panel or a vertical board there was absolutely no difficulty. The operators proceeded in the ordinary way, and the engineer went behind, examined his contacts and his springs, and he could alter and change and shift, without anybody in front having the least idea there was anybody behind. There was one other point that he wished to urge, and it was this, that they might make their apparatus as perfect as the apparatus described by Mr. Sinclair and the apparatus he had seen in use in Sweden and in Berlin. They might have adept operators, but unless they had subscribers who were equally clever in the manipulation of their apparatus, and unless they had subscribers who took an interest in the telephone work of their offices, and unless they had subscribers who would co-operate with the telephone company or the Post Office department, or whatever it might be that did the work; until they got mutual forbearance, mutual assistance and support from each side, they would never create satisfactory telephone working in this country. He could say without the slightest hesitation that there was no place that he had ever visited where the telephone work was better done than it was in Berlin, and they had it well done there on a system that was technically defective. It was a system consisting of a single wire—it was a system where they used practically obsolete apparatus. The reason was this, there was absolute co-operation between subscriber and operator, and half the work was done by the subscriber.

Mr. G. L. ADDENBROOKE said he himself was connected with the telephone company from 1883 to the end of 1886, nearly four years, and during that time he thought the telephone company might be said to have got into shape. He had always felt, speaking commercially as a user of telephones, that an extremely rapid service was of far less moment to commercial men than thoroughly good speaking. The question of whether they had to wait five minutes, or ten minutes or a quarter of an hour was nothing to the necessity of being able to speak thoroughly well. There certainly was a great improvement in the London work through the adoption of the double-wire circuit, but it was lamentably behind the service in the country, and in the country the telephone was of less importance. As regards co-operation of subscribers, that was no doubt a very technical matter, and he could appreciate the position the Company took up. He thought Mr. Sinclair had hardly done justice to previous work in the few remarks at the latter end of his Paper. Mr. Sinclair said he had found it necessary to have a central trunk service for London. Of course that was literally true, but he thought not quite in the manner people would gather from the Paper. The trunk service was established about 10 or 11 years ago. Towards the end of 1883 or the beginning of 1884 the question of trunk communication began seriously to crop up owing to the difficulty of getting through to other exchanges, particularly to some of the Eastern exchanges and those in the City. The matter was debated for some time and a meeting was held at the Euston Hotel Mr. Morgan was the Managing Director at that time. He (the speaker) did not know how he got to that meeting, but he was there although he took a very small part in the discussion. Practically at that meeting the trunk system was decided on, and it was put into practice in a few months. Their board was designed by Mr. Hawes, and the London exchange system was really put down on a basis which had gone on ever since. Therefore it was only fair that some credit should be given to those who really did initiate that service.

Mr. F. B. O. HAWES said he was himself no longer connected with telephony, but he had always felt that there was a great dearth of papers of this kind. He hoped they would have many more of them. There were one or two points regarding which he would like a little more information than Mr. Sinclair had given. In London at the present time call wires were used between the exchanges for working trunks or junction wires, and he thought it would be useful if Mr. Sinclair would tell them what proportion of trunks they worked in that way. That was to say, how many junction wires one call wire served. Another point about which he would like to hear was as to the motors used in the exchanges; the generators for the ringing currents were, he believed, driven by small motors, and it would be interesting to learn what motors were found most serviceable. As to flat boards he did not agree with the points Mr. Sinclair had urged in their favour. The United Telephone Company were the first in England to use multiple switchboards. They were designed by the speaker, and were intended to be used in an upright position, but at Mr. Clay's suggestion they were used lying down, and the reason for that Mr. Sinclair said he did not quite understand. In those days they had no experience of how many subscribers one operator could attend to on a multiple board, and they had thought they had better err on the right side, and so provided one operator for each 50 subscribers, by fixing the boards lying down. This, as it turned out, proved to be more operators than was required, and they would have worked much better standing up. Having been designed for use upright, several of the contacts were affected by dust, and there was some trouble from that cause. Still, at the same time, the disadvantages of the flat board were not fairly shown in that case. They also had trouble about repairs, and he could not see how any flat board got over that trouble. A system had to be constantly worked now, and therefore if they had to do any repairs it must be while the switchboard was at work. Coming to the question of fitting up the boards, when a board was started with a certain capacity new jacks would have to be added from time to time when enlarging the exchange, and the addition of those jacks while the boards were in use was a tremendous piece of work. With the flat board it was almost impossible to get openly at this work and to see what one was doing satisfactorily. The difficulties, he should say, were enormous. Dealing with the size of the board, and taking Mr. Sinclair's figures, it appears that a switchboard on the flat system for 6,000 subscribers would be one yard square. Now, if they took a table a yard square, and tried to sit on one side and reach over to the opposite corners, they would find it almost, if not quite, impossible. They would have to stand up to the work, and if an operator had to keep on jumping out of her chair for a large proportion of calls it would not help to expedite matters. Another matter he would like Mr. Sinclair to tell them about from his experience was as to the cords getting entangled as they came down on the board. It was certainly the case with the board of which he had had experience. It appeared to him that in pulling out one cord they would be very liable to pull out another with it. Mr. Kingsbury referred to the dirt getting in to the flat boards, and he (the speaker) thought it was a serious matter. He would go further than Mr. Kingsbury went, and would say that whatever sort of multiple board was used the dirt would cause leakage from line to line; they would get the same amount of cross talk from line to line through dirt, whether it was the one-series system or the arc system. He thought a little more might have been said about the "Up" and "Down" trunk wires with advantage. At first sight, with junction wires between two exchanges, it would appear to be most economical to use them irrespective of what class of calls was put on, whether from B to A or from A to B; but when they considered the matter further, and looked into the details of the work, it was very evident there was a great benefit in dividing up the trunks. He fought very hard for that in the old days, and at last got it done. The advantage was that, although they were not using them quite as economically in one respect, they could use them much quicker, and so get more work out of them. Talking about working quickly, Mr. Addenbrooke's remarks about time not mattering must be received with some caution. As Mr. Addenbrooke had also remarked, the central junction exchange was a very old idea indeed in London, and it was an idea which very many people he knew claimed as entirely their own. Mr. Preece had referred to the "Express" system in Chicago. In London they had something approaching the "Express" system. The National Telephone Company had a system which connected stockbrokers together, and that system he had always heard was a perfect one. It was held up very often as being an example of an ideal exchange. That exchange he believed was worked by a very ancient apparatus discarded from other exchanges, and it was merely due to the fact that there were no junction wires, and only a small number of subscribers that the service was so extremely rapid. Then there was the question of the subscriber doing the work of ringing up himself, as Mr. Preece had described was the case in Berlin. When a subscriber had a lot of work to do himself, he did not notice the time that elapsed so much as if the operator did it, but the speaker thought the latter was the most rapid. But there was this disadvantage about that, that supposing the connection was made, the subscriber might go on ringing until he was black in the face without result.

Mr. G. J. SOMERVILLE said Mr. Sinclair had mentioned as a weak feature in the American divided board that no connection was made without being dealt with by two operators. It was certainly a very weak feature of any board at which one operator could not complete any connec-

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tion asked for. This difficulty was not altogether absent, however, from the multiple boards used generally in this country. They were informed that the length of each section on these boards was 6ft. 6in. It therefore followed with the upright boards that an operator was expected to stretch a distance of 3ft. 3in. from the point opposite which she sat, and that ought to be done without any inconvenience to her neighbours or interrupting their work. She might be able to accomplish it if she had plenty of room, but they had to remember that there were four operators sitting in front of each section, so that the space allotted to each was only 19½in. In the case of flat boards the matter was even worse. They had been told the width of the board was 40in. To make some connections an operator therefore was called on to insert a plug in a jack which, being on the opposite side of the board, was not less than 4ft. distant from where she sat. Taking into account that there were eight operators working at the same section, and that a plug and cord had to be passed between the other cords in use at the time, he thought they would agree that the operation was nearly impossible. In practice the operator did not attempt it, but asked for and received assistance in making nearly 25 per cent. of the connections required, so that the weak feature mentioned was not by any means absent from the switchboards in use in the National Telephone Company's service. Reference has also been made to the listening keys. These are used to connect the operator's telephone to the subscriber's wire. Of course some means are necessary for this purpose, but those now universally used by the National Telephone Company are not good, as they were responsible for introducing into the system a very grave defect. With this key the operator had the opportunity of overhearing any conversation which was carried on by the subscriber for whom she had made the connection, or in fact any conversation passing through the exchange. It was useless to say that it was never used for that purpose; it could be so used at all times, and is thus the source of one of the very worst defects which can exist in any telephone system, viz., the absence of secrecy. It was also to this key, as at present used, that subscribers were indebted for the annoying interruptions and continual questions by the operator "Have you finished?" He was very much pleased to hear Mr. Sinclair assert that he was an advocate of the use of flat boards and the call-wire system; although, judging from the results, he should imagine that until quite recently his advocacy must have been of a very mild type. It is the Mann system that is being introduced into the National Exchange in Manchester, and from the way Mr. Sinclair now praises this system, doubtless he will by-and-bye advocate its use even in London. His objection to its being introduced here is without foundation. The real difficulty is in connection with the static capacity of the signal wires, but that can be overcome, and t' ere is no reason for the operator at King's Cross, when desiring to communicate with Lime-street, doing either of the two things he says are inevitable, viz., to cut herself off from her own call-wire, or to join her call-wire with its 50 subscribers to the call-wire to the city.

*Mr. DANE SINCLAIR, in his reply, said Mr. Kingsbury condemned the call-wire system. If he took his experience of it from the Law system he (the speaker) did not wonder at it. When he (the speaker) first joined the telephone service in Glasgow the Law system was then at work, with 200 or 300 subscribers, and was so unsatisfactory that after eight months it was turned out. But in this, as in all other things, there had been developments. There came along the Mann system. This made a deal of difference. The difference was that with the Law system, as first used, every subscriber had the power of breaking into the circuit and cutting off all the subscribers on the other side of him. That and the make-and-break in his apparatus more than counter-balanced the advantages. When they came to the other call-wire system the subscriber could no longer break in, but had to wait his proper turn, which made all the difference. In a great centre of the size of Glasgow it was necessary to go into it fully, and he could tell them that at a meeting of experts called from all parts of the country it was laid down that where they had an exchange with no junction wires, then—although a great many of them were opponents of the call-wire *per se*—under that condition the call-wire did give the most absolutely perfect service. Therefore, when they had an exchange with a large proportion of local work they got the advantages without the disadvantages. Coming to Mr. Kingsbury's remarks with regard to the flat board, there was really no time to go into the matter deeply. But in the days when this point was discussed a table was placed on edge, and those present were set to see whether they could reach higher stretching upwards or further when the thing was flat in front of them. It was found that they could reach further on the flat to the right hand and the left, but could not reach quite so far in front as when the thing was in a vertical position. He was standing by listening, and he came to the conclusion that there was so little difference between the two that it was absolutely academic to try and score a point one way or the other. Then Mr. Kingsbury gave many another reason why the flat was not so good as the upright, and stated that there were various difficulties. He (the speaker) supposed there were difficulties; but he had yet to live to see the switchboard with no difficulties. Therefore it came to a choice of difficulties. One speaker had said that it was a serious matter to increase the number of jacks on the flat board, because it would have to be done when it was at work. His reply was that it was not necessary to do this when at work. The few hours when they were not at work in the evening was quite sufficient. When it came to the question of the flat board in use to-day, and the upright board in use to-day, he could say conscientiously that it was a more simple matter to lift a row of jacks out of their place on the flat than to get them out of their place on the upright; but there was not very much in it. He was not going to discuss the point referred to later by Mr. Preece, the difficulty for a man to get down amongst the wires to work. It was difficult, but it was not impossible, because they were carrying this thing out in practice. Mr. Kingsbury had referred to the fact that there were fewer calls at Glasgow with the call and flat board than at Manchester. It happened that the figures were taken on the holiday season in Glasgow, and that accounted for the fact that the Glasgow figures were so low. They all knew that Mr. Preece had advocated, and rightly so, a metallic circuit from the beginning of telephony, and great credit was due to him in that he was so early a champion of a good cause. But it must be remembered that there was the commercial element to consider as well as the engineering. When Mr. Preece spoke of Berlin he quoted the very reason why he (the speaker) liked the call wire; it threw the responsibility of actual work from off the hands of the operator into the hands of each individual subscriber, but with this difference, that if the subscriber who was called up at the other end did not respond the subscriber calling got an instantaneous reply from the exchange as to what the reason was. He was assured that he had been connected on; and that was, perhaps, the greatest reason for the success of the call-wire as compared with the battery system. When the signal was given to the exchange, they wanted an absolute certainty that when they did something they would get something. With the ringing system they might call and the indicator might drop, but the operator was going to answer when she was ready. He did not mean for a moment to suggest that the operators did not answer as quickly as possible, but as between the two systems, in the one case the subscriber commanded the situation, and in the other—well, he did not. With regard to the central trunk exchange idea, it was after a little time, like many another good system, carried too far, and in practice they had to undo a great deal of it. They found, taking two small exchanges in the suburbs of London, that the wires must run into some central point, where they would command the ability of being joined on with other exchanges. But taking any big city with 20,000 calls per day between two exchanges, could anyone explain what was gained by putting all those calls through a third point or exchange? When it was looked into it was found that only one central exchange was required for the *overflow* work between the great exchanges and for branch exchanges; that was the system that was being worked out in London to-day. As he had said in the Paper, any exchange which had 40 messages from or to any other exchange was provided with direct junction wires, but if the messages were fewer than that they went through the central exchange.

OBSERVATIONS ON ISOLATED NERVE.*

BY AUGUSTUS D. WALLER, M.D., F.R.S.

The present investigation arises from experiments undertaken to determine autographically the varying relations between the magnitude of electrical change and the magnitude of stimulation in nerve under various chemical conditions.†

The main principle upon which the inquiry is based is the proposition established (by Du Bois-Reymond, and by Hermann in particular) to the effect that disturbed protoplasm is electro-negative to the normal. An accessory principle, to which reference will also be made, is that upheld (by Hering in particular) to the effect that protoplasm in which disturbance has just ceased is electro-positive to the normal. In accordance with the first principle, injured is electro-negative to normal protoplasm, and excited is electro-negative to resting protoplasm. In accordance with the second principle, recently excited is electro-positive to normal protoplasm.

Nerve (the excised and still living nerve of the frog) is, for the purpose of this inquiry, considered as a convenient strand of excitable yet hardly exhaustable protoplasm, giving off to the galvanometer a demarcation or injury current (Hermann) from a less disturbed portion (longitudinal surface L) to a more disturbed portion (transverse section T), which current, during disturbance of the whole nerve effected by weak tetanisation at the two exciting electrodes, but principally affecting a less disturbed portion L, undergoes a negative variation (Du Bois-Reymond), the magnitude of which is taken as the index to the magnitude of chemico-physical change aroused in the nerve under various chemical conditions.

Care is observed to avoid the ordinary fallacies and to obtain a "negative variation" as far as possible clear of electrotonic effects. Action-currents (significant physiological effects in nerve) are distinguished from physical effects by means of anæsthetics, CO_2, Et_2O, $CHCl_3$. ‡

The physiological state of the nerve is tested by tetanising currents of low and uniform intensity, of uniform duration (7½sec., and later 15sec.), at uniform intervals (1min.), in both directions. The series of negative variations or action currents led off to the galvanometer, gives a corresponding series of deflections, which are registered on a slowly-descending photographic plate.

The plan of procedure adopted throughout has been to take for a period a normal series of deflections, then to submit the nerve to the action of a reagent (without removal from the electrodes in the case of gases, but with such removal in the case of solutions), finally to take for a further period the series of increasing or decreasing or reversed deflections of the chemically-modified nerve. Alterations of resistance were controlled by aid of a standard

* Abstract of the Croonian Lecture to the Royal Society, 1896.

† Physiol. Soc. *Proc.*, June, 1895.

‡ Physiol. Soc. *Proc.*, February, 1896.

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deflection of 0 001 volt let into the nerve and galvanometer circuit at beginning and end of experiment.

The results so far acquired may be considered under the following heads:—(1) The effects of anæsthetics and of some gases. (2) The effects of several chemical substances in solution. (3) The effect of carbon dioxide. (4) Theoretical considerations.

(1) *Anæsthetic vapours* were employed at the outset of these observations with a view of distinguishing between physiological and physical effects.

(2) *Action of Reagent Soluble in Normal Saline.*—The nerve is bathed for one minute in more or less dilute solutions (acids, alkalis, neutral salts) and replaced upon the electrodes. Distilled water gradually abolishes excitability. Dilute acid solutions, M/40 to M/10, cause primary augmentation, followed by gradual diminution. Stronger acid solutions, M/10 to M/5, cause primary diminution and abolition.

Alkalis.—Caustic potash is far more active than caustic soda. Potassium salts are more active than sodium salts.

Neutral Salts.—The influence of the base predominates in a total action due to the entire molecule. Calcium chloride in M/10 solution augments the electrical response, and antagonises potassium chloride, which diminishes or abolishes it. Mercuric chloride is the most lethal of any salts hitherto tested; its M/100 solution abolishes the response. Isomeric compounds differ in efficacy.

ON THE BEHAVIOUR OF ARGON AND HELIUM WHEN SUBMITTED TO THE ELECTRIC DISCHARGE.*

BY J. N. COLLIE, PH.D., F.R.S.E., AND WILLIAM RAMSAY, PH.D., F.R.S.

The experiments to be described fall into two classes; the first series relates to the distance through which electric sparks from an induction coil will strike through argon and through helium at atmospheric pressure, contrasted with the length of the spark-gap in other gases; and also with the pressures at which the spark-discharge changes into a ribbon-like discharge in different gases. The second series, which was made with the object of ascertaining how much of one gas is detectable in its mixture with another, at different pressures, deals with the spectra of gases in electrodeless vacuum tubes. As both sets of phenomena relate to the passing of electric discharge through gases, we have thought it well to consider them together.

The attention of one of the authors was drawn to the spark-gap, as a possible means of obtaining information regarding the atomicity of argon and helium, by Mr. Natterer, who was kind enough to send copies of his Paper on the subject†. Natterer's conclusion, drawn from a great many experiments, was that the spark-gap at atmospheric pressure varied in length inversely as the atomicity of the gas; thus, in mercury gas, which is acknowledgedly monatomic, the distance traversed by a spark from electrodes of approximately constant potential, was very much greater than in diatomic gases, such as oxygen, hydrogen, nitrogen, or carbon monoxide; and in these, greater than in gases of more complex molecular structure. Our experiments show that while with argon the distance traversed by the spark is considerably greater than with air, oxygen, or hydrogen, with helium the spark is capable of passing through most unusual distances.

To carry out such experiments the tube must contain movable electrodes; and yet, in order to avoid contamination of the gases, they must have sealed joints. Closing with india-rubber corks appeared to work well in Natterer's experiments; but then he had large quantities of common gases at his disposal. In our experiments this was, unfortunately, not the case. The current was an intermittent one from one of Apps' large induction coils, driven by a storage cell giving about 8 volts. The hammer of the coil was not altered in position during the experiments.

It was found impossible to make measurements of the extreme possible length of a spark. After the coil had been running for some time an isolated spark generally passed, even when the electrodes were far apart. But consistent measurements could be obtained when a rapid discharge began to occur on bringing the electrodes together. It was found possible to obtain constant readings of distance to within half a millimetre, and to form an accurate estimate of the intensity of the rain of sparks, as contrasted with intermittent discharges.

The mean results are as follow:—

Oxygen	23·0mm.
Air	33·0 ,,
Hydrogen	39·0 ,,
Argon	45·5 ,,
Helium	probably 250 or 300mm.

* Abstract of a Paper read before the Royal Society.

† *Wied. Ann.*, 1889, p. 663

The tube was not long enough to obtain measurements with helium. But another tube with permanent electrodes, distant from each other 200mm., gives, not sparks, but a ribbon of flame, due apparently to the luminosity of the first spark remaining until the second has begun its journey. This band is of a blue colour, and and does not show the yellow D_3 line very brightly. The other helium lines are much more brilliant. Indeed, the D_3 line is not a marked feature of the helium spectrum at high pressure, with an unaided Ruhmkorff coil discharge.

It will, we think, be acknowledged that the length of spark in helium is a very remarkable phenomenon. To what is it to be attributed? Any attempt to answer this question must necessarily, in our ignorance of what takes place during passage of discharge through gases, be of a speculative character. And inasmuch as it is probably connected with other properties of helium, we shall postpone our attempt at an explanation until our further experiments have been described.

After these experiments had been made it was discovered that the spark discharge changes to a ribbon discharge at some definite pressure with all gases. The discovery was an accidental one. We wished to repeat the experiments on the helium ribbon, and the tube was filled with the first sample of helium that came to hand; it had been prepared from bröggerite, and had received some contamination from air and nitrogen. To our surprise we failed to obtain a ribbon discharge at ordinary atmospheric pressure; only a rain of sparks could be seen, and it was not until the pressure had been lowered by several hundred millimetres that the discharge became ribbon-like. This observation led to experiments, of which the results are summed up in the following table.

Gas.	Pressure of changes of character of discharge.
Air	73 or 74mm.
Hydrogen	42 or 43 ,,
Oxygen	81 ,,
Carbon dioxide	92 or 94 ,,
Cyanogen	23 ,,
Nitrogen	33 ,,
Carbon monoxide	49 ,,
Helium	1,270 ,,

These phenomena are, without doubt, very complex; but one fact is unmistakeable: that helium presents a behaviour very different from that of all other gases. In short, a tube like those termed "Plücker's tubes" need not be filled with helium at a low pressure, but shows all the phenomena of a vacuum-tube at ordinary atmospheric pressure. The order of arrangement of the other gases, moreover, is not the same as that which obtains with the shower of sparks passing through the gas. This may be due to some molecular change due to lowering of pressure; but such a supposition is of a purely speculative character.

Our next series of experiments relate to the visibility of the spectrum of one gas in presence of another. The gases employed were hydrogen, oxygen, nitrogen (atmospheric), argon and helium; our primary object was a practical one—to ascertain whether the spectrum affords an adequate test of the purity of the gases. For example, if the spectrum of nitrogen is no longer visible in a mixture of argon and possibly nitrogen, can it be assumed that nitrogen is wholly absent? How much must the percentage of nitrogen in such a mixture be reduced before the spectrum disappears?

Broadly stated, these experiments show that while relatively large amounts of helium and argon require to be present in hydrogen and nitrogen before their spectra become visible, an exceedingly minute amount of hydrogen or nitrogen is visible in helium or argon; and that a rise of pressure increases the visibility of nitrogen, both in helium and argon. Also that a large proportion of helium must be added to argon to become visible; while a minute trace of argon is visible in helium. And combining these results with those relating to the *spark-gap* or to the continuous discharge, it would appear that at atmospheric pressure, a discharge passes much more readily through helium than through the other gases, while at very low pressures, if conveyance of current can be inferred from luminosity of spectrum, the current passes more readily through all other gases than through helium; and that a current is conveyed more readily by nitrogen than by argon.

In the present state of our ignorance on what occasions the passage of current through gases, it is perhaps premature to speculate. But accepting the hypothesis which appears to be gaining ground, namely, that a species of electrolysis takes place during the passage—a tentative explanation may be put forward. It may be supposed, as Dr. Lang has pointed out,* that a gas, such as hydrogen, at atmospheric pressure, is partially, but very slightly, ionised, or perhaps better, polarised; if that expression refers to atoms capable of receiving and transmitting an electrical charge.

Now, the conveyance of the current is conditioned by at least two circumstances—first, by the number of such atoms per unit

* "Dielectricitätsconstante," *Wied. Ann.*, 56, p. 543.

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volume; and second, on their relative velocity, which may be taken as proportional to the square root of the density of the gas. Hence, it might be inferred that if only few atoms are present, great resistance will be offered—first, because of their fewness; second, because of the frictional resistance offered by the molecules of gas, as distinct from the atoms. It is not so easy to understand why a high electromotive force is required to overcome this resistance, unless it be supposed that the atoms capable of conveying charges neutralise each other by combination before the charge can be transmitted from one electrode to the other. Waiving this difficulty for the present, the hypothesis agrees with the known fact, that decrease of pressure promotes dissociation, where the number of ions or molecules produced by dissociation is greater than the original number of undissociated molecules; and with increased dissociation there should be, as there appears to be, decreased resistance in the case of diatomic gases, such as hydrogen, oxygen, and nitrogen.

In considering gases, presumably monatomic, such as argon and helium, we see that the former offers considerably less resistance to the discharges at atmospheric pressure than the diatomic gases; and the latter very much less. These peculiarities may be due to their monatomic character, and the great difference between the length of the spark-gap in argon and in helium may be dependent on their difference of densities, and be connected with the length of the mean free path of their molecules. When pressure is lowered these gases appear to conduct less well than the diatomic gases; and it may be that their molecular constitution is less affected, if affected at all, by diminution of pressure.

The behaviour of mixtures of argon and helium at low pressures is somewhat inscrutable. Why should argon convey current almost to the exclusion of helium if, indeed, visibility of its spectrum be taken as an indication of conductivity? In this respect argon rather resembles the diatomic gases.

It may be objected that, in making such observations, one consideration has been neglected. It is the nature of the electrodes. This may indeed play a not unimportant part in the phenomena. It is unquestionable that hydrogen and helium are both absorbed by platinum, and it would appear that nitrogen, too, can be made to combine, for it is removed from a vacuum tube containing it, if the platinum is "splashed" on to the walls. But the experiments on mixtures of gases were performed in vacuum tubes without electrodes, and the influence of the electrodes comes in only with experiments on gases at atmospheric pressures, and in those in which pressure was reduced. Their pressure may, however, conduce to some kind of polarising influence, and the conclusions, such as they are, may be vitiated by neglecting this factor.

We trust that these somewhat rash speculations will be forgiven; the subject is a difficult one, and we have carried out the experiments more with the view of obtaining practical help in recognising the purity of argon and helium than of carrying out a research on the relative conductivities of gases. There is evidently a wide field for research, and we shall be glad if this description of our methods of manipulation, and of the somewhat meagre results which we have obtained, may induce others, better qualified than we, to make similar investigatons.

CHANGE OF RESISTANCE DUE TO ELECTRIC RAYS.*

BY E. ASCHKINASS.

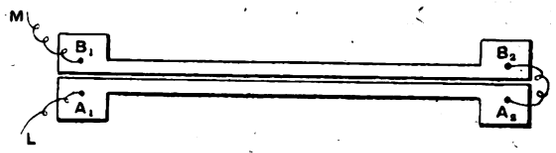
In November, 1894, I reported to the Physical Society of Berlin upon changes of resistance observed in tinfoil gratings and other metallic conductors after they have been exposed to electric radiation.† It was only after closing my work that I came across Branly's investigations,‡ according to which certain substances especially metal filings, undergo a diminution of resistance when electric sparks pass in the neighbourhood. At that time I was unable to decide whether the two phenomena were identical.

Meanwhile, Mizuno‖ has verified my observations on tinfoil gratings, and observed that the diminution of resistance does not occur when a larger interval separates the tinfoil strips. From this he concluded that the phenomenon "did not depend upon a molecular, but upon a purely mechanical" process. For the gratings are prepared by cutting a sheet of tinfoil into a large number of narrow strips by parallel cuts, the current having to traverse the whole series along a zig-zag path. Either the gratings are mounted on a frame, or the tinfoil is stuck along its whole surface upon a foundation. Now the cuts can never be made quite rectilinear, even with the sharpest knife, but the edges of the various strips always appear studded with loose metallic particles under the microscope. Now, according to Mizuno, the electric waves produce a motion of the particles in such a manner that many contacts are made at the cuts. This would lead to a decrease in the total resistance, and the phenomenon would be explained in the same manner as that of the metallic filings. Shortly afterwards Haga§ arrived at the same result.

In the following I shall myself communicate some results which show that the changes of resistance of the tinfoil gratings are indeed due to occurrences at the cuts of the gratings, and are therefore identical with the phenomenon first discovered by Branly.

A piece of tinfoil, which was mounted upon cardboard or glass, was cut along its whole length with a sharp knife (see figure). To the four ends, A_1, A_2, B_1, B_2, of the two strips binding screws were attached. First of all, A_2 and B_2 were joined by a short wire, and the wires L and M joined to A and B served to introduce the whole arrangement into the gap of a Wheatstone bridge. The current, therefore, flowed from A_1 to A_2, B_2, and B_1. Under the influence of electric waves a permanent change of resistance was observed, as before. It could be counteracted by a slight mechanical concussion. Then the junction A_2 B_2 was withdrawn, and the connection M was joined to A_2. Thus only the strip A_1 A_2 was introduced into the circuit. With this arrangement no influence of the electric waves was perceived; the same applied if the strip B_1 B_2 alone was put in circuit. Hence the change of resistance does not occur in the mass of tinfoil nor at the contacts A_1 A_2, B_1 B_2.

Next, the connections L and M were put to A_1 and B_1, and the connection A_2 B_2 was re-established. The whole was put in circuit with a sensitive galvanometer, and a feeble current was passed. The deflection of the magnetic needle was kept within suitable limits by choosing an appropriate current. Then the connection A_2 B_2 was broken, and the current could no longer pass. But as soon as electric waves were produced in the neighbourhood, the needle was deflected and assumed a new position of equilibrium. Hence the current flowed across from one strip to the other. By heating or concussion the needle could be brought back into its original position.



Different tinfoil resistances prepared in the manner indicated had different sensibilities. But the phenomenon disappeared completely when the interval between the two strips was too large. The greater the sensitiveness for electric oscillations, the smaller is the concussion sufficient to bring the galvanometer needle back to its original zero.

From these experiments it results without doubt that the changes of resistance of tinfoil gratings are due to cross contacts between the strips, and that we have here to deal with the same phenomenon as was first observed by Branly, and recently by Lodge,† Minchin,‡ Von Lang,‖ and others. The apparent changes of resistance of wires, which I had previously observed, might also be explained by the influence upon the contacts at the terminals.

As regards the explanation given by Mizuno, it does not appear to be quite plausible. For then it would be very remarkable that platinum mirrors and certain other substances show an increase in resistance§ under the influence of electric waves. Besides, I have regularly observed in tinfoil gratings and wires that before the action of the oscillations no mechanical concussions, however strong, produce any change of resistance. This can hardly be harmonised with Mizuno's theory of easily-movable metallic particles, especially since after the action only a very slight concussion is required to re-establish the original resistance. Branly also is of opinion that his experiments do not admit of a purely mechanical interpretation of the phenomenon.¶

Electric Pumping.—The firm of Apollonj have obtained from the Municipality of Rome a concession for the electrical transmission of power from some falls at Acque Albule, near Tivoli, and its distribution in the city. The power will be employed for the working of a number of small motors intended to raise the level of the Trevi waters, now distributed to supply the lower parts of Rome.

* *Wied. Ann.*, No. 3, 1896, pp. 408-411.
† *Verh. Phys. Ges. Berlin*, Vol. XIII., No 4, p. 103, 1894.
‡ E. Branly, *Comptes Rendus*, 111, p. 785, 1890; 112, p. 90, 1891 *Lumière Électrique*, 40, p. 301 and 506, 1891.
‖ *Phil. Mag.* 40, p. 497, 1895; see also *The Electrician*, December 6, 1895, p. 187.

* *Wied. Ann.*, No. 11, 1895, p. 571; see also *The Electrician*, December 13, 1895, p. 212.
† "The Work of Hertz," 1894, *The Electrician* Printing and Publishing Company.
‡ *Phil. Mag.*, 37, p. 90, 1894.
‖ *Wien. Ber.* (2), 104, p. 1, 1895.
§ *Lum. El.*, 40, p. 511, 1891. Aschkinass, *L. C.*, p. 109.
¶ *Lum. El.* 40, p. 511, 1891. *Jour. Phys.* (3) 4, p. 273, 1895.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April 10, 1896.*

The American Bell Telephone Company.—The annual meeting of this Company was held in Boston on March 31st, and the report for the year ending December 31st last shows the following results: gross earnings $5,124,952, expenses $1,911,193, net earnings $3,213,759. Further statistics show that on December 31st the Company had 674,976 telephones in use, 260,324 miles of wires on poles, 12,861 miles of wires on buildings, 184,515 miles of wire underground and 2,028 miles of submarine wire, making a total of 459,728 miles. The total number of daily connections were 2,351,420. During the year the Company's leasing instruments expended for new construction $6,463,000, for addition to real estate $465,000 and for repair and construction $7,223,000, making a total of $14,150,000 applied to extension and care of the telephone plant in the United States. The principal cities and towns in most of the states east of the Mississippi River are now connected by telephone, and conversation can be held by that method over distances of 1,500 miles, which is said to be more than twice the length of line anywhere brought into use for this purpose outside of the United States. Within the last five years alone 130,000 miles of telephone wires have been placed under ground.

The Mutual Life Insurance Company of New York.—This concern announces that it will hereafter accept risks on the lives of electrical engineers at the ordinary rates, without extra premium. It defines the term "electrical engineers" as meaning consulting electrical engineers and men who have independent charge of a dynamo or holding a still higher position in connection with an electrical plant.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *April 20, 1896.*

The Electrical Exhibition of the Société Internationale des Electriciens.—This society has arranged for an exhibition of electrical apparatus on May 2nd, 3rd and 4th. The exhibits will be divided into three classes, according as they are connected with the domestic, medical or the educational side of electricity.

Société Française de Physique.—The annual Easter exhibition of this Society was naturally noticeable for the large number of Röntgen apparatus and photographs shown. Acetylene also was a prominent feature. Amongst the other exhibits shown may be mentioned that of the firm of Gaiffe et Cie., comprising a large number of electro-medical apparatus designed by M. D'Arsonval, and that of the old established works at Cail. The exhibit of the latter firm consisted of a dynamo intended for research work at the Sorbonne, giving 0·2 ampere at 3,000 volts.

Société Internationale des Electriciens.—The annual general meeting of this Society took place on April 1st under the Presidency of M. R. V. Picou. The voting resulted in the election of the following for the year 1897-8:—*President:* M. d'Arsonval. *Vice-Presidents:* MM. de Nerville, Pellat, E. Sartiaux. *Secretaries:* MM. Gosselin, Laffargue, Poincaré. *Treasurer:* M. Violet. *Members:* MM. Baudot, Brillié, Cance, Curie, Dujardin, Fayot, Grosselin, Hospitalier, Miet, Mildé, Minet, Monmerqué, Montpellier, Picou, Raffard, Richard, Street, Vaschy, Voisenah. *Financial Committee:* MM. Armengaud, Berthon, G. Masson. M. Paul Janet, who has taken the place of M. de Nerville as head of the Laboratoire Central d'Electricité, described how a voltmeter for 20,000 volts was standardised at this laboratory. The instrument in question was a Kelvin electrometer with two quadrants and an aluminium needle. In order to make the axis of suspension coincide exactly with the centre of gravity, the needle carried underneath two perpendicular axes, on which were placed aluminium nuts. Variations of the sensibility of the instrument could be afforded in the usual manner by means of weights of 28, 84 and 336 milligrammes, which gave readings of 100, 200 and 400 volts per division. The method of calibration employed was a direct comparison with an absolute electrometer of MM. Abraham and Lemoine. The result was a curve which was sensibly proportional from 0 to 18,000 volts, though somewhat convex between 0 and 4,500 volts.

Electric Traction at Rouen.—Rouen has followed the good example set by Havre in 1894, and has recently converted its system of horse tramways into an electric network. The work was carried out by the French Thomson-Houston Company, and the line came into operation on the 22nd of last month. The total length of line amounts to 37 kilometres, 25 kilometres of which previously existed. Broca rails, weighing 44 kilogrammes per metre, are used, the gauge being 1·44 metre, and the maximum gradient 5 per cent. The power house is situated on the banks of the Seine, and comprises four Babcock and Wilcox boilers having 160 square metres heating surface, a Green economiser, three Corliss-Farcot single cylinder engines running at 70 revolutions, each belt driving a Thomson-Houston 200-kilowatt dynamo, over-compounded for 550 volts at full load and 500 volts on open circuit at a speed of 425 revolutions. There are the usual dynamo instruments and feeder panels on the switchboard. The feeders, four in number, have a total length of 6 kilometres, their sectional area being 200sq. mm. The return conductors are of bare copper, and have a sectional area of 150sq. mm., and are laid in wooden troughs filled with bitumen. The trolley overhead line is of bare copper wire of 8·25mm. diameter, and is suspended from iron poles 7 metres high. The cars, 60 in number, each carry 24 passengers inside and 16 out. They weigh 7 tons and are 8 metres long. Each car is driven by two motors of the Thomson-Houston type, built at the works of the Postel-Vinay Company at Paris. These motors are rated at 25 H.P. each, and are hermetically enclosed in cast steel casings. Single reduction gearing is used.

CORRESPONDENCE.

RÖNTGEN RAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is a mistake to suppose that the action of X-rays on a film is dependent on the glass backing, so that no action can be got on a ferrotype plate.

The truth is that a ferrotype plate is just about as rapid as a glass plate, though, of course, for practical purposes it is not so convenient.

Another fact is that extra thick films on glass are, as I expected, much better than thin ones.—Yours, &c.,

OLIVER J. LODGE.

University College, Liverpool, April 20, 1896.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: While experimenting with "X" rays obtained from a Jackson focus tube, the following results, which we venture to think of considerable interest, were obtained.

It seemed possible to cause the tube to pass through two distinct conditions. Starting with a spark of about two inches, and a fairly low vacuum, we noticed that the tube became generally luminous and filled with a bluish green haze, while brilliant green flickering patches appeared upon the glass. Under these conditions a screen prepared with potassium platino-cyanide glowed brightly when held near the tube, but shadows of the bones of a hand did not appear strongly marked upon it. The length of the spark was then increased, and while the screen became more and more brilliantly fluorescent, the shadows grew fainter, until a point was reached when there was scarcely any trace whatever of the hand upon the screen. The green patches on the tube were still visible, and the anode had become red hot, the screen was fluorescing vigorously, and yet practically no trace of the bone shadows could be seen. At this moment the spark was further increased, and the whole appearance of the tube instantly

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changed. A vivid green mist filled the interior, all patches disappeared, the fluorescence gave a flicker and became slightly brighter, while at the same time deep shadows of the hand bones made their appearance. The effect must be seen to be fully realised.

It would seem then that during the first condition of the tube a radiation was given off which had the property of passing through bone, and thus behaving in a different manner to the "X" rays. What we call the second condition of the tube was reached, "X" rays were strongly given off, the bones appeared opaque, and the tube was in good order for obtaining "Röntographs."

As far as we have gone in the matter, it appears that a critical vacuum, together with a definite spark-length, is required to give the effect, and we would also suggest that a certain condition of the glass may be necessary. We have found, however, in several focus tubes which had been regarded as useless for the "Röntgen" effect, evidences of this peculiar radiation, to which even thin metals are considerably more transparent than to "X" rays. We hope to publish further results later.—Yours, &c.,

CHAS. E. S. PHILLIPS,
H. O. MANCE,
H. O'H. MOORE.

April 22, 1896.

[The curious phenomena observed by the writers appear to be precisely the same as those observed, for instance, by Prof. Silvanus Thompson, and communicated by him on April 7th to the Académie des Sciences (*Comptes Rendus*, Vol. CXXII., No. 14, p. 809). The concluding paragraph of Prof. Thompson's Paper reads as follows:—"By means of the fluorescent screen we are also able to show the heterogenity of the X-rays. With moderate vacua the X-rays do not penetrate the flesh to the exclusion of the bones as completely as do the rays emitted when exhaustion is pushed further. On the other hand, when exhaustion is carried very far, the X-rays not only penetrate flesh, but bone also. Hence there is a certain degree of exhaustion for which the difference in the transparency of flesh and bone is a maximum."—ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is highly desirable that the exposures necessary for obtaining good results by means of Röntgen's photography when applied to the human body should, if possible, be reduced. This is not so important when it is merely a question of photographing the extremities, for which the necessary exposures are in any case now not very prolonged. Even in these instances, in the case of children, shorter exposures would be an advantage, but the question of reducing the exposures becomes of real importance, more especially in connection with the thicker portions of the body. Indeed, in order to ensure convenience and certainty in detecting calcareous deposits in the interior organs, for photographing the spine and such like purposes, a considerable reduction in the exposures now required is a *sine quâ non*.

Happily, there is every prospect of great improvements in this respect. The chemical action of the Röntgen rays upon a photographic film may be either a direct action or may be a secondary effect due to fluorescence of the film itself or of its support. In either case only a very small portion of the energy in the rays is photographically utilised under ordinary circumstances. This is clear from the fact that a large number of photographs may be taken at once by means of superimposed films, and also by the fact that if a photographic film mounted on celluloid be observed through a cryptoscope, it will be seen to be exceedingly transparent.

Nearly three months ago, in some remarks that I made at the close of Mr. Porter's demonstration at University College on January 30th, I suggested as a means of more completely utilising the energy of the rays, and thereby shortening the necessary exposure, the use of suitable fluorescent material applied either in the form of a screen behind the photographic film, or introduced into the substance of the film itself. Since then I have made numerous experiments in the direction indicated, and some weeks ago obtained conclusive evidence that by means of a screen thickly coated with potassium platino-cyanide and gum, placed behind a celluloid photographic film, the necessary exposure could be greatly reduced, also that in a less degree the same result could be obtained by the similar employment of a screen coated with powdered fluorspar. The chief objection to this method lies in the fact that it is very difficult to avoid granular results. Unless the fluorescent material be in a finely divided condition its grain shows distinctly, and mars the detail of the finished picture. The platino-cyanide does not work so efficiently when finely powdered as when in moderately coarse crystals, but good results can be obtained by thickly coating a thin celluloid film with an emulsion of this salt ground to fine powder in collodion, and using the screen so prepared with its celluloid surface in contact with the sensitive surface of the photographic film. I have obtained considerably better results with a finely-ground sample of tungstate of calcium, prepared for me by Messrs. Hopkins and Williams. This may be used either in loose powder or made up with gum into a paste and dried. With this substance it is easy to obtain sharp and fully exposed negatives of the hand in from 5sec. to 10sec. with a moderately excited tube, with which, with ordinary arrangements, 1min. to 2min. exposure would be necessary. I have also tried some special plates prepared for me by Messrs. Marion, into the sensitive emulsion of which fluorescent substances such as powdered fluorspar and calcium tungstate were introduced before application to the glass. Though the results so far obtained by this method are not very satisfactory, owing to granularity, the presence of the fluorescent substance in the photographic film appears undoubtedly to increase its sensitiveness to the rays. Apart from the question of granularity, the introduction of fluorescent material into the film does not appear to take away the sharpness of the result, and the same may be said with regard to the application of a fluorescent screen behind the film, provided the surface of such a screen is even, and is in very close proximity to the sensitive gelatine.

No doubt much experimenting remains to be done in order to obtain the best possible results.—Yours, &c.,

A. A. C. SWINTON.

66, Victoria-street, S.W., April 22, 1896.

PHOTOGRAPHS OF INCANDESCENT LAMP FILAMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am not aware that experiments have been made to show whether or not certain substances—which in the solid condition at ordinary temperatures are non-transmitters of light—become transmitters of light by increase of temperature, say, to incandescence. Enclosed is a photograph of an incandescent lamp filament, taken by me a few days ago, and photographed by its own light.

The appearance is that where the filament crosses itself in the photo there is a brighter light given out. This would tend to show that the carbon became a transmitter of light when incandescent, so that the light from the rear portion of the filament penetrated the near portion, thus increasing the brilliancy at the points of apparent intersection of the filament with itself. The lamp was run off a 100-volt continuous-current circuit. This result may be of some interest to your readers.—Yours &c.,

ROBERT D. CASSELLS.

Glasgow, April 16, 1896.

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[In order to show the effect better, we have had a careful drawing made of Mr. Cassells' photograph. In those places where the filament overlaps itself, either in part or in the whole of its width, the filament is shown quite white; in parts which do not overlap it is shown shaded. Owing to the hypothetical transparency of the filament the outlines of parts overlapped by other parts are drawn in, since on the hypothesis they would be visible.—Ed. *E.*]

THE ATKINSON REGULATING TRANSFORMER.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In reply to Mr. Atkinson's letter published in your issue of April 10th, we must admit, and apologise for, the omission in our Paper of any reference to the transformer patented by him at the end of 1889. At the same time his invention is only interesting as being, so far as we know, the first instance of a transformer in which the magnetic circuit was made moveable relatively to the secondary or primary coils. It is quite as unsuitable for use as a feeder regulator as Mr. Kapp's, illustrated in our Paper, Figs. 4 and 5. It will be seen by reference to the patent specifications that the "Manchester Edison-Swan" regulator works on a different principle, excepting that the magnetic circuit is moveable relatively to the secondary coils.

In reply to the last paragraph of Mr. Atkinson's letter, we have the authority of the Manchester Edison-Swan Company for saying that they have not arranged to make these transformers under licence from Messrs. Easton, Anderson and Goolden (Limited).—Yours, &c., Edw. W. Cowan.
Alfred Still.

THE PRODUCTION OF ALCOHOL FROM ACETYLENE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of April 17th there appeared an interesting review of Dr. F. B. Ahrens' monograph, "Die Metallcarbide und ihre Verwendung," in the course of which the writer reverted to the question of the synthetical preparation of organic compounds, such as alcohol, starting with acetylene (C_2H_2) prepared electrically as the base. The first step shown is the conversion of acetylene into ethylene, and the writer cites experiments following Berthelot's method of reduction by nascent hydrogen of the ammoniacal solution of copper acetylide, which, however, gave no result. For the purpose of effecting this first step, that is

$$C_2H_2 + H_2 = C_2H_4$$

Acetylene + hydrogen = ethylene,

Roscoe and Schorlemmer quote V. Wilde as stating in "Ber. Deutsch. Chem. Ges.," VII., 353, that platinum-black in contact with a mixture of acetylene and hydrogen brings about the combination of these gases, ethylene (C_2H_4) and ethane (C_2H_6) being formed.

The production of this latter body would also give an alternative method for the production of alcohol; thus

$$C_2H_6 + Cl_2 = C_2H_5Cl + HCl$$

Ethane. Chlorine. Ethyl chloride. Hydrochloric acid.

$$C_2H_5Cl + KOH = C_2H_5OH + KCl$$

Ethyl chloride. Potash = Ethyl alcohol. Potassium chloride.

—Yours, &c., Llewellyn B. Atkinson.

April 20, 1896.

DIRECT-COUPLED RAILWAY GENERATORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In an editorial note published last week, with reference to the valuable and interesting series of articles by Mr. E. Tremlett Carter, which have recently appeared in *The Electrician*, we notice that you state that "there is not a single direct-coupled tramway or railway generator in the United Kingdom." Will you allow us to say that for some months past a 250 H.P. Willans engine, direct-coupled to a Siemens' dynamo, and running at 350 revolutions per minute, has been in daily work at the Stockwell generating station of the City and South London (Electric) Railway Company, where its running can be easily compared with that of belt-driving plant. We believe we are justified in saying that it has worked with the most complete success, and has afforded ample proof, if any is needed, of the suitableness of direct-coupled, high-speed plant for traction purposes, under the greatest variations of load. At one time the engine was exposed to such extreme variations that in the course of a few minutes the automatic cut-out would come into action several times, on each occasion making an instantaneous change from full (or excessive) load to no load at all. Under these circumstances there has been no tendency to race, nor has any trouble whatever arisen.—Yours, &c.,

C. S. Essex, Secretary,
Willans and Robinson (Limited).

LIGHT LOCOMOTIVES BILL.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The Light Locomotives Bill which was recently introduced in the House of Lords, is of such vital importance to the electrical industry that perhaps you will find space for the following.

Mr. Chaplin received the deputation headed by Sir David Salomons on February 12th, after which I had an interview with him, and I wrote to him at length on the following day. I need not, however, trouble you with my letter of that date, or Mr. Chaplin's courteous answer. When, however, on March 30th we were able to obtain a copy of the Bill I wrote to Mr. Chaplin a letter, copy of which I enclose, together with his reply. I am glad to be able to add that on Tuesday last Mr. Chaplin and Lord Harris did me the honour of receiving me at the Local Government Board. I found them most anxious to do all in their power to meet the reasonable requirements of all the industries interested in this particular Bill. They, however, are of opinion that it is essential some restriction should be placed on weight, as otherwise they fear that heavy traction engines will be run about the country and through our towns at a considerable speed. I am glad, however, to be able to add that though they were not able, until after consulting with their technical advisers, to determine the exact limit of weight that the Government may think necessary, yet I have no doubt when the Bill is read a second time in the House of Lords we shall find, instead of two tons, if not five, at any rate four, tons will be substituted. Mr. Chaplin said that this is a matter of experiment, and that the Government, while most anxious to assist the industries connected therewith in every possible way, felt that until some experience was gained on the subject they must be very cautious. Electrical omnibus traffic can certainly be conducted with success with a weight of five tons, and I have very little doubt that even if we are restricted to four tons, we shall be able to do very well with this traffic in our London streets and in other towns.—Yours, &c., S. Flood-Page.

102, St. George's-square, S.W.

[Copy.]

102, St. George's-square, S.W., April 1, 1896.

Locomotives on Highways.

Sir: I have the honour to remind you of the interview which you accorded me, after you had received the deputation on the above subject, on February 12th, together with my letter of February 13th, and the answer of your secretary thereto. I am afraid that in the multitude of the business connected with your department you have overlooked your kind promise to bear in mind my representation as to the vital importance to the electrical industry of not limiting the weight of the omnibuses or carriages to be used in towns to two tons. I may state that this limit, which is unfortunately contained in the Bill, has created great consternation amongst those connected with the electrical industry. It was only the day before yesterday that we were able to obtain a copy of the Bill, and I have already received communications from several of the leading representatives of electrical work, suggesting my writing to the papers, holding meetings, &c. I have, however, such confidence in your promise as to feel assured that such public agitation will not be necessary.

If this limit is maintained it will practically exclude the use of electricity for horseless omnibuses, though it is undoubtedly the safest, cleanest and best for such carriages.

On Wednesday last I was speaking at the meeting of the Associated Chambers of Commerce as one of the Council of the London Chamber, and remembering your promise that you would bear in mind my representations on this subject, I stated that we might look forward to the Bill with complete confidence that there would be no restriction put on horseless omnibuses not found necessary with the existing omnibuses, and no unnecessary interference with the natural development of the electrical industry as applied to omnibuses, &c., in towns. Judging from the welcome

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this announcement received from the delegates of the Associated Chambers, I have no hesitation in saying that if it had entered into my mind that this prohibitory restriction of weight would have found place in the Bill, I should have been able to get a resolution passed unanimously asking you to withdraw your present limit if, in fact, you thought it essential that there should be any limit whatever or any restriction beyond that for street traffic in London at the present moment. You are aware that laden waggons of 16 tons are now legally permitted to traverse our streets, while the large three-horse omnibuses, weighing very many tons are allowed the free use of the Paris streets.

This question is one of such absolutely vital importance to the electrical ndustry, which, as you are aware, has been most seriously hampered in this country by what is now recognised as erroneous legislation, that I do hope you will be able to remember your most kind promise to give effect to my representations, and that you will prevent the agitation which must immediately be excited if this most lamentable, unnecessary and unjust restriction is maintained in the Bill.

Naturally I will not ask you to see me, with one or two other representatives of the industry, during the short Easter holidays, but I shall be most glad if before any public meeting is called, you would see me, with one or two representatives of the electrical and carriage-building industries, so that, if possible, the necessity for this agitation may be done away with.

I have the honour to remain, sir,

Your obedient servant,

(Signed) S. FLOOD-PAGE.

To the Right Hon. H. Chaplin, M.P., &c.

[COPY.]

Local Government Board, Whitehall, S.W., April 2, 1896.

Dear Sir: Mr. Chaplin desires me to reply to your letter on the subject of the Light Locomotives Bill.

The Bill has been introduced in the House of Lords in consequence of the pressure of other business in the House of Commons. The question of the weight of the articles to which the Bill is to apply is a matter of detail, and Mr. Chaplin is perfectly ready to receive and consider suggestions on the subject, which is a new one to all concerned, and of which there has been so little practical experience.

He has forwarded your letter to Lord Harris, who has charge of the Bill in the House of Lords, and from whom your suggestions will, he is sure, receive every attention.

When the Easter holidays are over Mr. Chaplin will be very willing to see you, in company with Lord Harris, or to receive in writing any further statement on the subject which you may like to submit.—Yours faithfully,

(Signed) H. C. MUNRO.

Combination Railway Generators.—The Akron, Bedford and Cleveland Railway, U.S.A., which was laid down last summer, is about 30 miles in length, and is, says the *Electric Railway Gazette*, provided with two power stations, one located about six miles from the Akron end, and the other about six miles from the Cleveland end. At present there are in operation eight double-truck cars, each being equipped with two Westinghouse 50 H.P. motors. A speed of over 30 miles per hour on the level may be obtained. Each station is equipped with two 250-kilowatt generators, constructed by the Westinghouse Company, and which are capable of furnishing either direct current for the operation of the road, or two-phase alternating current for power or lighting purposes. The machines are provided, in addition to the commutator for direct current, with four collecting rings and brushes for the two-phase current, the armature winding being tapped at suitable points by wires which pass through the shaft and are connected to the rings. When the machine is operated as a railway generator the main current passes through the series-winding as usual; if, however, the machine is to be used as an alternating-current generator, the terminals of the series-winding are connected across the brushes of a small commutator carried upon the shaft just outside the bearing. The current supplied to this commutator comes from independent coils wound on what may be called the spokes of the armature. These coils act as a secondary of a transformer, the primary of which consists of a few turns of winding upon the same spokes through which passes the alternating armature current. The current flow in the secondary increases and decreases in direct proportions to variations in the strength of the main current, and, being commutated and used to assist in the field excitation, the latter is increased in proportion to the load on the machine. The armature core consists of thin steel discs, and the field core is built up of thin steel plates cast into the iron yoke or frame of the machine. The generators have eight poles, and run at 450 revolutions. The normal E.M.F. at full load at the direct-current brushes is 550 volts, and that at the alternating-current brushes at full load is about 385 volts. The machines can be used as alternating and direct-current generators at the same time; but when so used they will not, of course, regulate for both loads.

LEGAL INTELLIGENCE.

Gaskell and Grocott v. Gosling.

This case again came before the Court of Appeal (consisting of the Master of the Rolls and Lords Justices Lopes and Rigby) on Wednesday for judgment, being an appeal by the defendants in the action of Gaskell and Grocott *v.* Francis and Cunliffe Gosling (reported in *The Electrician* of February 14th last, the original action being reported in our December 6th issue) from a judgment of the Lord Chief Justice. The plaintiffs are makers of porcelain parts of electrical apparatus, and carry on business at Longport, Staffs. Their action was brought to recover from the defendants (who are members of the banking firm of Gosling and Sharpe) £488. 9s. 3d., the price of goods alleged to have been sold and delivered between December, 1893, and January, 1895. The action raised the important question as to whether trustees for debenture-holders, who appointed a receiver to carry on the business of a company which was in liquidation, were themselves liable to pay for goods sent in to the Receiver. The goods in question were so supplied, and when payment was asked for it was said that the goods were supplied to the Company, and that the Company must be looked to for payment. Down to 1892 a firm called Poole and White (Limited) carried on business in Bread-street, London, and became indebted to Gosling and Sharpe for about £3,000, which was secured by a trust deed on July 22, 1892; the trustees certified that the debenture-holders' security was in peril, and thereupon the debenture-holders appointed a man named Kelly as Receiver. On September 1st a petition was presented by a creditor to wind up the Company, under which, on September 14th, a compulsory order was made. After the winding-up order the business was carried on by the man Kelly. In 1893 the plaintiffs called at the office and saw Kelly, and ascertained that the business was being carried on for the benefit of the debenture-holders, and from time to time they took orders and supplied goods to Kelly in his capacity, as they alleged, of Receiver. Three sets of debentures (amounting to £11,000) had been issued, for £7,000, £3,000 (those held by the defendants), and £1,000. But Kelly, being appointed on behalf of the second set of debenture-holders, it was not until February, 1895, that the first debenture-holders came in and turned him out. While Kelly was carrying on the business over £700 worth of goods were delivered by the plaintiffs, but by means of small credits that sum had been reduced to the amount claimed. The defendants denied liability on the ground that the trustees to the debenture-holders had, under their powers, appointed a man named Kelly as Receiver, who carried on the Company's business as the agent of the Company, and that under such circumstances the Company was liable, and, alternatively, if it was held that the winding-up order made in September, 1892, revoked the trustees' powers, then that Kelly was liable personally for the amount claimed. The Lord Chief Justice held that the defendants were undisclosed principals, saying that it was necessary for Kelly to obtain money or credit to carry on the business, and that when he was appointed Receiver he disclosed the fact that he was Receiver, and his Lordship gave judgment for the plaintiffs for the amount claimed, with costs, and against this decision the defendant appealed.

The MASTER OF THE ROLLS, in the course of an elaborate judgment, and after narrating the facts of the case, said that he held that the goods in question, which were all ordered after the time when the Company was in liquidation, were ordered by Kelly as the agent of Messrs. Gosling, the trustees who allowed him to act as their agent, and that therefore they were the undisclosed principals. He came with less hesitation to that decision when he considered that if the argument of the defendants was true they were reaping the profits of the plaintiff's goods without any liability to pay for them. If that was the law he could not help thinking that it was a dishonest law, and he came to the conclusion that the decision of the Lord Chief Justice was right, and that the appeal ought to be dismissed.

Lord Justice LOPES said that he was of the same opinion. Even assuming for the purposes of the case that up to the presentation of the petition Kelly was the agent of the Company, and that the Company were liable, he (his Lordship) came to the conclusion that after the winding-up order there was ample evidence to justify the Lord Chief Justice in finding that the defendants were the undisclosed principals of Kelly.

Lord Justice RIGBY said that he had the misfortune to disagree with the other members of the Court. In his opinion no control was exercised or stipulated for by the trustees over the Receiver, or if any was it was very insignificant. The Receiver was appointed for the very purpose of securing payments of interest to the series of debentures, and it was the duty of the Receiver to pay the interest if he had funds in hand to do so. The position showed, in his opinion, that at any rate down to the date of the winding-up order that the trustees had not taken a single step which would have even a tendency to make them responsible to the creditors of the business, or to the Receiver, and had no interest which would make them responsible. And no evidence was suggested of any interference by them after the date of the winding-up order. They no doubt could have made void the appointment of the Receiver, and have entered into possession, but so also could the trustees of the first series of debentures. Neither of them were under an obligation so to act or incurred liability in omitting to do so. He thought that the action against the defendants failed, and that the appeal ought to be allowed.

The appeal was therefore dismissed with costs.

A stay of execution was granted pending an appeal to the House of Lords.

Mr. Jelf, Q.C., and Mr. Hansell appeared for the appellants, and Mr. Herbert Reed, Q.C., and Mr. W. F. Hamilton for the respondents.

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Swinburne and Co. v. J. D. F. Andrews and Co.

At the Westminster (London) County Court, on Monday, a case was heard in which the plaintiffs sought to recover payment in respect of a dynamo and arc lamps supplied to the order of the defendants. The plaintiffs' case was that they were instructed to make some arc lamps of a peculiar kind from drawings supplied by defendants, and in order to carry out the work a good deal of extra expenditure was incurred. When the order was completed application was made for payment, and it was alleged that not until the matter was put into the hands of the solicitors was any complaint made as to the goods being defective. For the defence it was contended that both dynamo and lamps were defective, and that the work had not been carried out according to instructions. It was further contended that the charge for extras which the plaintiffs now sought to recover were grossly exaggerated and contrary to the terms of the order. After hearing the evidence, the Judge said the plaintiffs' charges appeared to be somewhat heavy with regard to the extra work, and, without going into figures, he should give them judgment for £45 and costs.

Holdsworth v. St. Pancras Vestry.

In the Queen's Bench Division on Friday last, before Mr. Justice Cave and a common jury, Mrs. Elizabeth Holdsworth, wife of a plasterer, residing at Somers Town, London, sued the St. Pancras Vestry to recover damages for personal injuries sustained through alleged negligence. Counsel for the plaintiff stated that about eight o'clock on February 23rd, last year, she was in Gee-street, St. Pancras, when an explosion took place through gas having accumulated in the culverts and street boxes through which the defendants' electric wires passed. Immediately after the explosion she became unwell, felt pains in her head and lost the sight of the right eye, which was, however, restored. Plaintiff alleged that the defendants were guilty of negligence in not properly ventilating the culverts and road boxes, that the insulation was imperfect, and that in consequence of the defects in the defendants' distributing system, there was risk of an explosion if coal-gas got into the boxes. Defendants admitted the explosion, but pleaded that plaintiff was not injured by it, and also denied that they had been guilty of any negligence.

The jury ultimately found for the plaintiff for £105, for which sum judgment was given, but a stay of execution was allowed on condition that the money was paid into Court within a week.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning. New Catalogues, Price Lists, and similar matter should be sent early in the week.]

SPECIAL NOTICE—The 1896 (fourteenth annual) edition of "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK is NOW READY. The published price of the Directory and Handbook is 7s. 6d., post free 8s. 3d. abroad 9s. The book is greatly enlarged, is quite up-to-date, and includes the new Board of Trade Regulations

NEW BOOKS AND EDITIONS.

The following New Books and Editions can be obtained of the Booksellers or direct from the Publishing Offices:—

"THE ALTERNATE CURRENT TRANSFORMER," Vol. I.—By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. The New Edition will be ready in a few days. Price 12s. 6d., post free. Vol. II., price 12s. 6d. post free.

LABORATORY NOTES AND FORMS.—With the above title, we have ready a set of 40 Elementary and Advanced Exercises for use in Electrical Engineering classes. These have been prepared by Dr. J. A. Fleming, and will be found of great service to Teachers, Demonstrators, and Students. The object of this series is the saving of the time of the teacher and his assistants, and to serve as a record of the work done by the student. Each Form is supplied either singly at 4d., or 3s. 6d. per dozen nett; in sets of any three 1s. nett; or the set of Twenty Elementary (or Advanced) Exercises can be obtained price 5s. 6d. nett. The complete set of Twenty Elementary and Twenty Advanced Exercises are price 10s. 6d. nett, or in handy portfolio, price 12s. nett, or bound in strong cloth case price 12s. 6d. nett *(now ready)*. Strong portfolios can be had, price 1s. each. A full prospectus sent post free.

"THE WORK OF HERTZ."—By Dr. O. J. Lodge, with many original illustrations, price 2s. 6d. nett, is now ready.

"ELECTRIC LAMPS AND ELECTRIC LIGHTING," by Prof. J. A. Fleming, M.A., D.Sc., F.R.S., is now ready. The book is handsomely bound, and full of original illustrations, designs, initials, &c. Price 7s. 6d., post free. Prospectus post free.

"ELECTRIC MOTIVE POWER."—A new work, by Mr. Albion T. Snell with this title, is now ready, containing the latest information respecting the application of electric energy to mining and general power transmission purposes, in which the author has had much experience. The book is well printed, on good paper, and contains 230 illustrations. Price 10s. 6d. post free (abroad 11s.).

"ELECTRICAL ENGINEERING FORMULÆ," a pocket-book by Messrs. W. Geipel and H. M. Kilgour, is now ready; price 7s. 6d., by post 7s. 9d. (abroad 8s.). A large paper edition with wide margins can be supplied, price 12s. 6d., post free 13s. (abroad 13s. 6d.). Prospectus on application to the Publisher.

"DRUM ARMATURES AND COMMUTATORS."—By Mr. F. Marten Weymouth is also ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"THE INCANDESCENT LAMP AND ITS MANUFACTURE."—This book, written by Mr. Gilbert S. Ram, is now ready; price 7s. 6d. (abroad 8s.). Prospectus on application.

"PRACTICAL NOTES FOR ELECTRICAL STUDENTS."—By Messrs. A. E. Kennelly and H. D. Wilkinson, price 6s. 6d., post free.

"THE ART OF ELECTROLYTIC SEPARATION OF METALS."—A second issue of Dr. Gore's book is now ready, price 10s. 6d. post free.

"ARMATURE WINDINGS OF ELECTRIC MACHINES."—By H. F. Parshall and H. M. Hobart. This work has been compiled from Notes made by Mr. Parshall in his capacity as chief Designing Engineer of the Edison and General Electric Companies of America, and is intended to serve as a working treatise on dynamo design. Large 4to, 370 pages, 140 full-page illustrations and 65 full-page tables. 30s., post free.

"COMPREHENSIVE INTERNATIONAL WIRE TABLES FOR ELECTRIC CONDUCTORS."—By W. S. Boult, price 5s., post free.

"SUBMARINE CABLE-LAYING AND REPAIRING."—By H. D. Wilkinson, M.I.E.E., &c., fully illustrated, will be ready first week in June.

TENDERS INVITED.—The Technical Education Committee of the Oldham Corporation desire tenders for the wiring of the Technical School in Ascroft-street, the installation consisting of 34 arc lamps, and specifications, &c., can be had from Mr. S. Wilmott Newington, borough electrical engineer, Gas-street, Oldham, and tenders must be sent to Mr. A. Nicholson, town clerk, the Town Hall, Oldham, by noon of May 1st. Some other particulars appear in our advertisement columns.

——— The Electric Light Committee of the County Borough of Oldham invite tenders for the supply of one 360 H.P. steam engine and dynamo. Specifications may be obtained from Mr. Arthur Andrew, Gas and Water Offices, Oldham, to whom tenders are to be sent by May 12th. Some further information is given in our advertisement columns.

——— The Public Lighting Improvement Committee of St. Helier, Jersey, invite communications from persons wishing to establish a lighting station in that town for the supply of electric, gas, or other forms of light for both public and private purposes. Communications should be sent to Mr. P. Baudains, Ecr. Constable, Town Hall, St. Helier, Jersey. Some further essential particulars will be found in our advertisement columns, and other information can be obtained on application to the Town Hall.

——— Tenders are required for the provision and fixing of electric bells, telephones, fire alarms, &c., at the Brook Fever Hospital, Shooter's Hill, S.E., for the Metropolitan Asylums Board. Copies of the specification (which has been prepared by Prof. Alex. B. W. Kennedy), forms of tender, &c., can be obtained at the chief offices of the Board, Norfolk House, Norfolk-street, W.C. Tenders must be delivered at the offices by 2 p.m. on Wednesday, May 6th. Further particulars are given in our advertisement columns.

——— The Electric Lighting Committee of the Coventry Corporation invite tenders for the supply and erection of (*a*) boilers and fittings, mechanical stokers and economiser, feed pump, &c.; (*b*) steam engine, alternator, oil filter, fittings, &c., steam, exhaust, feed, blow-off, and sundry pipes, valves, &c. Plans and specifications can be obtained from the consulting engineer, Mr. Robert Hammond, Ormond House, Great Trinity-lane, London, E.C., and tenders, addressed to the Town Clerk (Mr. Lewis Beard), St. Mary's Hall, Coventry, must be in by Tuesday, May 12th.

——— The Corporation of Sunderland require tenders for an evaporative tubular surface condenser, with air and circulating pumps. Tenders must be in by 5 p.m. on Wednesday next.

——— The Vestry of St. John, Hampstead, invite tenders for the supply, delivery and erection of a steam alternator, switchboard, steam and exhaust pipes, feed water heater, tank, and appurtenances, and these can be tendered for either as a whole or in part. Tenders must be in by 4 p.m. of the 27th inst.

——— Tenders are invited for the purchase of about 45 tons of old copper, a large quantity of other metals, india-rubber, and other old telegraph stores of the General Post Office. Tenders must be sent in to the Controller of Stores, G.P.O., St. Martins-le-Grand, E.C., by 10 a.m., Monday, May 4th.

——— Tenders are invited for supplying and fixing the necessary machinery for the electric lighting of the public baths and washhouses in Manor-place, Walworth, S.E. Tenders to the Vestry Clerk, Vestry Hall, Walworth-road, S.E., by 3 p.m. 29th inst.

——— The Société Nationale des Chemins de Fer Vicinaux, Brussels, invite tenders for electrically equipping about 20 kilometres of light steam railways in the centre district. Tenders to the Société, 26, Rue de la Science, Brussels, by May 27th.

——— Tenders are invited for the supply and installation of the plant and fittings required for the electric lighting of the steamer "Geheimer Baurath Wellmann" at Stralsund. Tenders to the Werft-bureau, Wasserbauinspektion, Stralsund, Germany.

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TENDERS ACCEPTED.—The Bedford Urban Sanitary Authority have received the following tenders for the supply of a 240 B.H.P. double-acting compound engine and one 150-unit alternator :—

Engine and Alternator.

S. Z de Ferranti (Limited)	£2,350
Brush Electrical Engineering Company	2,253
D. Stewart and Co.	2,195

Alternator only.

Easton, Anderson and Goolden (*accepted*)	651
Siemens Bros. and Co.	1,250
John Fowler and Co. (Leeds)	1,090
Crompton and Co.	980
Mather and Platt	930
Manchester Edison-Swan Company	928
Electric Construction Company	903
Johnson and Phillips	850

Engine only.

W. H. Allen, Son and Co. (*accepted*)	700
G. E. Belliss and Co	1,050
W. Sisson and Co.	790

——— The Bedford Urban Sanitary Authority have also received the following tenders for the supply of cables :—

W. T. Glover and Co. (*accepted*)	£4,854 0 0
General Electric Company	8,280 17 2
Fowler-Waring Company	6,385 1 10
India-Rubber Company	5,652 1 3
Telegraph Manufacturing Company	5,572 12 11
Siemens Bros. and Co.	5,327 2 6
Johnson and Phillips	5,189 11 3
W. T. Henley's Company	5,119 8 11
Callender Company (not in accordance with specification)	3,912 13 6

The following tenders were also received for the construction of five underground sub-stations :—

T. H. Coleman (*accepted*)	£235 0 0
J. P. White	325 0 0
T. Langton	295 0 0
H. E. Tathersly	272 10 0

——— The Walsall Town Council have accepted the following tenders :—Walsall Electrical Company, arc lamps, £6 each ; W. Macfarlane and Co., arc lamp posts, £11. 14s. 6d. each ; Callender Company, extension of electric light mains.

——— The tender of the Glasgow Branch of the General Electric Company has been accepted for the supply of a dynamo required at the Dalmarnock Sewage Works.

MACHINERY, BOILERS AND OLD STORES FOR SALE.—The Eastern Telegraph Company announce that they have for disposal a large quantity of old stores, &c. List and particulars can be obtained on application to Room 320, Winchester House, Old Broad-street, London, E.C.

APPOINTMENTS.—Mr. Arthur Ellis has been appointed to the position of electrical engineer at Bolton, in succession to Mr. J. H. Rider, at a salary of £300 per annum. Mr. Ellis was apprenticed to Messrs. C. A. Parsons and Co. ; afterwards he held a position as second engineer to the Newcastle and District Electric Lighting Company. He was next employed by the Cambridge Electric Supply Company, being clerk of the works during the construction of the generating station of that Company, and on the retirement of Mr. G. Wilkinson from Southport he was appointed electrical engineer at a salary of £208 per annum.

——— Mr. G. H. C. Risch, jun., has been appointed electrical engineer to the West Ham Town Council. The salary is £300 per annum.

APPOINTMENTS VACANT.—The Directors of the Great North of Scotland Railway Company require an electrical engineer to undertake the duties of electric lighting and telegraphic superintendent. Salary, £250 per annum. Applications to the Secretary (Mr. W. Moffat), Aberdeen, by the 30th prox. Some additional particulars appear in our advertisement columns.

——— An assistant is required for the Physical Department of the City and Guilds Central Technical College, Exhibition-road, S.W. Salary £100 per annum. Applications to Prof. Ayrton. Some further particulars will be found in our advertisement columns.

——— A Principal is required for Sind College, Karachi, India, and will be required to teach physics and chemistry. Salary Rs.500 per mensem for 21 months, with £50 for passage. Applications to Dr. M. J. Jackson, care of Messrs. H. S. King and Co., 65, Cornhill, E.C.

——— The Technical Instruction Committee of the Borough of Plymouth require a Master for the Physics Department at the Technical Schools. Applications to the secretary, Mr. T. W. Byfield.

MEN WANTED.—The Gas Committee of the Borough of Salford require a switchboard attendant.——Two drivers of steam turbo machines are required.——An electrical engineer experienced in the running of Parsons steam turbines is required. Some particulars are given in our advertisement columns.

OBITUARY.—Mr. George Warren, for many years chief of the telegraphic department at Osborne, the Queen's Isle of Wight residence, died on Tuesday last.

PERSONAL.—Mr. Percy Dewhurst notifies that he has severed his connection with Mr. E. Dewhurst, of Preston and Blackpool, and that he has commenced business as an electrical engineer at 90, Church-street, Blackpool.

LIQUIDATIONS.—A meeting of some of the principal unsecured creditors in Woodhouse and Rawson United (Limited) met at the Bankruptcy Court, London, on Tuesday, to discuss as to whether proceedings should be taken against the directors, auditors, and other officials of the Company, to recover certain sums, which, according to the opinion of counsel, have been paid *ultra vires* in the form of over-paid commission and in respect of unearned dividends. It will be remembered that on the receipt of counsel's opinion, Mr. Stewart, late Official Receiver, invited the debenture holders in Woodhouse and Rawson United (Limited) to take steps to recover the sums referred to, amounting in all to £24,000 (£4,000 alleged overpaid commission, and £20,000 distributed in dividends, but, according to the opinion, not properly so distributed). The Ten per Cent. and the Six per Cent. Debenture holders declined to take any steps in the matter, and Mr. Justice Vaughan Williams then permitted the Official Receiver to place the matter before the unsecured creditors for their consideration, the Court deciding to allow the claim against the Directors and officials to be put up to tender. It was this proposal that the creditors met to discuss, and after consideration it was decided that steps should be taken to ascertain the opinions of the whole body of unsecured creditors, with a view to a tender being submitted by the Official Receiver, and subsequent proceedings being taken on behalf of the creditors. So soon as the amount of the tender is agreed upon it is proposed that a guarantee fund be lodged indemnifying the Official Receiver against all costs in any action that may be brought to recover from the Directors and officials the sums above set out. Creditors are invited on the receipt of a circular from a sub-committee appointed to deal with the matter to forward their comments and to set out the amount they are prepared to guarantee. The total liability of the Company to unsecured creditors is, we understand, about £15,000, and it is estimated that the amount of the necessary guarantee fund is not likely to exceed £500.

——— A meeting will be held at the office of Messrs. T. Horsfield and Co., 60, King-street, Manchester, on May 18th, at 3 p.m., to receive an account of the winding-up of Lowcock, Hill and Co. (Limited).

——— At a meeting of the proprietors of E. and E. Taylor (Limited), electrical and hydraulic engineers, on the 7th inst., it was resolved to wind up the Company voluntarily, and Mr. R. Harrison, 27, Chancery-lane, London, W.C., was appointed liquidator.

DISCHARGE IN BANKRUPTCY.—Mr. George F. Rogers, electrical engineer, of 41, Maxilla-gardens, Notting Hill, W., and 5, Great Winchester-street, E.C., intends to apply for his discharge on the 28th inst., at the Bankruptcy Court, Carey-street, W.C.

DIVIDEND.—A second and final dividend is payable at the office of Mr. J. M. MacLeod, 101, St. Vincent-street, Glasgow, on May 10th, in the bankruptcy of Messrs. D. and G. Graham, electrical engineers, late of Douglas-street, Glasgow.

MESSRS. CROMPTON AND CO.—We are now able to announce that this firm have secured a suitable site at Chelmsford for the erection of new works.

EXPORTS OF ELECTRICAL APPARATUS AND MATERIAL.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and material, but not including electrical instruments or machines, which are not separately specified) from April 9 to 21, 1896, with the ports of destination :—

Argentina—Pasages, £23,200 ; Rosario, £202. *Australasia*—Adelaide, £27 ; Auckland, £35 ; King George's Sound, £170 ; Melbourne, £78 ; Newcastle, £84 ; Otago, £62 ; Perth, £597 ; Sydney, £1,052 ; Wellington, £244. *Belgium*.—Antwerp, £218 (electric fuses) ; Brussels, £268. *Brazil*—Buenos Ayres, £12. *Canada*—Montreal, £18. *Ceylon*—Colombo, £128. *China*—Shanghai, £518. *Denmark*—Copenhagen, £13. *Greece*—Piraeus, £19. *Holland*—Amsterdam, £25 ; Rotterdam, £132. *India*—Bombay, £445 ; Calcutta, £1,093 ; Madras, £10 ; Rangoon, £12. *Japan*—Kobe, £324 ; Yokohama, £140. *Malta*, £1,196. *Portugal*—Oporto, £50. *Russia*—Revel, £65. *Siam*—Bangkok, £10. *South Africa*—Beira, £17 ; Cape Town, £514 ; Delagoa Bay, £100 and 34 tons iron telegraph poles ; Durban, £6 ; East London, £1,843 ; Port Elizabeth, £212. *Spain*—Bilbao, £20 ; San Sebastian, £20. *Straits Settlements*—Singapore, £25. *Sweden*—Stockholm, £251 ; Gothenburg, £137. *West Indies*—Demarara, £18.

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Foreign-Made Electrical Apparatus and Material.—Foreign-made electrical goods to the value of £1,098 have been exported to *Australasia*: £288 to Brisbane, £135 to Sydney, and £675 (telephones) to Wellington.

TUDOR ACCUMULATORS.—There is just issued by Mr. A. B. Pescatore, of 5, Cross-street, Manchester, a useful price list of Tudor accumulators, accompanied by tabular statements of capacity, working rates, weights, dimensions and other particulars relating to both stationary and portable types. Users of these accumulators will find the general instructions issued with the list of service. Owing to an important improvement in the manufacture of the Tudor plates, a considerable reduction in the prices of these batteries is announced, especially in the case of stationary cells. The "S" type of cell, which is described in the catalogue, has been specially designed for isolated installation work, and the new portable cells have been perfected, type P.E. being specially designed for tramway work.

GENEVA EXHIBITION.—We have received an illustrated pamphlet entitled "Geneva and the Swiss National Exhibition," and containing some particulars of the forthcoming show, together with a general plan of the grounds. The exhibition will be opened on May 1st, and is arranged in 47 groups, in which will be displayed native industrial products. The machinery hall will be well provided with electrical apparatus of the latest type. There will also be an electric tramway, about 1½ miles in length, which will enable visitors to travel quickly from one part to another of the extensive grounds. M. Turrettini, the well-known engineer and Mayor of Geneva, is the President of the Exhibition.

PRICE LIST.—Lancashire boilers are far more extensively used in electric supply stations than the majority of engineers imagine; and they are to be found in some of the largest, best-worked and most economical stations throughout the United Kingdom. No less than 60 per cent. of the number of boilers in provincial stations are Lancashire boilers, and of these a considerable number have been made and supplied by Messrs. Tinkers (Limited), of Hyde, whose steel boilers are well known for excellence of manufacture. We have received a copy of a neatly-bound and illustrated price list of the Lancashire boilers and fittings made by this firm. The contents include a detailed description of the design adopted by Messrs. Tinkers in their boilers, price lists for boilers of various pressures up to 200lb., and some description of the boilers supplied by the firm for the Salford electric supply station. There is a good illustration of the somewhat cramped and crowded boiler house at this station. We have recently seen the particulars of some trials of steam plant, including this make of boiler, which testify to their excellent efficiency and steaming powers.

NON-SLIPPING STAIR TREADS, &C.—A useful catalogue is issued of Mason's patent "Unwearable" stair treads, man-hole covers, &c., which are manufactured by the Safety Tread Syndicate, of 15, Barbican, E.C., and Glasgow. It is scarcely necessary to point out the advantages of these treads, which have been supplied to the Tower Bridge amongst other important structures, and are in use in many of the principal Government offices. The treads are a combination of chilled steel, iron or other hardened metal with lead, the metals being so arranged that one withstands the wear while the softer gives the foothold, one of the many advantages claimed by the makers being that the treads are noiseless, as the lead is the only metal coming into direct contact with the traffic. Among the numerous manufactures of the Syndicate is a patent non-slipping iron ladder, which will be found of use for public lamp cleaners.

THE "JOURNAL."—Part 121 of the *Journal* is now ready (price 3s. 6d.), and can be obtained of the publishers, Messrs. E. and F. N. Spon, 125, Strand, W.C. The part contains the continuation and conclusion of the discussion of the Papers read by Messrs. F. Bathurst and Sam Mavor on the wiring question, Mr. G. L. Addenbrooke's Paper on "High-Voltage Lamps and their Influence on Central Station Practice," and Mr. E. Basil Wedmore's Paper on "A Simple Method of Analysing Periodic Curves," and also a classified list of articles on electricity and magnetism appearing in the principal technical journals during the month of February.

AYR.—At the last meeting of the Police Commissioners a letter was read from Mr. Ernest G. Pink, electrical engineer, in which he deals with the interruptions which have occurred in the supply of electric current. It will be remembered that three interruptions have happened—the first on March 26th, owing to a fault in the armature of the day-load exciter; a second on April 6th, owing to the load being too high for the day-load plant; and a third on April 10th of a more serious nature, the lights being out for 40 minutes. Mr. Pink is unable to assign any practical cause for the third extinction.

BAKER-STREET AND WATERLOO RAILWAY.—It is stated that the threatened opposition to the Bill promoted by the Baker-street and Waterloo Electric Railway Company has been withdrawn. The Company seek powers to construct a short extension of their authorised line so as to enable them to connect the system with the terminus of the M. S. and L. Railway Company. The additional capital required is £100,000.

BEDFORD.—After a lapse of 12 months the question of the electric lighting of the Shire Hall has again come up for discussion. The Bedfordshire Standing Joint Committee have now referred the matter to a special committee.

BELFAST.—A meeting of the City Council in Committee was held last week, when the Lord Mayor (Alderman Pirrie, J.P.) stated that the Special Committee recently appointed to meet the Belfast Street Tramways Company in reference to the question of the introduction of a system of electric traction had received the important proposals from the Company relative to the electrical equipment of their system and doubling the existing lines, which it is estimated would entail a capital expenditure of £200,000. This outlay would be expended in the following manner:—

1. Doubling single line (to be authorised by order in Council)...	£28,000
2. Doubling single line on Ligoniel and Sydenham lines	8,250
3. Purchase of these lines	20,000
4. Street work for electric traction, 23½ miles, at £2,200	51,700
5. Power plant	24,675
6. One hundred electric motor cars at £500 each	50,000
7. Widening existing lines to 6ft., purchase of County Down Railway Tramways and contingencies.....	17,375

If the term were extended to 21 years the Company would be willing to sell the Sydenham, Ligoniel and County Down Railway tramways to the Corporation on the same terms as their own, and withdraw their opposition to the Boundary Bill. In view of the large expenditure involved the Company could not see their way to introduce electric traction unless they obtained an extension of the term of their lease, but if the Corporation granted them an extension of seven years they would carry out the views set forth in the recent report of the deputation appointed by the Corporation to visit continental cities where electric traction was employed. After a two hours' discussion it was proposed "that the Council approve of the recommendation to permit the Company to get an amended Bill, the terms to be settled by the Town Clerk, but that none of its powers be exercised without the consent of the Corporation." An amendment declining to accept the Company's offer and refusing to grant an extension of the existing lease was carried, but on the suggestion of Councillor Woodside it was decided to print and circulate the Company's offer amongst the members of the Council.

BOLTON.—An elaborate report on the question of introducing electric traction on the local tramways has been prepared by the late Borough Electrical Engineer (Mr. J. H. Rider) and the Borough Surveyor (Mr. W. H. Brockbank) and is being considered by the joint sub-committee specially formed to consider and report upon the matter.

BRADFORD.—Mr. Rienzi Walton held a Local Government Board inquiry on Tuesday last into the application of the Town Council to borrow £40,000 for electric light extension purposes. In support of the application the Town Clerk (Mr. W. T. McGowen) stated that the Bradford Corporation were the first public body to adopt electricity as an illuminant. They established an electricity supply station in 1889 at an expenditure of £20,000, and the public were so pleased with the light and the price charged that in 1890 the works had to be extended at a cost of an additional £30,000, and again, in 1893, another sum of £30,000 was spent in extensions, making altogether £80,000, for which borrowing powers were obtained. £74,162 of this sum had been expended, and liabilities had been incurred for a further £3,514, leaving a balance of £2,332. As to the present loan, it was estimated that £2,600 would be required for the site, £11,500 for buildings, &c., £10,325 for machinery (£4,400 for engines, £2,650 for dynamos and £3,000 for boilers), and £7,000 for cables, the three-wire system being now adopted. Mr. A. H. Gibbings supplied the inspector with technical details, and referred to the constant and rapidly-increasing demand for current. There was no opposition to the application.

BRISTOL.—In April, 1895, a report was presented to the Town Council by the Electrical Committee recommending considerable extensions of the electric lighting area, principally with a view to supplying current for private lighting, in order to bring the output more nearly up to the capacity of the then existing plant at the station. Many of the extensions suggested were agreed upon, and an expenditure of about £10,000 was authorised. Recently the Committee have reported upon the result of these extensions, and shows that success has resulted from the policy adopted. Whereas in April, 1895, only 17,420 8 c.p. lamps were supplied, the number is now 28,210, and in addition applications have been received for a further 1,200 lamps. This larger output of current has naturally considerably reduced the cost of production per unit, and in addition, instead of having to ask the Council to provide in the general district rate for sums in aid of the undertaking

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(as in 1895), it has been found unnecessary to ask for anything beyond the sum for the cost of street lighting, as all expenses for the repayment of loans and interest, working expenses and maintenance of the undertaking can now be paid out of revenue. The Committee are convinced that still more profitable results may be obtained by a further extension of the system for private supply, but as the output now approaches very closely to the maximum capacity of the plant, if such extension is made further capital expenditure will be required. The Committee have carefully considered the localities from which the most profitable results may be expected, and the electrical engineer, Mr. H. Faraday Proctor, has prepared an estimate showing that the cost of enlarging the station, purchasing additional machinery, and extending the mains to the localities suggested would amount to the sum of £75,000, and the Committee estimate that this would ensure an increase of lampage up to 76,000 8-c.p. lamps. The Committee ask the Council to approve their recommendations, and the matter is to be discussed at the next meeting.

Bray.—A deputation, consisting of Messrs. E. Garcke, S. Sellon, A. E. Porte and others, waited upon the Town Commissioners with reference to the construction of the proposed electric tramway. Mr. Garcke said he would satisfy the Commissioners that the British Electric Traction (Pioneer) Company were prepared to carry out the works and maintain the tramways in a manner satisfactory to them; but before incurring any expenditure, he would like to know whether the Commissioners were in favour of the principle of electric tramways. Should they give the scheme their support, the necessary capital for constructing the tramways would be forthcoming. The system they proposed to employ was the overhead trolley, which he thought most suitable for the town. A special meeting of the Commissioners will be held on Monday next to consider the matter.

Church Lighting.—St. Matthew's Church, Ealing, is to be wired for the electric light at a cost of £120. As the District Council have decided to supply current for the lighting of places of worship at a discount of 25 per cent., it is anticipated that all the other churches in the district will also adopt the electric light. ——The electric light was installed at St. George's Church, Worcester, more than 12 months ago, and one of the churchwardens now states there has been very litt'e difference in the amount paid for electric current during the past year and the average amount paid for gas in the preceding years, and if the larger area at present illuminated (the new church being larger than the former) be considered—to say nothing of the superiority of the light—the difference very trifling. This proves that, with economy and care, the electric light does not involve a very large increase of expense.

City and South London Railway.—This Company's Bill was down for reading in the House of Commons on Monday last, but its consideration was adjourned till this day (Friday). An amicable arrangement is stated to have been come to between the promoters of the Bill and the members who have been opposing it on behalf of the Church of St. Mary Woolnoth.

Cork.—At a recent meeting of the Public Works Committee, the engineer to the promotors of the Cork Electric Tramway Company having submitted amended plans and particulars of the scheme, the modifications were approved.

Electricity in Mining.—At the recent meeting of the shareholders of the Lancaster Gold Mining Company, the chairman said, in reference to the plant with which the Board intended to equip the mine, that, although they were convinced that electricity would play a great part in the mining operations on the Rand, yet they did not want to pin their faith entirely to it. The installation would be such that they would use electricity, and have steam as an auxilliary power. The hauling on the incline would be done by electricity, because it had been demonstrated on the Rand that hauling by this means on the incline is a success. The electrical plant would be on the three-phase system, which he thought was the best system for generating power and at the same time giving current for lighting purposes. A novel feature of the workshops would be that every tool would be driven electrically. The first cost of this plant was a little larger, but there was a gain in capacity, and the cost of maintenance would be reduced to a minimum.

Fire.—With regard to the report of a fire on the premises of the General Electric Company, Queen Victoria-street, London, this was a very trivial affair, damage to the extent of £2 only being done. Of course, business is not in any way interfered with.

Glasgow.—Mr. Primrose, at the last meeting of the City Council, referred to the recent report of the Special Sub-Committee on Street Lighting, and to the experiments that were now being carried out by that Committee. He pointed out that, as there was now a probability of the introduction of electric traction on the city tramways, a solution might be found of the question of the lighting of the leading thoroughfares by electricity, and that it might be found profitable to unite the street lighting with the development of their electric tramways.

Greenock.—At the meeting of the Police Board on Tuesday last a long discussion took place on a proposal to make extensions to the gas works. Dr. Calder and other members of the Board opposed the proposal, and contended that before going to any expense in the matter they ought to consider the question of lighting the town by electricity. The recommendation was, however, agreed to.

Grimsby.—The Town Council have at last decided to make a move in the electric lighting question. At the last meeting it was decided to refer the question of putting the Grimsby Provisional Order into force to the Lighting Committee, who are to collect information as to cost of establishing electricity supply works, and to report at an early date.

Halifax.—Mr. Rienzi Walton held a Local Government Board inquiry at Halifax on Wednesday into the application of the Corporation for sanction to borrow £20,000 for the purpose of extending the electric light works. The Town Clerk (Mr. K. Walton), in support of the application, said that the Corporation had already obtained borrowing powers for £39,950, and up to the present £43,355 had been expended. Current was being supplied to an equivalent of 12,000 8 c.p. lamps, and the demand was rapidly increasing. The deficiency on the first year's working was £1,090, including interest; but the works had been in existence only 15 months. Councillor Hebden opposed the application, on the ground that no provision had been made for developing electricity as a motive power in the town. The station plant was practically lying idle during the day; but if they could obtain a day load the Committee would be able to reduce the price to consumers. He contended that £5,000 of the £20,000 now applied for should be used for the purpose indicated by him.

Hospital Lighting.—The contract for wiring and fitting the new General Hospital, at Birmingham, has been placed with the Birmingham Electric Supply Company, and current for lighting as well as for power purposes is to be taken from the Company's mains.

Hotel Lighting.—Plans have been prepared for the erection of a new first-class hotel at Southend-on-Sea, which is to be lighted electrically throughout.

Lambeth.—A discursive debate on the electric lighting question took place last week at the meeting of the Vestry, when several resolutions were submitted for approval, amongst others, that the report of the Electric Lighting Committee recommending the transfer of the Vestry's Provisional Order to Mr. Sax be agreed to. An amendment that the report should be referred back was defeated, and the Committee's report was so far approved. The matter, however, did not end here, and after a lengthy discussion it was decided to again adjourn the subject to the next meeting of the Vestry, when eight further amendments await the members. Several public meetings have been held since the Vestry meeting, and at each a resolution condemning the action of the Vestry in this matter has been passed.

Lecture.—Mr. W. B. Sayers delivered an interesting lecture on the 16th inst. before the members of the Glasgow Philosophical Society on the "Domestic Applications of Electricity."

Liverpool.—On the recommendation of the Committee of Works permission has been given to the Liverpool Grain Storage and Transit Company by the Mersey Docks and Harbour Board to lay down plant for the electric lighting of their premises at the Alexandra Branch Docks.

Llandrindod Wells.—A hitch has occurred in the negotiations for the introduction of the electric light. The contractor, Mr. E. Davies, wants the Council to indemnify him against all actions that might be brought against him by private persons for breaking up the streets for laying down conduits and mains, but as the Council have declined to do this it is probable that work will not be commenced until a Provisional Order has been obtained.

Peterborough.—Electric lighting matters are making very slow progress indeed in this town. Some time ago the Council decided to issue circulars to the ratepayers in order to ascertain the amount of support likely to be accorded to their proposed electric light scheme, and in reply it was stated that between 1,400 and 1,500 8 c.p. lamps would be required, but no further steps were taken in the matter. Recently, however, fresh circulars were issued, with the result that considerably less than 1,000 lamps are now required. There is something wrong here; the ratepayers evidently are under the impresion that the members of the Council are not in earnest about their electric lighting scheme, and hence the decline of interest in it.

Portsmouth.—At a recent meeting of the Town Council, on the recommendation of the Electric Light Committee, it was decided to carry out various extensions of the electric light mains.

Presentation.—On the 16th inst. Mr. J. H. Rider, late borough electrical engineer of Bolton, was presented by some of his friends

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with a valuable non-magnetisable gold watch in recognition of services rendered in connection with the introduction of the electric light into that town. The presentation was made by the Chairman of the Gas and Electricity Committee (Alderman Miles), who complimented Mr. Rider on the ability displayed by him in the management of the electrical department.

SHIP LIGHTING.—The recently launched P. and O. steamer "India" has been supplied with a very complete electric lighting installation by Messrs. Siemens Bros. and Co.——Baron Barreto's new yacht has also been fitted up for the electric light, the electric lighting machinery being supplied by Messrs. Laurence, Scott and Co. (Limited).

STOWMARKET.—The Urban District Council have given Messrs. Pedder and Prentice permission to erect a small electricity generating station at Stowmarket to supply current for public and private purposes.

STAFFORD.—The price of current has been reduced from 8d. to 4d. per unit for all current used above an average maximum demand of three-quarters of an hour per day during the summer.

SURBITON.—At the last meeting of the District Council an application was received from the Artisans' Land and Mortgage Corporation for permission to take electric current from the mains of the Kingston Corporation to light certain houses in the Surbiton district. The Clerk was instructed to reply that consent would not be given at present, as the Council had not yet decided as to whether they should themselves establish electricity works.

THORNABY-ON-TEES—Some time ago we animadverted on the attitude taken up by the Stockton Corporation and their gas manager (Mr. Ford) towards the electric light. Mr. Ford is of opinion that "at any moment an invention might take place which would infinitely cheapen the lighting of towns by electricity." There is evidence, however, that this excessive caution is not appreciated by the Corporation's probable customers. At the last meeting of the Thornaby-on-Tees Town Council Mr. Walker moved that a committee be appointed to consider and report upon the present supply of gas within the borough, and also to consider the advisability of making arrangements with any corporation or company for the supply of electricity for lighting purposes. On the suggestion of Alderman Anderson the motion was altered so as to refer the whole question to the General Purposes Committee, and in this form it was passed by a large majority. While the Stockton Corporation's gas engineer is making up his mind important probable customers are taking steps to supply themselves with current. This is hardly a dignified position for an important local authority to assume, more especially as the Stockton Provisional Electric Lighting Order was obtained so long ago as 1890.

TRAIN LIGHTING.—Following the lead of the North British and the Great Northern of Scotland Railway Companies, the Caledonian Company are now making some experiments as to the suitability of electricity for train lighting.

WORCESTER.—The City Council have decided to make a charge of 1½d. per unit for all current supplied to the Water and Sewage Committee for working the motors for pumping at the waterworks. The price hitherto charged has been 1d. per unit.

WORKS LIGHTING.—The Raleigh Cycle Company have decided to erect new works at Lenton, near Nottingham, and arrangements have been made to put in a very complete electric lighting installation at an early date. It is calculated that over 5,000 incandescents will be required.

PATENT RECORD.

A record of Applications for Patents and Patent Specifications Published is compiled for this journal by MR. J. C. CHAPMAN, *Fel. Chartered Inst. Patent Agents, of 70, Chancery-lane, W.C., from whom any information on the subject may be obtained.*

APPLICATIONS FOR PATENTS.

NOTE.—*The Specifications of Applications for Patents are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions, or where complete specification accompanies application an asterisk is suffixed.*

April 2, 1896.

7,174. J. C. GREEN. Winnipeg. A metal for heating by electricity.

7,195. S. Z. DE FERRANTI. London. Improvements in dynamos.

7,222. A. S. ELMORE. London. Improvements in apparatus for manufacturing tubes by electrolytic deposit. (J. O. S. Elmore, India.)

7,237. I. T. BOMAR. London. Improvements in electric fire alarms.

7,264. G. F. KRIEGER. London. Improvements in electric igniting devices for gas burners.

7,255. H. H. LAKE. London. Improvements in secondary batteries. (J. Julien, Belgium.)

7,259. W. P. THOMPSON. London. Improvements in and in the construction of soluble metal electrodes for accumulators. (J. Julien, Belgium.)

April 4, 1896.

7,318. E. E. GOLD. London. Improvements in electric heaters.

April 7, 1896.

7,389. W. L. WILHELM and B. J. TILLMAN. London. Improvements in telephone transmitters.

April 8, 1896.

7,475. H. H. FRANKLIN. London. Improvements in electrical p'lot or shallow water signals for vessels.*

April 9, 1896.

7,484. EVERSHED AND VIGNOLES (LIMITED) and S. EVERSHED. London. Improvements in electric meters.

7,530. G. H. ATKINSON. London. A new or improved electrical alarm apparatus.

7,555. H. C. REAGAN, jun. London. Improvements in electric railways.*

7,557. R. HIRSCH, M. R. HIRSCH and J. F. TROTTMAN. London. Improvements in commutator brushes and brush holders.*

April 10, 1896.

7,588. T. MEACOCK. Birmingham. Electric ram lift.

7,621. J. D. F. ANDREWS. London. Improvements in electric switches or apparatus for connecting electric circuits.

7,622. J. D. F. ANDREWS. London. Improvements in insulating materials and their applications to electric wires.

April 11, 1896.

7,649. H. EDMUNDS. London. Improvements in or connected with electric cables or conductors.

7,650. H. EDMUNDS. London. Improvements in wire ropes and armourings or coverings for electric cables.

7,668. F. LISTER. Keighley. Improvements appertaining to road vehicles propelled by steam, oil, electric or like motor mechanism

7,694. F. C. ESMOND. London. Improvements in or connected with electric traction. (Date applied for under Patents, &c., Act, 1883, Sec. 103, September 11, 1895, being date of application United States.)

7,716. R. J. HATION and W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED). London. An improved connection for electric light cables.

April 13, 1896.

7,760. F. W. HEATON and H. SMITH. Salford. Improvements in double-pole switches for electric lighting.

7,789. J. BROCKIE. London. An improvement in electric arc lamps.

7,791. L. ST. PETER. London. Improvements in electric stop-motions for engines.*

7,794. H. A. C. HELLYER. London. Improvements in shade-holders for incandescent electric lamps.*

April 14, 1896.

7,834. A. S. KROTZ, W. P. ALLEN, and O. S. KELLY. Manchester. Improvements in underground systems for electric railways.*

7,881. J. DEVONSHIRE. London. Improvements in electric current transformers and method of cooling the same. (W. S. Moody, United States.)*

7,882. J. DEVONSHIRE. London. Improvements in regulating alternating-current electric motors of the induction type. (W. B. Potter, United States.)*

7,883. J. DEVONSHIRE. London. Improvements in regulating alternating current electric motors. (C. P. Steinmetz and E. J. Berg, United States.)*

7,884. J. DEVONSHIRE. London. Improvements in safety devices for alternating electric current power systems. (E. J. Berg, United States.)*

7 885. J. DEVONSHIRE. London. Improved compound mould for forming incandescent electric lamp bases. (J. Henny and A. Pederquist, United States.)*

April 15, 1896.

7,928. M. MERCIER. Manchester. Electric signal indicator.

7,973. A. HEIL. London. Improvements in electrical accumulators.

April 16, 1896.

8,062. P. W. T. DAVIES. London. Improvements relating to electric railways.

8,067. R. P. WILSON. London. Magneto-electric governing appliance for steam engines, water wheels, and such like apparatus.

8,068. R. P. WILSON. London. Magneto-electric regulating and controlling appliance for dynamos and other electrical apparatus, adapted also for indicating and recording purposes.

8,080. E. COMMELIN and R. VIAU. London. An improved electrical accumulator under pressure.

April 17, 1896.

8,134. L. W. BRENER. London. A new or improved welding process.

8,141. SIEMENS BROS. and Co. (LIMITED). London. Switch apparatus for electromotors with automatic resistance regulator. (Siemens and Halske, Germany.)*

8,163. L. MESMER-WEBER. London. A new or improved alarm clock and apparatus for automatically operating electric signals at definite hours.*

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SPECIFICATIONS PUBLISHED.

NOTE.—All Specifications can now be obtained at the uniform price of 8d. each.

1895.

5,451. WRIGHT. Electric meters.
5,892. HALL and OTHERS. Regulating electric currents.
7,504. FERRARIS and ARNÓ. Distributing alternating currents.
7,788. RIDINGS and OTHERS. Arc lamps.
8,373. RAWSON. Voltaic batteries.
8,966. ROWLAND. Electromotors.
9,167. DEARLOVE. Telegraphic working through cable lines.
9,521. IMRAY (Société Industrielle des Telephones). Photographic telegraph recorder.
9,966. DAVIS. Arc lamps.
22,133. HEMPEL and OTHERS. Telephone message counters.

1896.

474. BERSEY. Electrically-propelled vehicles.
477. STEWART. Electric storage accumulators.
780. LEITNER. Secondary electric batteries.
1,054. FITZGERALD and BERSEY. Voltaic batteries.
1,744. KORDA. Electric traction.
3,032. KRAPF. Electric railway signalling apparatus.
3,082. CUSHMAN. Armatures for induction motors.
3,093. DEVONSHIRE (Knight and another). Dynamo-electric machines.
3,094. DEVONSHIRE (Berg). Regulating alternating currents.
3,682. SIEMENS BROS. AND CO. (LIMITED) and KINGDON. Electric switches.

COMPANIES' MEETINGS AND REPORTS.

Oriental Telephone and Electric Company (Limited).

The second ordinary general meeting of this Company was held on Wednesday at the Cannon-street Hotel, London, Mr. Wm. Addison presiding.

The SECRETARY (Mr. Alexander B. Chalmers) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said: Before moving the adoption of the report and accounts I may congratulate the shareholders on the satisfactory progress that has been made by the Company, and especially on the realisation of what has been for years the hope of your Board in being able to recommend out of the net profits of the year a dividend at the rate of 5 per cent. With reference to the loss of our exchange in Colombo, of which the report makes mention, the Board has been throughout the year in continuous negotiation with the Government of Ceylon, which had already given us notice that it would not renew our licence about to expire at the end of December, 1895. Speaking with all the respect due to a Government, I am bound to say that we have been treated in a manner very discouraging to private enterprise, and unfair to a Company which had invested a considerable sum of money in the Colony, and was ready to invest still more freely if only it could have obtained continued security from the Government; nor have the Directors received that measure of support from the Colonial Office which, under the circumstances, they think they were entitled to ask. In the end the Board had to accept a sum which represents only a small part of the value of the exchange, upon which had been spent in cash £4,856 odd, to which must be added goodwill and compensation for forcible dispossession. If you look at the balance sheet you will find that the suspense account, in regard to the Colombo exchange, amounts to £2,481 odd. This amount could easily be liquidated by the profit on the Consols we hold, if they were to be sold, together with the amount now proposed to be carried forward, and after paying the dividend now recommended; but as the matter has only been finally closed within the current year, the Directors have thought it best to carry the amount to a suspense account, leaving its ultimate adjustment for future consideration. I have nothing further to add to the report; but before formally moving the adoption of it and the accounts, I shall be pleased to answer any questions any of the shareholders may desire to ask.

Commander HUGH H. HANNAY, R.N., animadverted on the shabby manner in which the Government of Ceylon had behaved to the Company in the matter of its plant. In view of the fact that the Company had bought its holding of Consols at about 96, which now stood at 113, had the Directors taken into consideration the advisability of selling the same and thereby making a profit of £2,000? He did not know whether it would be wise to do so or not; he wished merely to throw out the suggestion.

The CHAIRMAN, in reply, said that the Board had had the subject under consideration, but had not acted in the matter because they did not know what to do with the money, seeing that all other kinds of securities had risen in the same proportion. He then formally moved:—

"That the Directors' report, together with the accounts and balance sheet to December 31, 1895, be approved and adopted, and that a dividend of 5 per cent., free of income tax, be declared upon the paid up capital of the Company for the year ended December 31, 1895."

Mr. HENRY GREWING seconded the motion, which was carried unanimously.

In reply to Mr. Hibbert, who advocated that the shareholders should be called together at least twice a year in order that the Company's affairs might obtain greater publicity, and thus increase probably the value of its property in the market, the CHAIRMAN said that the Directors would take the subject into consideration.

On the motion of the CHAIRMAN, seconded by Mr. THOS. LLOYD,

Mr. Benjamin St. John Ackers was re-elected a Director of the Company, as was also Mr. G. B. Frost, on the motion of the CHAIRMAN, seconded by Mr. H. GREWING.

Messrs. St. John Ackers and Frost having expressed their warm acknowledgments,

Messrs. Deloitte, Dever, Griffiths and Co. were re-elected auditors of the Company for the current year, on the motion of Commander HANNAY, seconded by Mr. SEAMAN, and the proceedings terminated with a vote of thanks to the Chairman and Directors.

Telephone Company of Egypt (Limited).

The thirteenth ordinary general meeting of this Company was held on Tuesday, at the offices of the Company, 14, Austin-friars, Gen. Alexr. Fraser, C.B., R.E., presiding.

The SECRETARY (Mr. Alex. B. Chalmers) read the notice calling the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said: You will see from the report that the credit to revenue account for 1895 is £4,821. 3s. 10d. The concessions made to the Government in the beginning of the year caused a considerable loss of income, but we hope that increased business will more than cover that loss in the course of time. The balance of £4,821. 14s. 3d., together with £1,254. 3s. 10d. brought forward from 1894 leaves the sum of £6,085. 18s. 1d. for disposal. Of this we propose to place £1,500 to a reserve account, to which we also transfer £3,000 detailed in the balance sheet of December, 1894, to contingency and suspension account, to pay a dividend of 6 per cent. on the Preferred shares, and to carry forward £964. 12s. 1d. The concessions alluded to above carry with them a contract with the Government for ten years' service from January 1, 1895. Our relations with the Government have been, happily, of the most satisfactory character, and we have offered to do all we can to assist it in its military operations. We have placed our agency in Egypt in the hands of Mr. Edward I. Manak, who had done good service for the Company in the past, and who, we hope, will justify his appointment in the future. Our staff, under Mr. Evans, the general manager (especially Mr. Stevenson at Alexandria), have done work worthy of your thanks, while Mr. Chalmers, the secretary, and his staff in London have, by their ability and assiduity, successfully coped with an increasing business. It will be gratifying to you to observe that the litigation alluded to in our last report has been again given in appeal in the Company's favour. I now have to propose the adoption of the report and accounts, and the approval of the declaration of the dividend set out in the report.

Mr. THOMAS LLOYD seconded the motion, which was carried unanimously.

The CHAIRMAN then moved the re-election of Mr. Thomas Lloyd as a Director, which was seconded by Mr. H. GREWING, and carried unanimously.

The auditors (Messrs. Price, Waterhouse and Co.) were reappointed, and the Directors' remuneration voted at £350 for the current year, after which a cordial vote of thanks to the Chairman terminated the proceedings.

The report of the Directors for the year ended December 31st last was as follows:—

The revenue shows a credit balance of £4,821. 14s. 3d. transferred to profit and loss, which, with £1,254. 3s. 10d. brought forward, gives £6,085. 18s. 1d. for disposal. The Directors propose to place £1,500 to reserve, transfer to the same account £3,000 credited last year to contingency and suspense account, and to pay a dividend of 6 per cent. on the Preferred shares, and to carry forward £964. 12s. 1d. The Egyptian Government having requested a revision of the charges made by the Company for conducting its telephone service, an agreement was entered into last year whereby the Company made liberal concessions to the Government on a contract for ten years, commencing January 1, 1895. These concessions involved a large decrease in the amount received from the Government for the past year, but the Directors hope that, eventually, the increase of the general business may compensate for this loss. The exchange at Mansourah was reopened on December 27th, and other important extensions are in view which, it is hoped, may be carried out during the present year. The exchange at Cairo is being remodelled, and new switchboards of an improved pattern are in course of erection. The litigation in which the Company was involved resulted in an appeal being made by the plaintiff; judgment, was, however, again given in favour of the Company, which closed the matter finally.

Eastern Extension, Australasia and China Telegraph Company (Limited).

The report of the Directors of this Company for the half-year ended December 31st last, to be submitted to the forty-fifth ordinary general meeting, to be held at Winchester House, London, E.C., on Wednesday next, at two o'clock, states that the gross receipts, including Government subsidies, have amounted during the period to £311,582. 10s. 11d., against £261,322. 14s. 6d. for the corresponding period of 1894. This large increase is mainly due to the exceptionally heavy traffic transmitted to and from Western Australia in connection with the gold mining industry that has recently sprung up in that colony. The working and other expenses, including £20,713. 2s. for cost of repairs to cables and expenses of ships, absorb £84,044. 6s. 4d., against £89,740. 14s. 9d. for the corre-

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sponding period of 1894, leaving a balance of £227,538. 4s. 7d. From this is deducted £4,318. 8s. 4d. for income tax, £20,000 transferred to the fire insurance fund, £31,895 for interest on debentures, debenture stock, and contribution to sinking fund, leaving as net profit £171,324. 16s. 3d., which, with £70,504. 13s. 3d. brought forward, shows an available balance of £241,829. 9s. 6d. One quarterly interim dividend of 1¼ per cent. has been paid, and it is now proposed to distribute another of like amount on the 30th inst., making, with the interim dividends paid, a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share (or 2 per cent.), making a total distribution of 7 per cent. for the year 1895. The balance of £129,329. 9s. 6d. has been carried to the general reserve fund, which now stands at £561,546. 9s. 9d.

During the half-year the Company's system has been strengthened by the renewal of 340 knots of the New Zealand (original) cable and 109 knots of the Tasmanian (original) cable. The cost of these renewals, amounting to £38,733. 5s. 10d., has been debited to the general reserve fund, together with £186,043. 14s. 1d., the balance of cost of the alternative Singapore-Hong Kong cable. Further extensive renewal work will have to be carried out during the year.

During the half-year 409 of the Company's Five per Cent. Australian Government Subsidy Debentures, amounting to £40,900, were drawn by lot for payment at par on July 1st next.

With a view to placing the Company's tariffs on a more uniform and satisfactory basis, the Directors have decided to reduce the local rates as and from July 1st next. The immediate effect will certainly be a considerable falling off of revenue, but it is hoped thut the lower rates will lead to such an increase of business as may eventually recoup the initial loss.

Mr. John Denison Pender and the Most Hon. the Marquis of Tweeddale offer themselves for re-election as Directors, and the retiring auditors, Messrs. Deloitte, Dever, Griffiths and Co. and Messrs. Welton, Jones and also seek re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED.—The annual return of this Company, made up to February 21st, has just been filed. The nominal capital consists of £7,000,000 stock, which is fully paid up.

ANGLO-PORTUGUESE TELEPHONE COMPANY (LIMITED).—The annual return to April 9th has been filed. Out of a nominal capital of £75,000 in £1 shares, 50,000 shares have been issued as fully paid. Share warrants comprising 10 shares each are outstanding to the amount of £4,020.

CHLORIDE ELECTRICAL SYNDICATE (LIMITED).—The annual return to January 14th has only just been filed. The capital is £262,500, in 110,000 "A," 140,00 "B," and 12,500 "C" shares of £1 each. All the "A" and "C" and 100,000 "B" shares have been taken up, and 45,000 "A," 100,000 "B," and 12,500 "C" shares have been issued as fully paid. The full amount has been called and paid on the remaining 65,000 "A" shares.

CRYSTAL ELECTRIC LAMP COMPANY (LIMITED).—The annual return to January 6th has only just been filed. The nominal capital is £15,000, in 1,000 Ordinary, 1,600 Preference "A," and 400 Preference "B" shares, of £5 each; 1,000 Ordinary, 1,001 Preference "A," and 400 Preference "B" shares have been taken up, and all the Ordinary and Preference "B" shares have been issued as fully paid. The full amount has been called on 1,001 Preference "A" shares.

DIRECT ELECTRIC GENERATOR SYNDICATE (LIMITED).—This Company has entered into an agreement with Messrs. C. P. Shrewsbury, J. Cooper, F. L. Marshall and J. L. Dobell, for the acquisition of letters patent Nos. 8,759, 9,108, 9,569 and 14,181 (1892), No. 12,483 of 1894, Nos, 8,306, 8,876 and 20,843 (1895), and also provisional specifications 13,110 and 15,782 (1894), for the sum of £95,000, payable by the allotment of 95,000 fully paid shares of £1 each.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The annual return to April 7th has been filed. The nominal capital is £95,000, in 13,000 Ordinary shares and 6,000 Preference shares of £5 each. 12,931 of the former and all the latter have been taken up, and the full amount has been called and paid.

DOUGLAS SOUTHERN ELECTRIC TRAMWAYS (LIMITED).—The annual return to March 5th has been filed. The nominal capital is £50,000, in 30,000 Preference and 20,000 Ordinary shares of £1 each; 12,166 of the former and 5,904 of the latter have been taken up, and the full amount has been paid.

HASTINGS AND ST. LEONARD'S-ON-SEA ELECTRIC LIGHT COMPANY.—The report of the Directors of this Company states that there was an increase in the income from public and private lighting of £1,271 for the past year, but it has been found necessary to debit the accounts with the loss sustained on the sale of installation stock, and also the bad and doubtful debts in connection with the late installation business. The Directors, however, believe that with careful management, and a strict control on the expenditure, next year's working will show good results, and with that view they have written off every loss. With the view of increasing the popularity of the electric light the Directors have for some time given a continuous supply of current, and hope it may be possible to continue such supply, it having been greatly appreciated by numerous customers. The arc lighting of the sea front has not proved remunerative, and if the contract is renewed in June next year it must be on terms more favourable to the Company.

CITY NOTES.

MEMORANDA—Bank rate, 2 per cent. (Feb. 22, 1894). Price of silver 31d. per oz. (April-23rd). Consols (2¾ per cent.) 112⅛–112⅜ for money, 112⅛—112⅜ for account; 2½ per cent. 105¼—105½ (April 23rd). Stock Exchange Settling Days: Consols, May 4th; Stocks and Shares Continuation Day, April 27th; Ticket Day, April 28th; Pay Day, April 29th; Mining Share Carry-over Day, April 25th.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—The fifth drawing for payment of 120 Four per Cent. Mortgage Debentures of this Company will take place on Friday, the 1st prox., at noon at the offices of the Company, Winchester House, Old Broad-street, London. The third drawing of the Four per Cent. Registered Debentures (Series "B"), 15 in number, will take place on the same date and at the same place.

BRITISH MOTOR SYNDICATE (LIMITED).—A statutory meeting of this Syndicate was held last week at which Mr. Harry J. Lawson, chairman of the Company, presided. Mr. Lawson referred to the dividend of 10 per cent. now declared as the first ever made in the horseless carriage industry, this being at the rate of 30 per cent. per annum. He announced that the Company were purchasing all patents put before them which a committee of experts recommended as likely to secure a motor monopoly to the Syndicate.

CITY AND SOUTH LONDON RAILWAY COMPANY (LIMITED).—The traffic returns of this Company for the week ended April 19th were £921, against £856 in the corresponding week of 1895, an increase of £65. The total receipts for the half-year amount to £15,260, against £15,218 for the corresponding period of 1895, an increase of £42.

CONTINENTAL METROPOLITAN TRAMWAYS COMPANY (LIMITED).—The report of the Directors states that the question of the substitution of mechanical for horse traction has now reached an important stage, as the Paris municipal authorities have asked the various tramway companies for information as to terms (other than that of the extension of the concession) upon which they would agree to the general adoption of mechanical traction. The proposal of the Directors of this Company is the payment of an annual subsidy by the city, which would enable the Company to repay the necessary capital outlay within the period of the concession.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment by warrants on May 1st of interest for the half-year ending 30th inst. on their Four per Cent. Mortgage Debenture stock. The transfer books will be closed from the 27th inst. to May 1st inclusive.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment by warrants on May 1st of interest on their Four per Cent. Mauritius Subsidy Debentures for six months to 30th inst. The transfer books will be closed from 27th inst. to May 1st inclusive.

ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL COMPANY (LIMITED).—The report of the Directors of this Company for the year ended December 31st last states that the whole of the £25,980 Second Debenture Stock has been redeemed, and 10,337 Ordinary shares have been handed in for cancellation. This has enabled the Directors to write off the deficit standing in the books and to reduce the patent account by £1,441. The amount due to the Company from Elmore's Metall Aktiengesellschaft is now £19,007. With regard to the latter Company's accounts the capital has been reduced to £30,000, in order that the loss standing to the debit of profit and loss should be written off, and the sum of £2,500 has been spent in new plant during the past year. The Directors state that the sales have been more than double those of 1894. The transfer of a loss in 1894 of £8 to a profit of £3,654 is notified. An important reduction has been made in the charges in the profit and loss account as compared with 1894, and the Directors are considering the means of still further reducing them. A loss of £1,575 is shown upon the year's working; but the Directors point out that this has been brought about by the large sum (£2,554) which has been written off as depreciation on the various assets. The average selling price of the Company's manufactures is stated to have been nearly £5 per ton higher than in 1894. It is proposed to put down 16 additional large tanks at an early date, and in order to pay for the new plant, the additional copper required, and to pay off the overdraft at the German bankers', it is necessary to make a further issue of Debenture stock. The report bears a striking resemblance to its predecessors, and the outlook for the Ordinary shareholders appears to be very little improved.

GENERAL ELECTRIC COMPANY OF AMERICA.—A New York correspondent states that the report of this Company for the year ended January 31st last shows a surplus over charges of $1,338,967. The charges for depreciation stand at $511,000, leaving a balance of $877,000, or sufficient to pay, if divided up, 3½ per cent. on the common stock.

LIVERPOOL GAS FITTINGS COMPANY (LIMITED).—The Directors propose to change the name of this Company to the Liverpool Gas and Electric Fittings Company (Limited), and a resolution authorising the change will be moved at the annual meeting on May 6th.

LIVERPOOL OVERHEAD RAILWAY COMPANY.—The traffic receipts of this railway for the week ended 19th inst. amounted to £1,151. The amount for the corresponding week last year, which included Easter Monday, was £1,386. Decrease £235.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—This Company's traffic receipts for the week ended April 17th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,683.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts of this Company for the half-month ended April 15th are £2,802, compared with £2,307 in the corresponding period of 1895. The December receipts, estimated at £5,103, realised £5,185.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Divi-dend.	Name	Previous Week's Price, Apr. 8.	Price Wednesday, Apr. 22.	Rate per Cent. Yielded.	Dividend Due	Business Done during Week ending Apr. 18. Highest	Lowest
			TELEGRAPHS.			£ s. d.			
£1,012,880	Stock	12 0	Anglo-American ..... xd	49 51	49 51	4 18 0	Jan., Apr., July, Oct.	50¾	49
£2,993,560	Stock	24 0	Do. Preferred ..... xd	92 93	92 93	5 7 6	" "	93½	91½
£2,993,560	Stock	5,0	Do. Deferred	10¼ 10½	9½ 10	.. ..	.. ..	10¼	9¾
£173,400	100	4¾	*African Direct Teleg. 4% Deb. (Reg. & Bearer)....	100 104	100 104	3 17 8	January and July ..	..	..
£250,000	£10	..	Amazon Telegraph (£10 paid)	10½ 11	1⅛ 11	.. ..	.. ..	..	..
130,000	£10	3/0	Brazilian Submarine	14½ 14¾	14½ 14¾	4 14 11	Mar., June, Oct., Dec.	14⅝	14⅜
£75,000	£100	5%	* Do. 5 per Cent. Bonds (2nd Series, 1903)	113 117	113 117	4 6 5	June and December	..	..
10,000,000	$100	$⅜	Commercial Cable Capital Stock	160 170	160 170	4 2 4	Jan., Apr., July, Oct.	..	..
16,000	10	8/0	Cuba Submarine	12½ 12⅝	14½ 13⅝	5 14 4	February and August	13⅝	..
6,000	10	19%	Do. Preference 10 per Cent.	20⅝ 21⅛	21⅛ 21⅛	4 13 0	" "	..	..
12,931	5	2/0	Direct Spanish (fully paid)	4 5	4 5	4 0 0	April and October ..	..	..
6,000	5	10%	Do. Preference 10 per Cent.	10 10½	10 10½	4 15 8	" "	..	..
£30,000	Stock	4½%	Do. 4½% Debentures of £50 each	100⅞ 100⅞	100⅞ 100⅞	4 8 6	.. ..	..	..
60,710	20	2,6	Direct United States Cable, 1877 ..... x1	9½ 10	9½ 10	4 0 0	Jan., Apr., July, Oct.	9½	9⅛
492,000	10	2,6	Eastern ..... xd	17 17½	17 17½	3 14 4	" "	17⅛	17⅛
70,000	10	6%	Do. 6 per Cent. Preference ..... xd	18 18½	18 18½	3 4 10	" "	..	..
£1,297,837	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	130 132	130 133	3 1 1	May and November	132½	130½
£102,100	100	5%	* Do. 5 per Cent. Debentures, 1899.....	104 109	106 109	4 13 10	February & August	..	..
250,000	10	2/6	Eastern Extension	17½ 18½	17⅝ 18½	3 16 9	Jan., Apr., July, Oct.	18½	17⅝
£320,000	Stock	4%	Do. 4 per Cent. Debenture Stock	128 131	129 131	3 1 5	February & August	130½	..
£54,100	100	5%	* Do. 5 p. c. (Austln. Gov. Sub.)Debs. 1900	101 105	101 105	4 16 7	January and July .	..	..
£80,600	100	5%	*Eastern and S. African 5 p. Cent. Mor. Deb.,1900	101 105	101 105	4 16 7	" "	103	..
£300,000	100	4%	* Do. 4% Mortgage Debentures, 1909 (regd.) ..	105 103	105 108	3 14 9	February & August	..	..
£300,000	£25	4%	* Do. 4% Mauritius Sub. Debs. (regd.)	112% 115%	112% 115%	3 10 11	May and November	..	..
180,227	10	2 6	Globe Telegraph and Trust..... xd	10⅛ 11	10⅛ 11	4 1 10	Jan., Apr., July, Oct.	10½	10⅛
180,042	10	6%	Do 6 per Cent. Preference ..... xd	16½ 17½	16½ 17½	3 9 7	" "	17½	16½
150,000	10	5/0	Great Northern.....	23 23½	23 23½	3 8 2	Jan., April, and July	23½	23⅛
£180,000	100	5%	* Do. 5 per Cent. Debentures, 1883 issue....	104 107	104 107	4 13 11	March & September	..	..
17,000	25	12,6	Indo-European	49 52	53 56	4 9 3	May and November	52	50⅜
37,548	10	..	London Platino-Brazilian	.. ..	.. ..	.. ..	" "	..	..
£100,000	100	6%	* Do. 6 per Cent. Debentures	108 111	108 111	5 8 7	March & September	..	..
£100,000	£100	4%	*Pacific European Tel. 4% Guar. Debs. "Red" 1942..	108 111	108 111	3 12 9	.. ..	..	..
11,339	5	4/0	Reuter's	5 6	5 6	.. ..	April and October ..	..	..
3,881	£100 Cert.	£3	*Submarine Cables Trust 6 per Cent.	133 138	133 138	4 8 3	" "	136	..
15,609	10	2/0	West African Telegraph	5½ 6½	5½ 6½	.. ..	January and July .	..	..
£238,300	100	5%	* Do. 5 per Cent. Debentures (red.).....	102 105	102 105	4 15 8	March & September	104	..
30,000	10	3/0	West Coast of America	1 2	1 2	.. ..	January and July .	..	..
£150,000	100	8%	Do. 8 per Cent. Debentures, 1902	93 101	97 103	8 0 0	June and December	99	..
88,321	10	1/3	West India and Panama	1 1½	1 1½	.. ..	" "	1⅛	..
34,563	10	6%	Do. 6 per Cent 1st Preference	11 11½	11½ 11⅝	5 2 2	May and November	11⅝	11⅛
4,669	10	6%	Do. 6 per Cent. 2nd Preference	9½ 10½	9½ 11½	5 14 3	" "	10	..
£80,000	100	5%	* Do. 5 per Cent. Debentures, 1917 (red.)	108 111	108 111	4 11 1	June and December	..	..
64,248	15	3/9	Western and Brazilian	8½ 9	8½ 9	5 5 8	May and November	..	..
33,129	7½	3/9	Do. 5 per Cent. Cumulative Preferred	6½ 6¾	6½ 6¾	.. ..	—	6¾	..
33,129	7½	1/6	Do. Deferred Ordinary.....	2½ 2⅝	2½ 2⅝	.. ..	—	2⅝	2½
£165,200	100	6%	* Do. 6 per Cent. Debs., Series "A" 1910	104 108	104 108	5 13 2	February & August	..	..
£206,400	100	6%	Do. 6% Mort. Debs., Series "B" 1910	104 108	104 108	5 12 2	" "	..	..
£1,177,000	$1,000	7%	Western Union 7% 1st Mort. (Building) Bonds....	113 118	113 118	6 2 3	May and November	..	..
£164,300	£100	6%	Do. 6 per Cent. Sterling Bonds (red.)	102 106	102 105	5 14 10	March & September	..	..
			TELEPHONES.						
44,000	5	2/6	Chili Telephone (fully paid)	3 3½	3 3½	.. ..	—	3½	..
224,850	10/0	1¼d.	Consolidated Telephone Const. & Maintenance ..	⅛ ⅛	⅛ ⅛	.. ..	May and November	..	..
171,504	£1	8·215	Oriental Telephone and Electric (fully paid).....	⅛ ⅛	⅛ ⅛	.. ..	Yearly	..	..
424,597	5	3/0	National	6¾ 7⅛	7 7⅛	3 18 4	June and December	7⅛	6¾
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	16 18	16 18	3 6 8	" "	18	17½
15,000	10	6%	Do. 6% Cumulative 2nd Pref. (fully paid)....	16½ 17½	16½ 17½	3 8 7	" "	..	..
119,234	5	2/6	Do. 5% Non-Cumulative 3rd Pref.	6⅜ 6¼	6½ 6⅝	3 12 9	—	7	6½
1,100,000	Stock	3½%	* Do. Debenture Stock, 4½% (red.)	100 100	100 100	3 4 8	January and July ..	..	..
58,000	5	3/0	United River Plate	3½ 4	3½ 4	.. ..	" "	3⅝	..
£146,733	Stock	5%	* Do. 5 per Cent. Debenture Stock (red.).....	99 101	96 101	5 0 6	" "	100	99
			ELECTRICITY SUPPLY COMPANIES.						
40,000	£10	10/0	City of London Electric Lighting (fully paid)	14½ 15½	14 15	3 6 8	—	14⅝	14¼
10,000	10	6/0	Do. 6% Cumulative Pref. (fully paid).....	16½ 17	16½ 17	3 10 7	—	16⅝	..
£1,000,000	Stock	5%	* Do. 5% Debenture Stock (red.)	134 138	134 138	3 13 8	June and December	..	..
19,900	£5	..	Electricity Supply Co. for Spain.....	.. ..	.. ..	.. ..	—	..	..
£90,000	£5	3/0	Charing Cross & Strand Electricity Supply Corp. ..	7½ 7⅝	7½ 7⅝	.. ..	—	7⅞	..
£57,400	£100	5%	Do. 5 per Cent. Debentures, 1900	— —	— —	.. ..	—	..	..
2,475	£8	..	County of London & Brush Prov. Ord. (fully paid).	8 9	8 9	.. ..	—	8⅛	..
10,000	£10	3/0	Do. Pref. (£8 paid)..... xd	12½ 13½	13½ 13½	.. ..	—	..	..
8,822	£5	..	House-to-House Electric	— —	.. ..	.. ..	—	—	..
15,000	£5	..	Kensington & Knightsbridge El. Light (fully paid).	— —	— —	.. ..	—	—	..
10,000	£5	6%	Do. 1st Pref. Cumulative (fully paid).....	.. ..	.. ..	.. ..	January and July ..	—	..
45,000	£5	3/0	Liverpool Electric Supply (fully paid)	7⅜ 7⅝	7⅜ 7⅝	3 16 2	—	—	..
111,000	5	..	London Electric Supply.....	.. ..	.. ..	.. ..	—	..	..
49,900	£10	5/0	Metropolitan Electric Supply (fully paid) .....xd	12½ 13	13 14	2 17 2	—	13¼	12⅞
£150,000	Stock	4½%	* Do. 4½% Debs.	119 120	118 120	3 15 9	June and December	120	119½
6,452	£10	4/0	Notting Hill Electric	8⅜ 9½	9 9½	.. ..	—	..	..
..	..	..	Rand Electric	⅛ ⅛ prem	⅜ ½ prem.	.. ..	—	..	..
19,980	£5	5/3	St. James and Pall Mall	10 10½	10½ 10⅝	.. ..	—	10⅝	10½
20,000	£5	7%	Do. 7 per Cent. Preference.....	9½ 10½	10 11	3 3 6	—	..	..
59,900	5	4/6	Westminster Electric Supply (fully paid)	9½ 10½	9½ 10½	3 8 4	—	10⅜	9⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
90,000	3	1/6	Brush Electrical Engineering	1⅛ 1⅜	1⅛ 1⅜	5 3 8	—	—	..
90,000	2	6%	Do. 6 per Cent. Pref. Non-Cumulative	1⅜ 1⅝	1⅜ 1⅝	3 4 0	—	—	..
£125,000	Stock	4½%	Do. 4½ per Cent. Debentures.....	111 114	111 114	3 19 4	March & September	113½	..
25,480	5	3/0	Crompton and Co., 7 per Cent. Cumulative Pref..	2½ 2⅝	2½ 2⅝	.. ..	January and July ..	..	..
89,261	5	1/6	Edison and Swan United.....	1⅛ 1⅜	1⅛ 1⅜	.. ..	..	—	..
£100,000	Stock	4½%	Do. 4% Mortgage Debenture Stock	104 107	104 107	4 5 1	..	—	..
£30,000	£5	..	Electric and General Invest. Ordinary (£1 paid) ..	.. ..	— —	.. ..	..	—	..
110,000	2	..	Electric Construction.....	1⅛ 1⅜	1⅛ 1⅜	.. ..	..	—	..
12,845	2	2 9⅜	Do. 7 per Cent. Cumulative Pref.	2⅛ 2⅜	2⅛ 2⅜	5 1 10	..	2⅜	..
91,195	2	10/0	Elmore's Patent Copper Depositing	⅜ ⅜	⅜ ⅜	.. ..	..	⅜	..
20,000	5	..	Fowler-Waring Cables (fully paid)	⅛ ⅛	⅛ ⅛	.. ..	..	..	..
50,000	10	15/0	India Rubber, Gutta Percha, &c., Works	20½ 21½	23 23	4 6 11	February & August	21½	20⅞
£200,000	100	4½%	* Do. 4½ per Cent. Debentures, 1896	.. ..	.. ..	.. ..	March & September	..	..
15,995	£10	..	International Okonite Ordinary.....	.. ..	.. ..	.. ..	—	—	..
16,000	£10	..	Do. 8 per Cent. Preference.....	.. ..	.. ..	.. ..	December and June	—	..
90,000	9	..	Manchester Edison-Swan "A" (£1 5s. paid).....	⅛ ⅜	⅛ ⅜	.. ..	..	..	..
37,350	12	24/0	Telegraph Construction and Maintenance .....xd	38 41	38 41	4 7 10	March and July ..	39½	39
£150,000	100	5%	* Do. 5 per Cent. Bonds	102 105	102 105	4 16 5	January and July	..	..
37,514	£5	..	Woodhouse and Rawson Ordinary (£3 15s. paid)..	.. ..	.. ..	.. ..	—	—	..
41,098	£5	..	Do. Preference (fully paid).....	.. ..	.. ..	.. ..	—	—	..
£100,000	10	10/0	W. T. Henley's Telegraph Works Ordinary.....x1	16½ 17½	16½ 17½	3 8 7	—	17⅛	16½
£30,000	10	7/0	Do. 7 per Cent. Preference .....xd	16⅜ 17⅛	16⅜ 17⅛	4 0 0	—	..	..
£50,000	Stock	4½%	Do. 4½% Mortgage Debenture Stock.....	107 112	107 112	4 0 9	—	..	..
			RAILWAYS AND TRAMWAYS.						
£630,000	Stock	1½%	City and South London Railway Con. Ordy.	40 42	40 42	2 19 6	May and November	41⅛	40½
7,350	10	6%	Do. 6% Perpetual Preference	14½ 15	14½ 15	3 6 8	.. ..	..	..
£10,171	Stock	4%	Do. 4% Perpetual Debenture	132 134	135 137	2 19 3	May and November	134	..
£7,500	£10	3½%	Liverpool Overhead Railway	14 14½	14 14½	2 1 9	—	—	..
10,000	10	5%	Do. 5% Preference	16⅜ 16⅝	16⅜ 16⅝	2 19 3	—	—	..
115,000	Stock	4%	Do. 4% Debenture	114½ 116½	114½ 116½	3 10 2	January and July ..	—	..

† In calculating the yield on this security, allowance has been made for accrued interest, but not for redemption.

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